DOCKETED	
Docket Number:	25-BSTD-03
Project Title:	2028 Energy Code Pre-Rulemaking.
TN #:	265860
Document Title:	Presentations from the 2028 Energy Code Accounting Workshop, August 28, 2025
Description:	This document includes all presentations from the August 28, 2025, workshop on the 2028 Energy Code accounting metrics. A recording of this workshop can be found on the workshops event page at https://www.energy.ca.gov/event/workshop/2025-08/staff-workshop-energy-accounting-methodologies-2028-energy-code. Links to all material related to the 2028 Energy Code, including updated metrics, can be found on the 2028 Energy Code page at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2028-building-energy-efficiency.
Filer:	Javier Perez
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	9/3/2025 3:24:33 PM
Docketed Date:	9/3/2025

Good morning and thank you for joining us.

The hearing will begin shortly.

Staff Workshop on Energy Accounting for the 2028 Energy Codes

August 28, 2025

Communication 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
- Maximum 2 minutes or less per speaker, 1 speaker affiliation

Todays Agenda

	Topics	Presenter
	General Structure of Hearing	Payam Bozorgchami
	Opening Remarks	Commissioner McAllister
	Rulemaking Introduction	Javier Perez
	2028 Measure Template	Javier Perez
	Break	
	2028 Restructured Code	Payam Bozorgchami
	Future Weather Analysis	Bruce Wilcox
	LSC & Source Energy Metric Updates	Snuller Price/Fangxing Liu
	Lunch	

Todays Agenda (continued)

	Topics	Presenter
	NR Sensitivity Analysis	Rahul Athalye
	Prototype Updates	Eric Shadd
	Break	
	Plug Loads	Dimitri Contoyannis
	End	Payam Bozorgchami

Comments on the 2028 Codes

- **Comments on Todays Hearing**
- **Due Date: September 12, 2025, by 5:00 PM**

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

- **Comments/Questions on Part 6 Restructured Standards to be emailed to: energycodeupdateinquiries@energy.ca.gov**

- Thank you for participating!

Questions?

Introduction to the 2028 Energy Code Proceeding

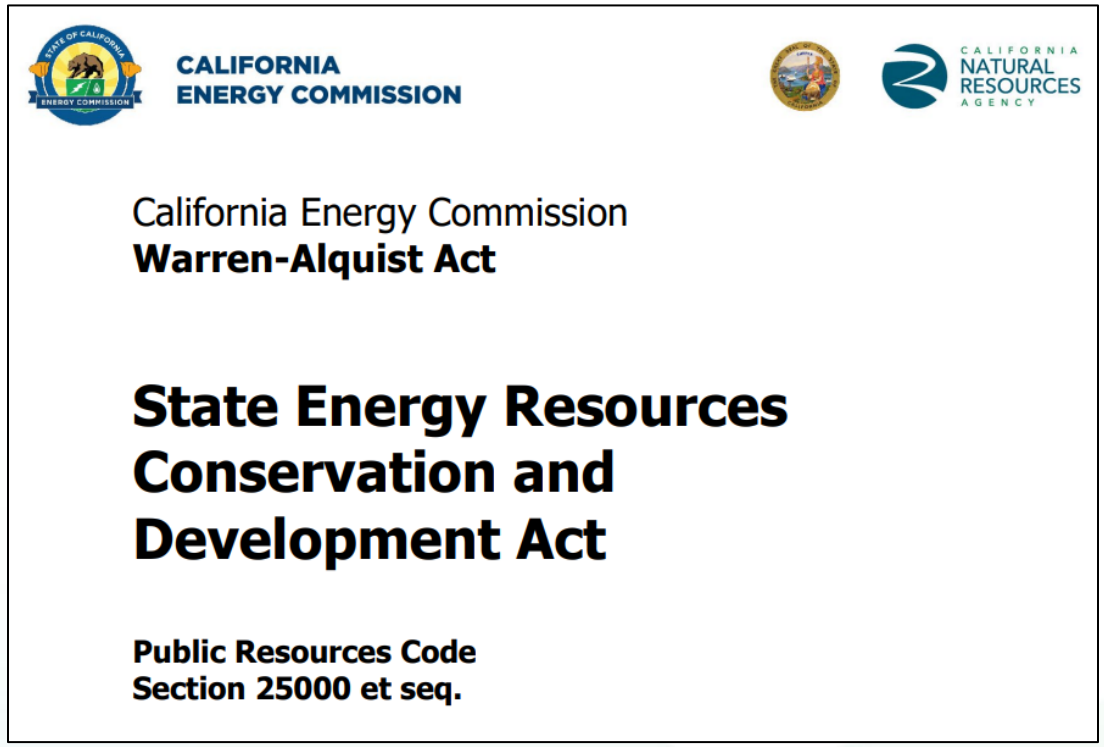
2028 Energy Code and the Measure Proposal Template

Javier Perez, Energy Code Project Manager

August 28, 2025

Authority and 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 Building Efficiency Standards and requires the building departments to enforce them through the permit process



AB130 (2025-2026) Updates

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

- CEC will not propose updates to single-family and multifamily building standards for 2028 code cycle
- Residential energy metrics will remain unchanged until 2031 Energy Code, including compliance metrics and weather files
- Future coordination to come with the California Building Standards Commission

For questions on local ordinances, please email LocalOrdinances@energy.ca.gov

Priorities of the 2028 Energy Code

State Goals

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

2028 Energy Code Strategies - Nonresidential Buildings and Covered Processes

- New and replacement HVAC and water heating systems
- Lighting power density and controls
- Building envelope
- Data centers
- Controlled environment horticulture buildings
- Process boilers
- Elevators

Standards Compliance

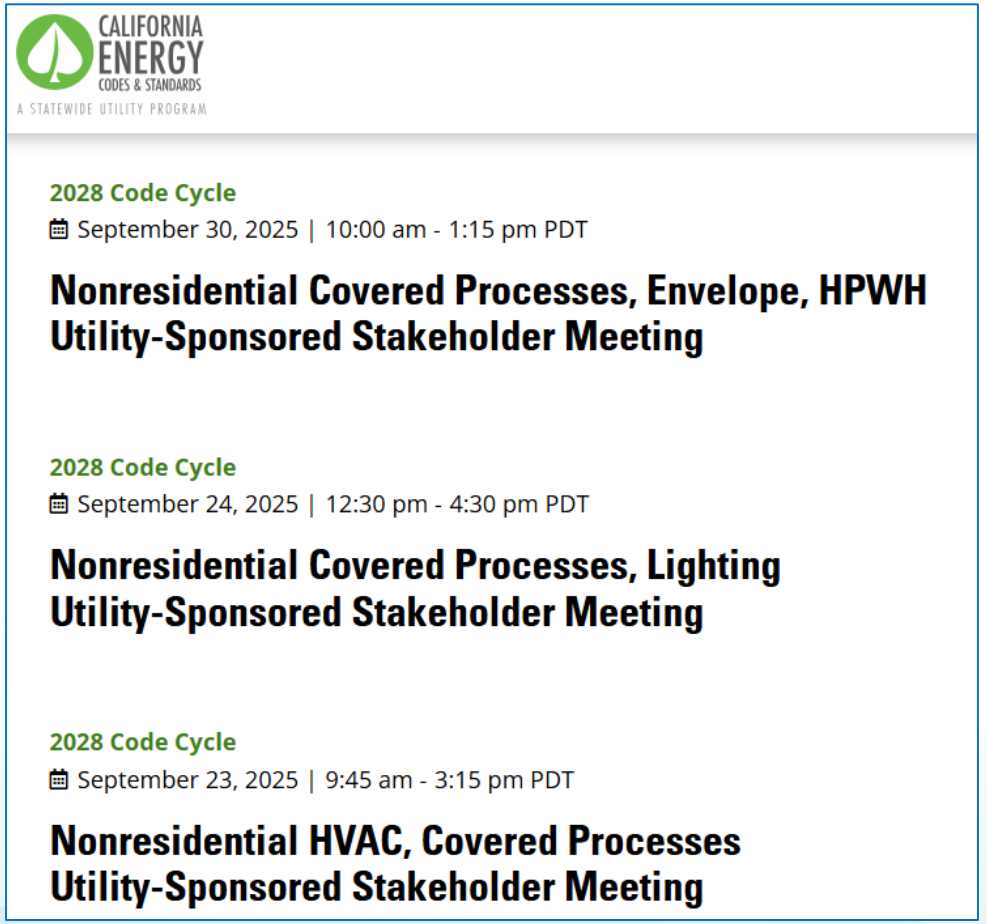
- ATTCP, data & tools

Codes & Standards Enhancement Team – Upcoming Workshops

Codes & Standards Enhancement (CASE) team

- Supports the CEC's efforts to update the Energy Code
- Sponsored by investor-owned utilities and LADWP and SMUD
- Three workshops currently scheduled

- https://title24stakeholders.com/public-meetings/



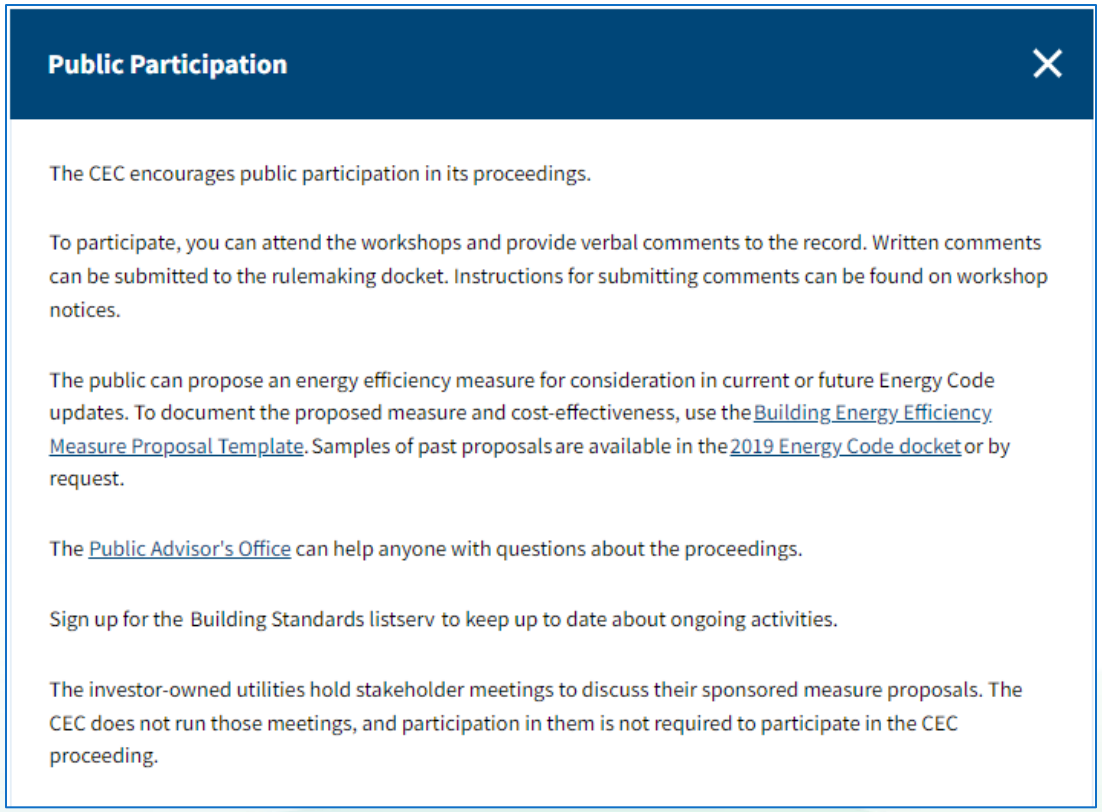
Tentative 2028 Timeline

2028 Energy Code Milestones	Timeline
Energy Code Accounting Workshop	August 28, 2025
CASE Team Workshops – Round 1	Sep. – Oct. 2025
Standards Compliance (SC) Workshop	Sep. 2025
SC Workshop – NR Acceptance Testing	Oct. – Nov. 2025
SC Workshop – Data & Tools	Nov. 2025 – Jan. 2026
Draft Measure Proposal Reports	Dec. 2025
CASE Team Workshops – Round 2	Jan. – Feb. 2026
Final Measure Proposal Reports	Mar. 2026
CEC Pre-Rulemaking Workshops	Apr. – May 2026
Formal Rulemaking	Jan. – May/Jun. 2027
CEC Adoption	May/Jun. 2027
Effective date	Jan. 1, 2029

The 2028 Measure Proposal Template

Background & Purpose

- Template first released to the public during the 2016 Energy Code update cycle
- Available for download here:
  - https://www.energy.ca.gov/media/11702
- Measure Proposals are Foundational Documents
  - Meets statutory requirement to show cost effectiveness
  - Documents necessary research supporting purposed changes to the Energy Code
  - Necessary to finalize key components of the rulemaking package:
    - Fiscal and Economic Impact Report (Form 399)
    - Nine Point Criteria
    - California Environmental Quality Act



Public Participation

The CEC encourages public participation in its proceedings.

To participate, you can attend the workshops and provide verbal comments to the record. Written comments can be submitted to the rulemaking docket. Instructions for submitting comments can be found on workshop notices.

The public can propose an energy efficiency measure for consideration in current or future Energy Code updates. To document the proposed measure and cost-effectiveness, use the Building Energy Efficiency Measure Proposal Template. Samples of past proposals are available in the 2019 Energy Code docket or by request.

The Public Advisor's Office can help anyone with questions about the proceedings.

Sign up for the Building Standards listserv to keep up to date about ongoing activities.

The investor-owned utilities hold stakeholder meetings to discuss their sponsored measure proposals. The CEC does not run those meetings, and participation in them is not required to participate in the CEC proceeding.

2028 Code Cycle Considerations

- Things to consider before beginning:
  - Reach out to us before starting (EnergyCodeUpdateInquiries@energy.ca.gov)
  - Consider priorities identified in Slide 4 (Priorities of the 2028 Energy Code)
  - Get key data sets for the analysis
    - LSC, source energy, emission factors, and demand factors available by September 5th, 2025
    - Nonresidential construction starts data available by end of September 2025
  - All 2028 material will be published at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2028-building-energy-efficiency

Template Sections: Important Updates

- Appendix X: requesting detailed assumptions, modeling approaches used for analysis
  - New appendix added for more complex proposals
  - Energy simulation assumptions and software enhancements
  - Detailed accounting of incremental first and maintenance cost assumptions
  - Requesting sufficient detail to replicate analysis
- First-year statewide installation totals
  - Quantify expected total installations of proposed product/widget where applicable
  - E.g., if proposal includes new control equipment, how many are expected to be installed as result of new code change?
    - This may not always correlate with number of buildings affected, or to all buildings covered
- General revisions
  - Updated language for clarity and consistency

Questions and Answers

- Any questions you don't think of now, send to:

  EnergyCodeUpdateInquiries@energy.ca.gov

- Comments or suggestions related to today's workshop can be submitted to our docket:

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

- Comments may be included in the "Comment Text" box or attached in a downloadable, searchable Microsoft® Word (.doc, .docx) or Adobe® Acrobat® (.pdf) file
  - Maximum file size is 10 MB.

Questions?

Introducing the Part 6 Restructured Standards

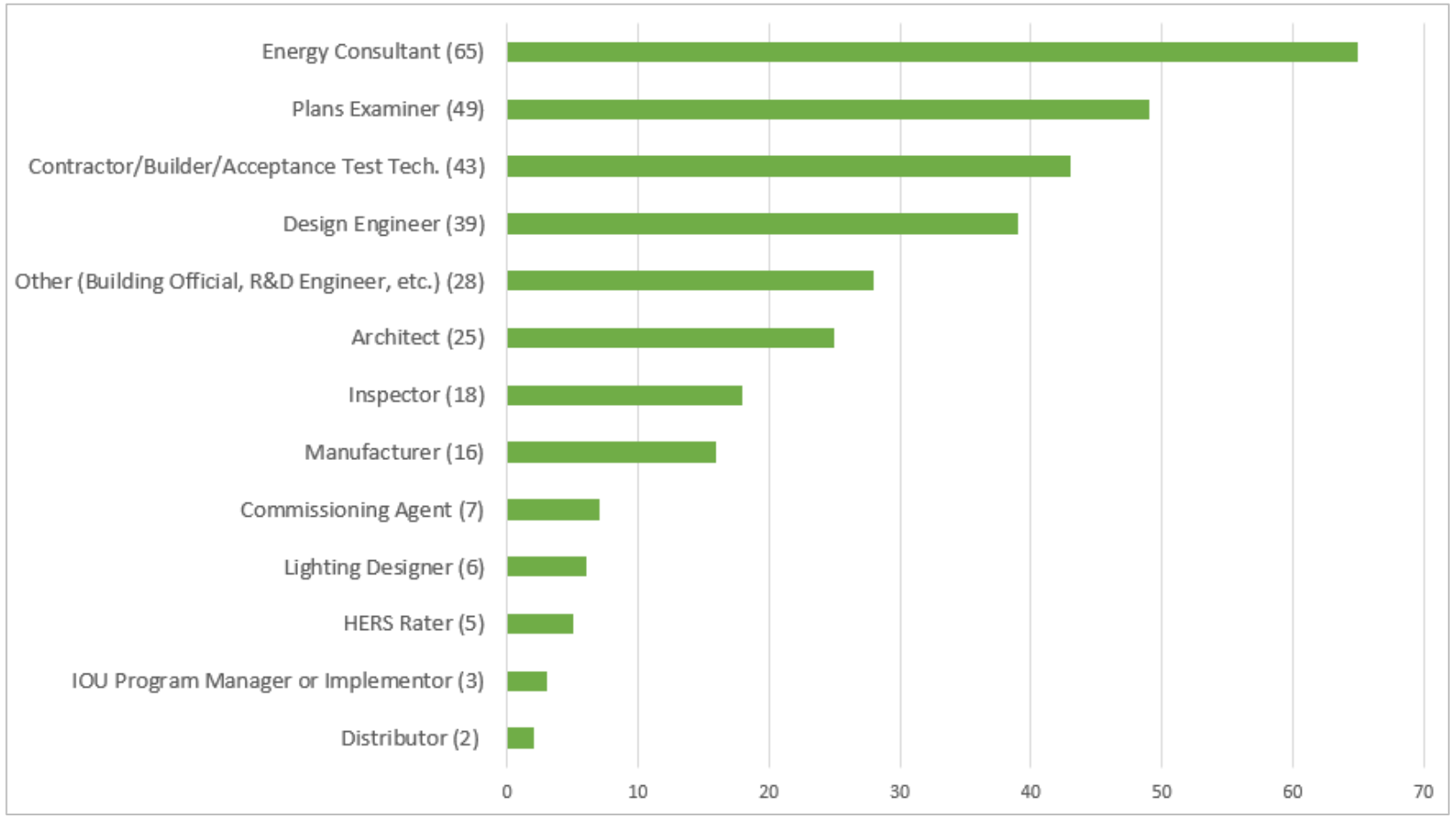
Payam Bozorgchami, P.E.

August 28, 2025

Agenda

- Background- Why & How?
- Features included in Restructured Standard
- Reorganize by building system
- Renumber sections
- Hyperlinks
- Index
- Italicize defined terms
- Restructured Standard - When & Where?
- Questions and comments

Roles That Participated in Public Input Fall 2023



MS Excel generated based on CEC Survey Fall 2023

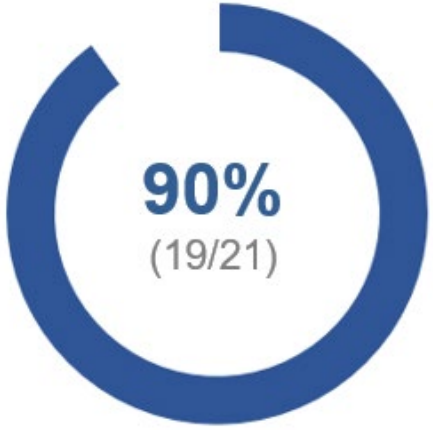
SURVEY
(306 total)

Energy Consultant (14)
Designer (8)
Contractor/ ATT (6)
Plans Examiner (6)
Other (BO, R&D Eng., etc.) (5)
Manufacturer (4)
Commissioning Agent (2)
HERS Rater (1)
Inspector (1)

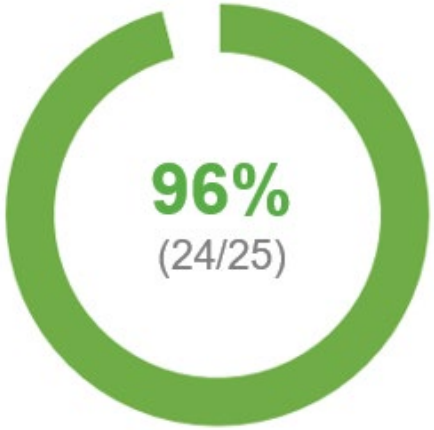
FOCUS GROUPS & INTERVIEWS
(47 total)

Focus Group Poll Results

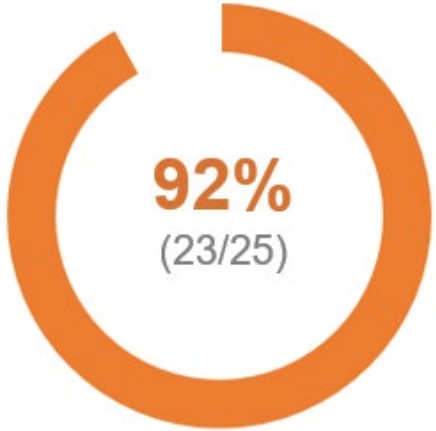
90% support renumbering to follow CBC/CRC



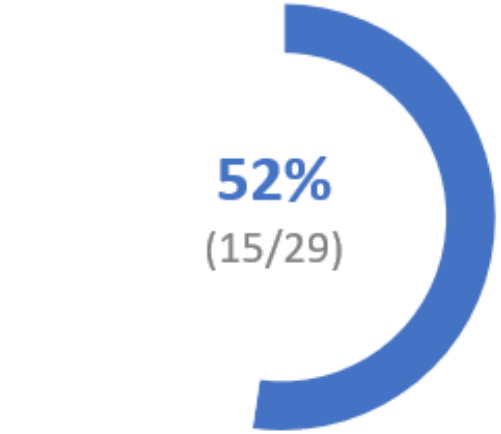
96% support tables after relevant code language



92% want hyperlinks within Standards & Ref. Appendices



52% want requirements to be repeated if they are the same



MS Excel generated based on Fall 2023 focus groups

Rank the options for Standards organization in order of preference (1) being your first choice and (3) being your last choice:

Points Based on Borda Count Ranking

By System Type	**63**	**< 1st Place overall**
By Building Type	50	< 2nd Place overall
Current Organization	34	< 3rd Place overall

Ranking is calculated with a points system, also called “Borda Count”, where the item ranked first will get 3 points, the item ranked second will get 2 points and the item ranked third gets 1 point.

Current vs. Reorganized Standards

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

CURRENT

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

REORGANIZED

Building System Chapter Structure

Existing 2022 §	Chapter 3 - ENVELOPE
	Section 300 – MANDATORY REQUIREMENTS FOR ALL OCCUPANCIES (NEW CONSTRUCTION, ADDITIONS AND ALTERATIONS)
110.60	300.1 - Mandatory Requirements for Fenestration Products and Exterior Doors
110.70	300.2 - Mandatory Requirements to Limit Air Leakage
110.80	300.3 - Mandatory Requirements for Insulation, Roofing Products and Radiant Barriers
	Section 301 - NONRESIDENTIAL AND HOTEL/MOTEL OCCUPANCIES
120.00	301.1 - General
120.70	301.2 - Mandatory (New Construction, Additions, and Alterations)
140.30	301.3 - Prescriptive (New Construction)
	301.4 - Performance (New Construction)
141.0(a) & (b)	301.5 - Additions, Alterations, and Repairs to Existing Buildings
	Section 302 - SINGLE-FAMILY OCCUPANCIES
150.0	302.1 - General
150.0	302.2 - Mandatory (New Construction, Additions and Alterations)
150.1(c)	302.3 - Prescriptive (New Construction)
	302.4 - Performance (New Construction)
150.2(a) & (b)	302.5 - Additions, Alterations, and Repairs to Existing Buildings
	Section 303 - MULTIFAMILY OCCUPANCIES
160.0 & 170.0	303.1 -General
	303.2 - Mandatory (New Construction, Additions and Alterations)
160.1	*Reference applicable sections in NR and SF that are duplicative*
	303.3 - Prescriptive (New Construction)
170.2(a) & (b)	*Reference applicable sections in NR and SF that are duplicative*
	303.4 - Performance (New Construction)
	303.5 - Additions, Alterations, and Repairs to Existing Buildings
180.1(a) & (b) & 180.2(a) & (b)	*Reference applicable sections in NR and SF that are duplicative*

Include Adopted 2025 Code Section Numbers

SUBCHAPTER 3 – ENVELOPE

SECTION 300— MANDATORY REQUIREMENTS FOR ALL OCCUPANCIES

300.1 *[§110.6]* Mandatory requirements for fenestration products and exterior doors.

300.1.1 *[§110.6(a)]* Certification of fenestration products and exterior doors other than field-fabricated. Any fenestration product and exterior door, other than field-fabricated fenestration products and field-fabricated exterior doors, may be installed only if the manufacturer has certified to the Commission, or if an independent certifying organization approved by the Commission has certified, that the product complies with all of the applicable requirements of this subsection.

300.1.1.1 *[§110.6(a)1]* Air leakage. Manufactured fenestration products and exterior doors shall have air infiltration rates not exceeding 0.3 cfm/ft^2 of window area, 0.3 cfm/ft^2 of door area for residential doors, 0.3 cfm/ft^2 of door area for nonresidential single doors (swinging and sliding), and 1.0 cfm/ft^2 for nonresidential double doors (swinging), when tested according to NFRC-400 or ASTM E283 at a pressure differential of 75 pascals (or 1.57 pounds/ft^2), incorporated herein by reference.

Exception to Section 300.1.1.1 *[§110.6(a)1]*: Field-fabricated fenestration and field-fabricated exterior doors.

NOTE: Pet doors must meet 0.3 cfm/ft2 when tested according to ASTM E283 at 75 pascals (or 1.57 pounds per square foot). AAMA/WDMA/CSA 101/I.S.2/A440-2011 specification is equivalent to ASTM E283 at a pressure differential of 75 pascals (or 1.57 pounds per square foot) and satisfies the air leakage certification requirements of this section.

300.1.1.2 *[§110.6(a)2]* U-factor. The fenestration product and exterior door's U-factor shall be rated in accordance with NFRC 100, or use the applicable default U-factor set forth in Table 300.1.1-A *[Table 110.6-A].*

Language adapted from Title 24, Part 6 Standards

Hyperlinks to Help with Quick Navigation

SUBCHAPTER 3 – ENVELOPE

SECTION 300— MANDATORY REQUIREMENTS FOR ALL OCCUPANCIES

300.1 *[§110.6]* Mandatory requirements for fenestration products and exterior doors.

300.1.1 *[§110.6(a)]* Certification of fenestration products and exterior doors other than field-fabricated. Any fenestration product and exterior door, other than field-fabricated fenestration products and field-fabricated exterior doors, may be installed only if the manufacturer has certified to the Commission, or if an independent certifying organization approved by the Commission has certified, that the product complies with all of the applicable requirements of this subsection.

……

300.1.1.5 *[§110.6(a)5]* Labeling. Fenestration products and exterior doors shall:

- Have a temporary label for manufactured fenestration products and exterior doors or a label certificate when the Component Modeling Approach (CMA) is used and for site-built fenestration meeting the requirements of Section 10-111(a)1. The temporary label shall not be removed before inspection by the enforcement agency; and
- Have a permanent label or label certificate when the Component Modeling Approach (CMA) is used and for site-built fenestration meeting the requirements of Section 10-111(a)2 if the product is rated using NFRC procedures.

300.1.1.6 *[§110.6(a)6]* Fenestration acceptance requirements. Before an occupancy permit is granted site-built fenestration products in other than single-family buildings shall be certified as meeting the Acceptance Requirements for Code Compliance, as specified in the Reference Nonresidential Appendix NA7 to ensure that site-built fenestration meets Standards requirements, including a matching label certificate for product(s) installed and be readily accessible at the project location. A certificate of acceptance certifying that the fenestration product meets the acceptance requirements shall be completed, signed and submitted to the enforcement agency.

Language adapted from Title 24, Part 6 Standards

Including the Index

A

ABOVE GRADE WALL.....301.3.1.9 *[§140.3(a)9]*, 302.2.3 *[§150.0(c)]*, 303.2.2 *[§160.1(b)]*

ACCENT LUMINAIRE ..... 200.1 *[§100.1]*, 601.3.1.3 *[§140.6(c)2G]*, 603.3.2 *[§170.2(e)4]*

ACCENT, DISPLAY AND FEATURE ...601.3.1.2 *[§140.6(b)4]*

Language adapted from Title 24, Part 6 Standards Index

3 01 .3.1.9

- Section "XXX.3" is Prescriptive
- Section "X01" is Nonresidential
- Chapter 3 (Envelope)

3 02 .2.3

- Section "XXX.2" is Mandatory
- Section "X02" is Single Family
- Chapter 3 (Envelope)

Italicize Defined Terms

SUBCHAPTER 3 – ENVELOPE

SECTION 300— MANDATORY REQUIREMENTS FOR ALL OCCUPANCIES

300.1 *[§110.6]* Mandatory requirements for *fenestration products* and exterior doors.

300.1.1 *[§110.6(a)]* Certification of *fenestration products* and exterior doors other than *field-fabricated*. Any *fenestration product* and exterior door, other than *field-fabricated* *fenestration products* and *field-fabricated* exterior doors, may be installed only if the manufacturer has *certified to the Commission*, or if an independent *certifying organization* approved by the Commission has certified, that the product complies with all of the applicable requirements of this subsection.

…….

300.1.1.5 *[§110.6(a)5]* Labeling. *Fenestration products* and exterior doors shall:

- Have a temporary label for *manufactured* *fenestration products* and exterior doors or a label certificate when the *Component Modeling Approach (CMA)* is used and for site-built fenestration meeting the requirements of Section 10-111(a)1. The temporary label shall not be removed before inspection by the enforcement agency; and
- Have a permanent label or label certificate when the *Component Modeling Approach (CMA)* is used and for site-built fenestration meeting the requirements of Section 10-111(a)2 if the product is rated using NFRC procedures.

300.1.1.6 *[§110.6(a)6]* Fenestration acceptance requirements. Before an occupancy permit is granted site-built fenestration products in other than *single-family buildings* shall be certified as meeting the *Acceptance Requirements for Code Compliance*, as specified in the Reference Nonresidential Appendix NA7 to ensure that site-built fenestration meets Standards requirements, including a matching label certificate for product(s) installed and be readily *accessible* at the project location. A certificate of acceptance certifying that the *fenestration product* meets the acceptance requirements shall be completed, signed and submitted to the *enforcement agency*.

Language adapted from Title 24, Part 6 Standards

Restructured Standards developed based on adopted 2025 Standards

Comments on the 2028 Codes

- **Comments/questions to be Emailed to: energycodeupdateinquiries@energy.ca.gov**

- Thank you for participating!

QUESTIONS OR COMMENTS

Weather File Updates for the 2028 Energy Code

August 28, 2025

Bruce Wilcox
Neal Kruis
Nathan Oliver
Michael Roth
Charles Barnaby
Ada Shen

With support from Southern California Edison

Agenda

- Hourly Weather in the Building Standards
- 2028 Weather Revision Goal
- CEC Cal-Adapt project
- The Future Typical Meteorological Year (TMY)
- TMY Hourly Variable Weightings
- Population weighting for selecting Statewide time coincident TMYs
- Historic Months Selected
- Medium Office Prototype Energy Use by Weather File and Climate Zone
- Historic and Future TMY Energy Use for the Medium Office Prototype
  - in Los Angeles
  - in Sacramento
- Recommendations

Hourly Weather Data in the Building Standards

- Hourly weather files are used for life cycle costing in standards development and for performance compliance
- Weather files have been updated at each recent standards cycle from historic measured data using the TMY procedure:
  - Historical weather months are ranked based on how close their data is to long term averages
  - The most typical months are assembled into a single year
- Improvements have included:
  - High quality solar radiation estimates from weather satellite data
  - Simultaneous data across the state and region to identify weather driven peak effects

For 2028 the goal is to make forward looking weather files based on future climate change over the next 30 years

CEC Cal-Adapt Project

- The CEC Cal-Adapt project provides predictions for future California weather derived from internationally developed Global Climate Models
  - These models include multiple climate change scenarios called Shared Socioeconomic Pathways (SSPs), developed by international climate scientists*
- CPUC Decision 24-08-005 adopted SSP3-7.0 as the reference Scenario for energy utility use in the Climate Adaption and Vulnerability Assessments (CAVA) ordered in D.20-08-046.
- Two Cal-Adapt data sets were available:
  - WRF outputs hourly data that could be used directly for simulations but could not easily be bias-corrected to match California observational data between 1998-2020.
  - LOCA2 outputs daily data that could be bias-corrected using a standard approach
- Daily data is sufficient to create targets for TMY month selection

*For more on climate projections and models, visit https://analytics.cal-adapt.org/guidance/about_climate_projections_and_models/

The Future Typical Meteorological Year (TMY)

- The project team used an adapted TMY procedure to select individual months from the statewide historic weather data (2000-2020) that most closely match the change in predicted LOCA2 future data for 2030-2059

- We redefined the TMY
  - From representing the average of 30 years of historical data
  - To representing the average of 30 years of predicted future data

We adapted the standard TMY Hourly Variable Weightings to the use the LOCA2 Daily Data

Hourly NREL/NSRDB		For Use with LOCA2	
Weather Variable	**Weighting**	**Weather Variable**	**Weighting**
Max Dry Bulb Temp	5%	Max Dry Bulb Temp	5%
Min Dry Bulb Temp	5%	Min Dry Bulb Temp	5%
Mean Dry Bulb Temp	10%	Mean Dry Bulb Temp	10%
Max Dew Point Temp	5%	Mean Dew Point Temp	20%
Min Dew Point Temp	5%		
Mean Dew Point Temp	10%		
Max Wind Velocity	5%	Mean Wind Velocity	10%
Mean Wind Velocity	5%		
Global Radiation	25%	Global Radiation	50%
Direct Radiation	25%		

Population weighting for selecting Statewide time coincident TMYs

Weather Station	Zone	Population	Weight
Arcata	1	191,087	0%
Sonoma County	2	974,506	2%
Oakland	3	3,990,009	10%
Paso Robles	4	2,089,109	5%
Santa Maria	5	425,468	1%
Los Angeles	6	3,002,383	7%
San Diego	7	2,330,845	6%
Fullerton	8	4,661,646	11%
Burbank	9	6,267,752	15%
Riverside	10	5,184,794	13%
Red Bluff	11	1,290,646	3%
Sacramento	12	5,381,437	13%
Fresno	13	2,858,245	7%
Palmdale	14	1,113,164	3%
Palm Springs	15	916,655	2%
Blue Canyon	16	538,370	1%
	Total	41,216,116	

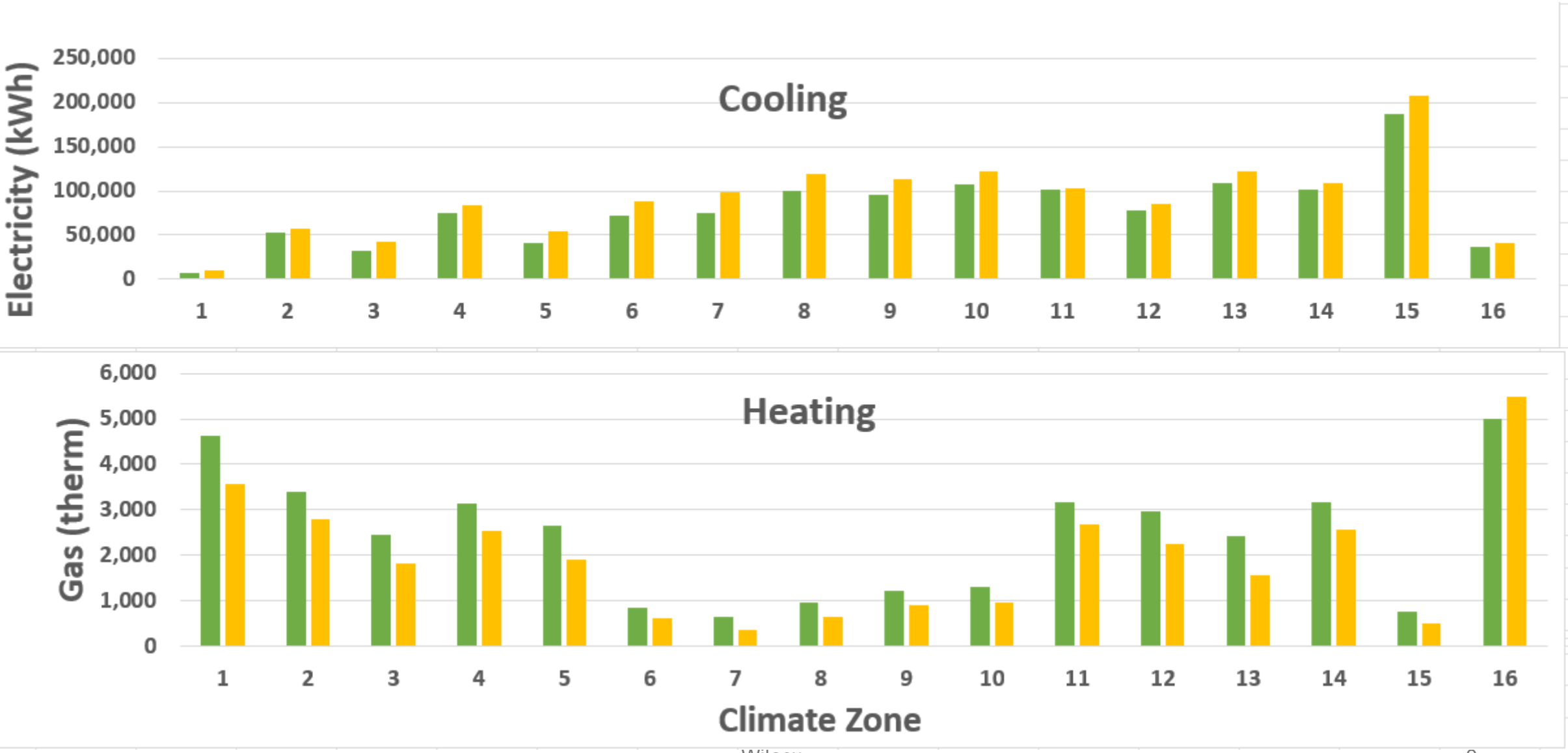
Source: California Energy Commission

Historic Months Selected

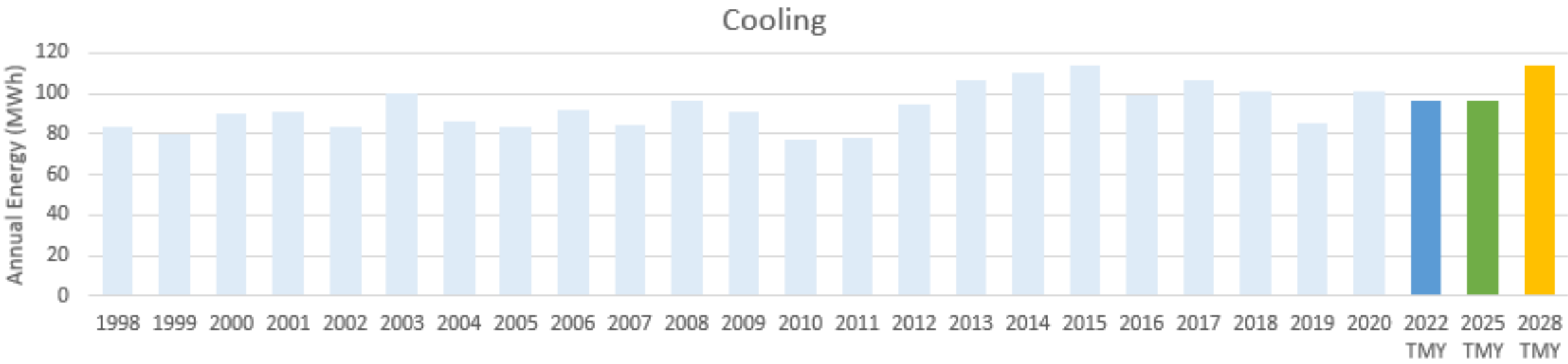
	2025 File	2028 File
Month	Historic Weather	Future Weather
January	2011	2019
February	2008	2014
March	2000	2016
April	2018	2018
May	2017	2000
June	2016	2006
July	2007	2006
August	2005	2015
September	2016	2014
October	2012	2012
November	2005	2016
December	2004	2018

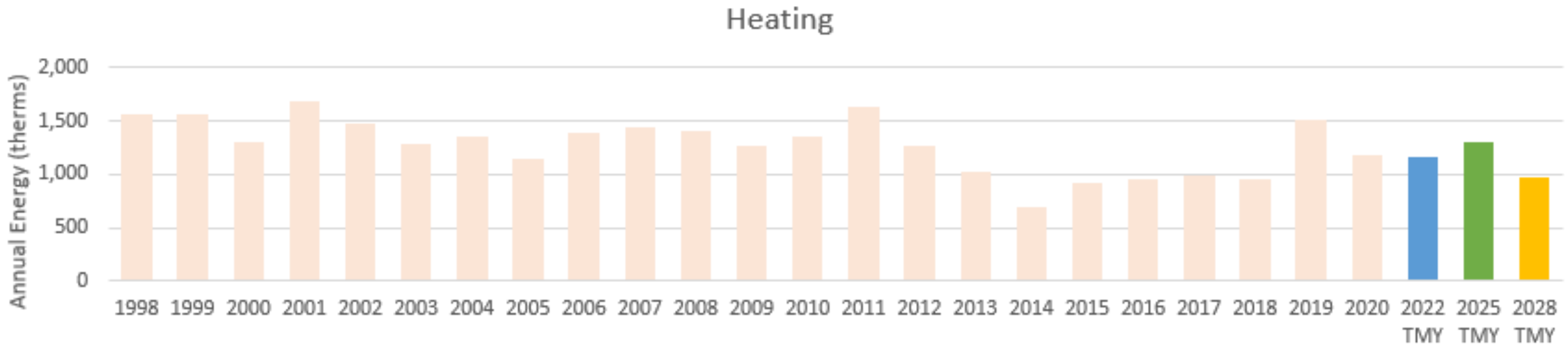
Medium Office Prototype Energy Use by Climate Zone

2025 Historic Weather 2028 Future Weather

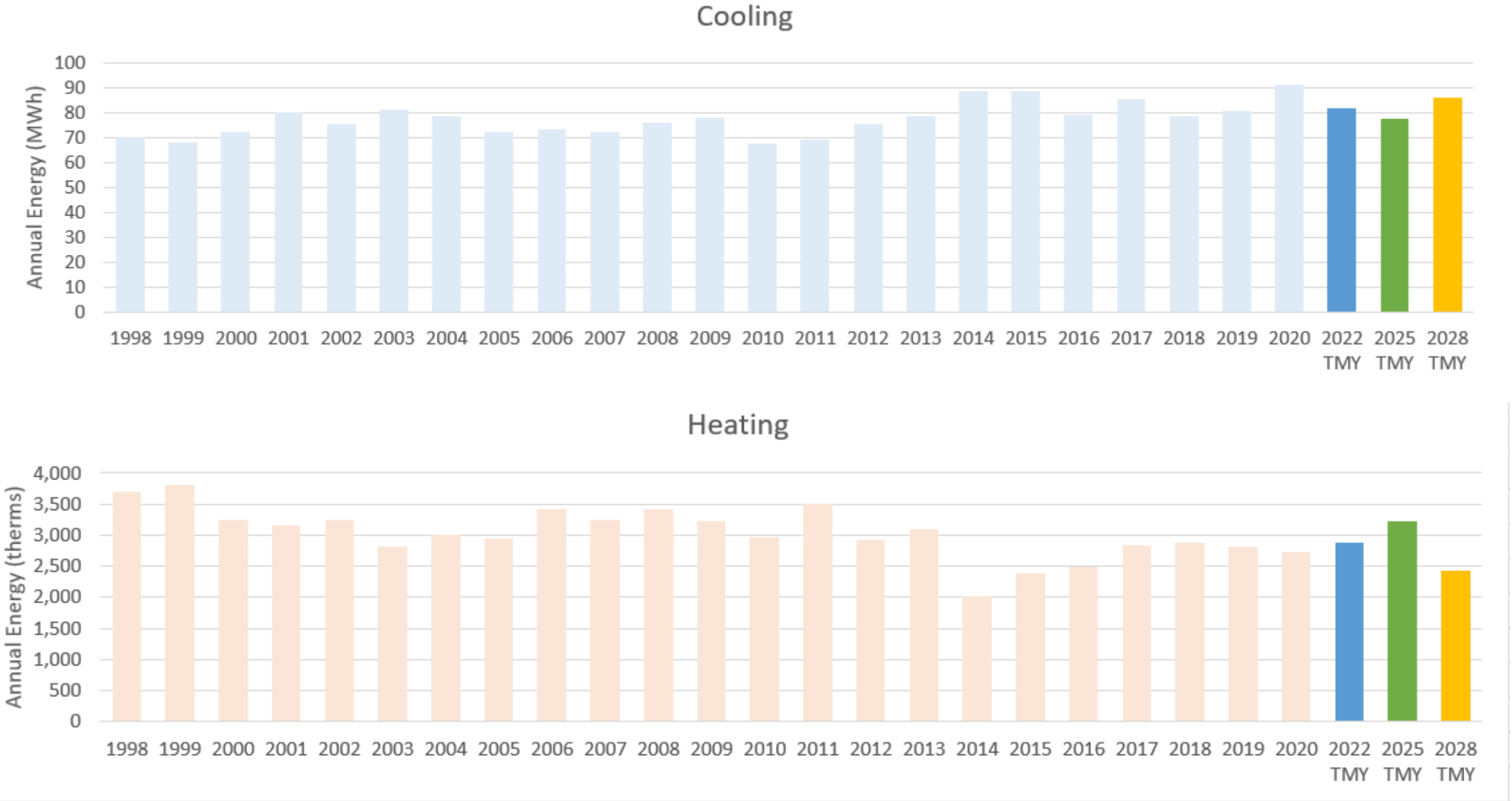


Historic and TMY Energy Use for the Medium Office Prototype in Los Angeles





Historic and TMY Energy Use for the Medium Office Prototype in Sacramento



Recommendations

- Use the staff proposed LOCA2 future weather-based TMYs for nonresidential building types in the 2028 Standards development process.

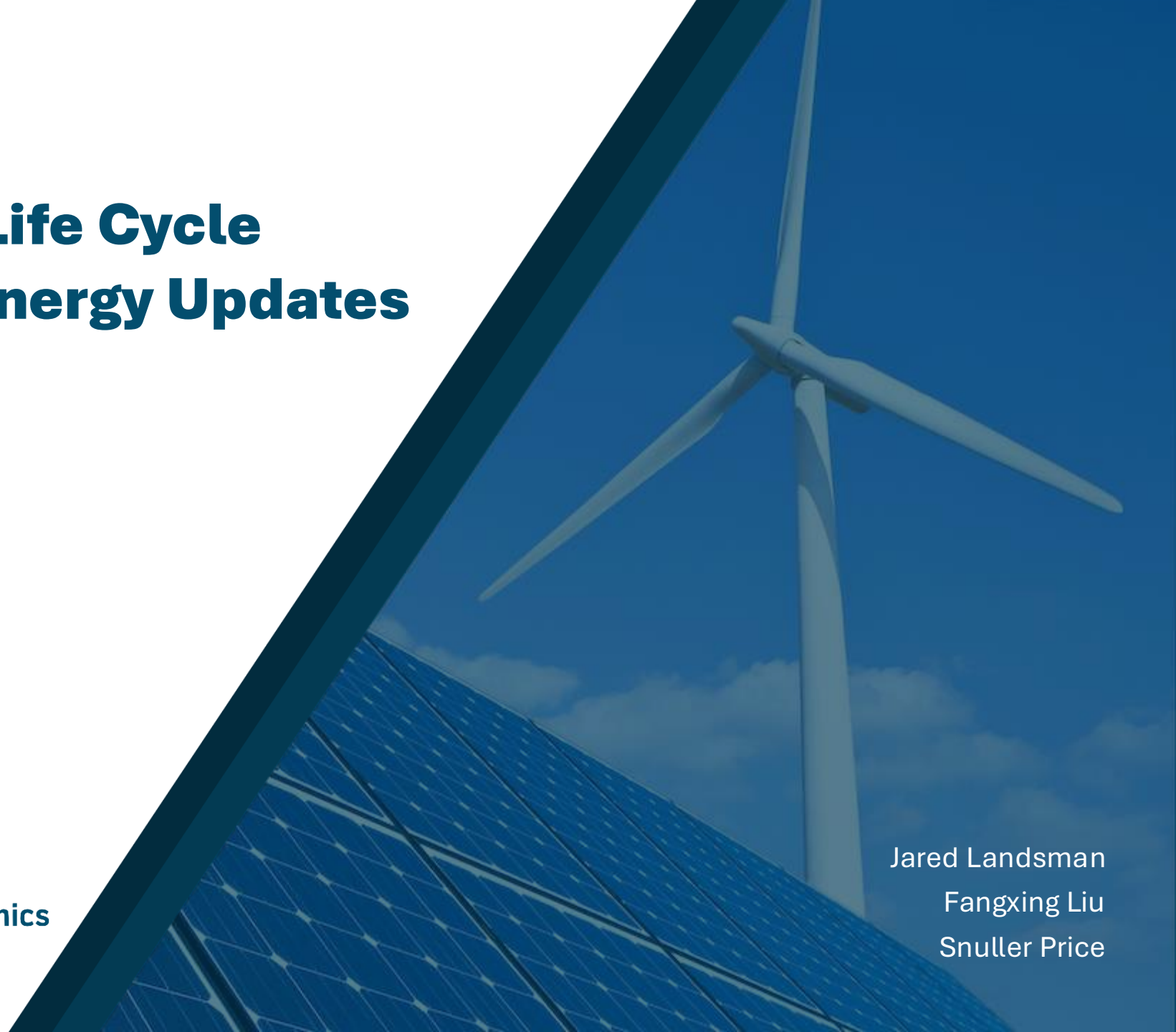
- Reassess possible improvements in the WRF future weather-based TMYs for future code cycles starting in 2031 for both nonresidential and residential building types.

Questions?

2028 Energy Code Life Cycle Costing & Source Energy Updates

Modeling Methodology & Results

August 28th, 2025



Jared Landsman
Fangxing Liu
Snuller Price

Energy+Environmental Economics

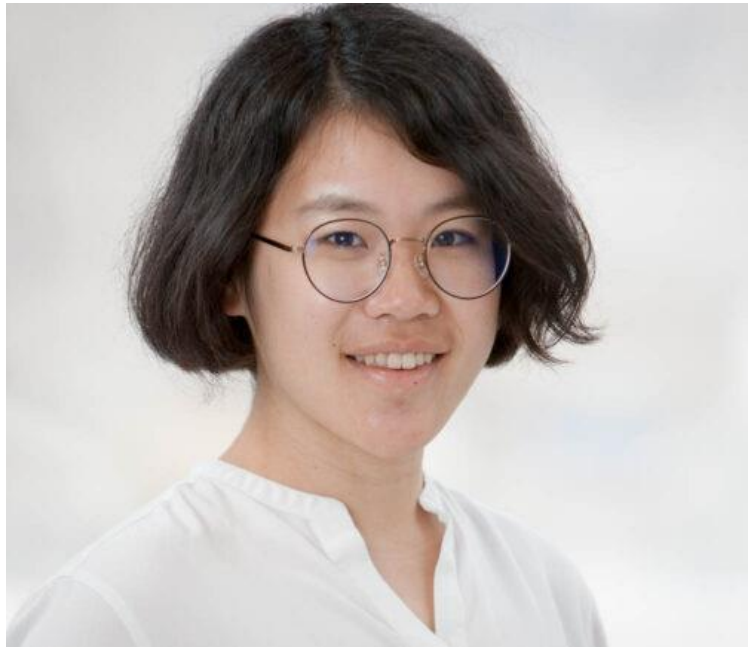
E3 Presentation Team

Snuller Price

Overall E3 Lead

Jared Landsman

Project Lead



Fangxing Liu

Project Manager

Agenda

1. **Metrics background & principles**
   Metrics definitions
   History of metrics

2. **Modeling overview**
   Major methodology updates for 2028 code cycle

3. **Evolving metrics in the changing grid**

4. **2028 code cycle metrics results**
   Electric LSC | Gas LSC | Propane LSC | Source Energy Factors

Metrics background & principles

Energy+Environmental Economics

Overview of Metrics for California Energy Code

Warren-Alquist Act (1975) established California's building energy code and requires cost-effectiveness over building lifecycle

- Must consider value of energy when "…amortized over the economic life of the structure compared with historic practice"

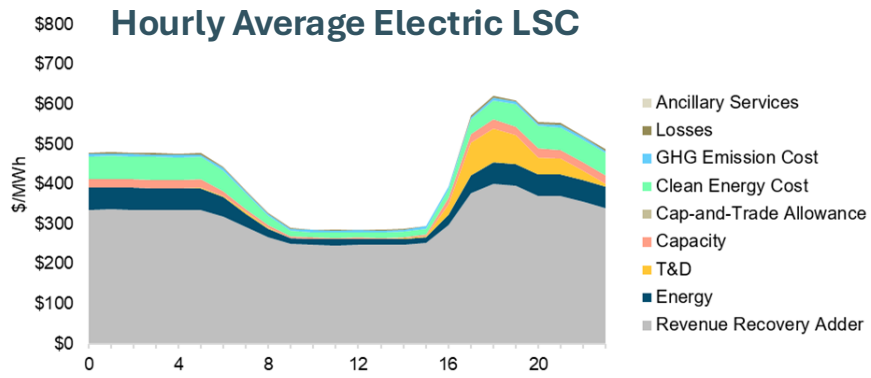
Two Metrics in Energy Code

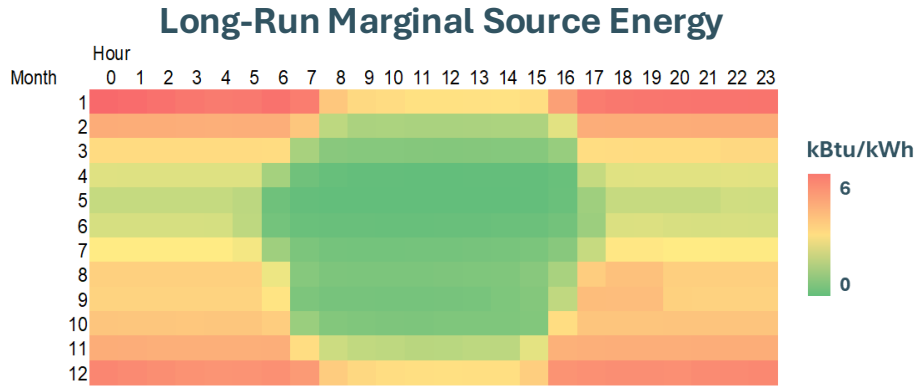
'Long-term System Cost (LSC) Factor' is used to measure cost-effectiveness

Represents long-run forecast of marginal system costs and revenue recovery costs over 30-year horizon

'Source Energy Factor' is used to measure energy savings

Reflect marginal source energy of fossil fuels combusted directly at building site or consumed to meet electrical demand



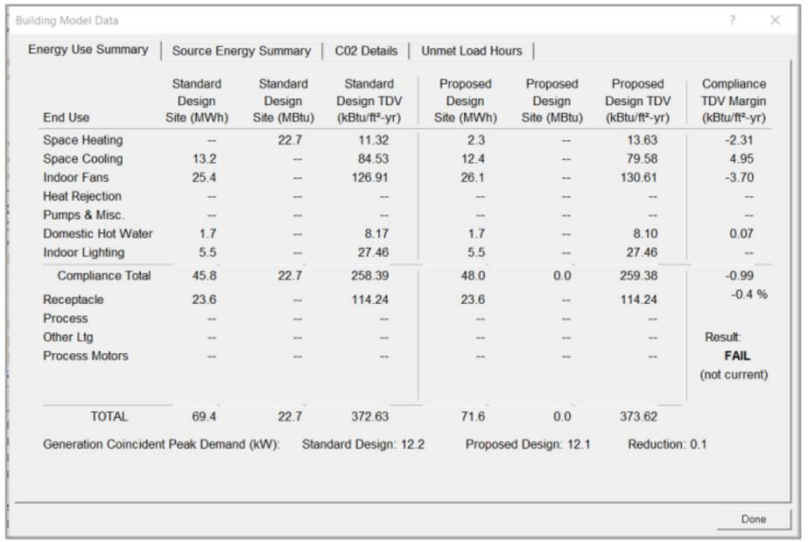


Two Uses of Energy Code Metrics

1. **New Measure Proposal – Used to evaluate cost-effectiveness and energy savings of measures proposed for inclusion in CA Energy Code**
   - Is incremental measure cost less than lifecycle savings?
   - Does the measure save energy?
2. **Project Compliance – Used to allow trade-offs in building design through performance compliance method**
   - Standard design results in 'energy budgets' of total annual LSC and source energy
   - Alternative designs that yield lower LSC and less source energy than Standard design comply with code

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM


Building Model Data

Energy Use Summary | Source Energy Summary | C02 Details | Unmet Load Hours

End Use	Standard Design Site (MWh)	Standard Design Site (MBtu)	Standard Design TDV (kBtu/ft²-yr)	Proposed Design Site (MWh)	Proposed Design Site (MBtu)	Proposed Design TDV (kBtu/ft²-yr)	Compliance TDV Margin (kBtu/ft²-yr)
Space Heating	--	22.7	11.32	2.3	--	13.63	-2.31
Space Cooling	13.2	--	84.53	12.4	--	79.58	4.95
Indoor Fans	25.4	--	126.91	26.1	--	130.61	-3.70
Heat Rejection	--	--	--	--	--	--	--
Pumps & Misc.	--	--	--	--	--	--	--
Domestic Hot Water	1.7	--	8.17	1.7	--	8.10	0.07
Indoor Lighting	5.5	--	27.46	5.5	--	27.46	--
Compliance Total	45.8	22.7	258.39	48.0	0.0	259.38	-0.99
Receptacle	23.6	--	114.24	23.6	--	114.24	-0.4 %
Process	--	--	--	--	--	--	
Other Ltg	--	--	--	--	--	--	Result:
Process Motors	--	--	--	--	--	--	FAIL (not current)
TOTAL	69.4	22.7	372.63	71.6	0.0	373.62	

Generation Coincident Peak Demand (kW): Standard Design: 12.2 Proposed Design: 12.1 Reduction: 0.1

Done

Assembly Bill 130 Signed June 2025

Important News

- Forthcoming 2028 update to the LSC and source energy methodology will ONLY apply to nonresidential building types
- Residential buildings will continue to be evaluated using the LSC, source energy metrics and weather profiles from the 2025 code cycle

Long-term forecast behind the LSC and Source Energy Metrics

+ **Both LSC and Source Energy factors are forecast over a 30-year outlook (2029 to 2058)**
+ **Leveraging the CEC IEPR significantly for forecasting**
+ **During this horizon we anticipate changes in California's climate, energy use, and energy infrastructure**

Climate

The 2028 metrics are correlated with anticipated impacts from climate change (milder winters, hotter summers)

Energy Use and Costs

- High adoption of electric heating and water heating appliances
- High adoption of electric vehicles (light, medium, and heavy)
- Wildfire mitigation, safety, and other costs leading to increases in electric and gas retail rates

Energy Infrastructure

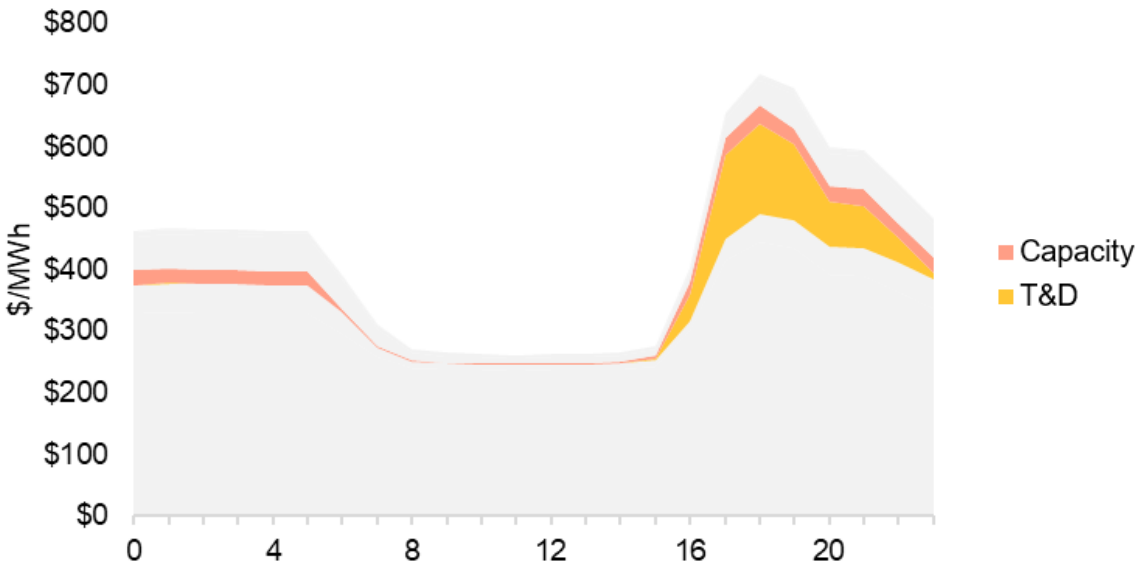
- Zero carbon electricity resource supply for 100% electric retail sales by 2045 (SB 100)
- Biomethane supply as a result of Short-lived Climate Pollutant strategy (SB 1440)

The electric LSC shape is driven by marginal electricity costs

+ Electric LSC shape is mainly driven by:

- **Generation capacity cost:** Marginal cost of procuring resource adequacy resources
- **Transmission and Distribution (T&D) capacity cost:** Costs of expanding transmission and distribution capacity to meet customer peak loads

Sample Annual Average Marginal Electric Cost Components



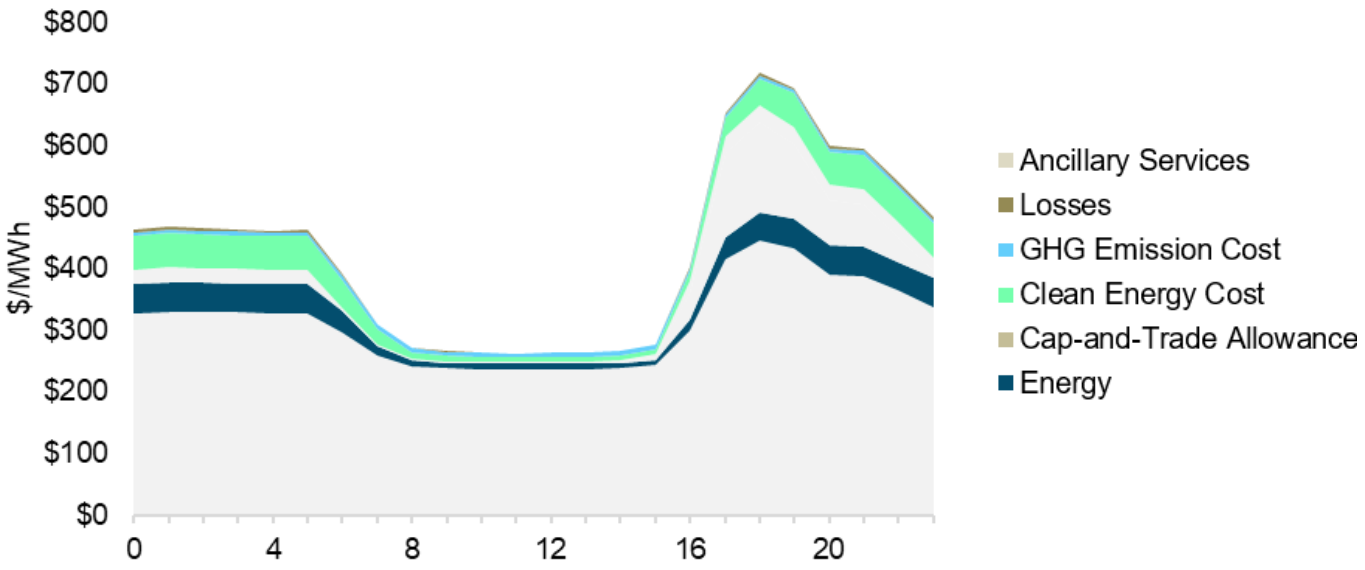
For Climate Zone 9

The electric LSC shape is driven by marginal electricity costs

+ Other marginal cost components include

- **Energy cost:** Cost of generation needed to meet load in each hour, or the wholesale electricity price
- **Cap-and-Trade Allowance:** Cost of CARB's cap-and-trade emission allowances
- **Clean Energy Cost:** Cost of procuring additional renewable resources to offset emissions from increased loads, in order to meet electricity sector emissions intensity targets
- **GHG Emission Cost:** The value of economic, environmental and social damages that result from the residual emissions

Sample Annual Average Marginal Electric Cost Components

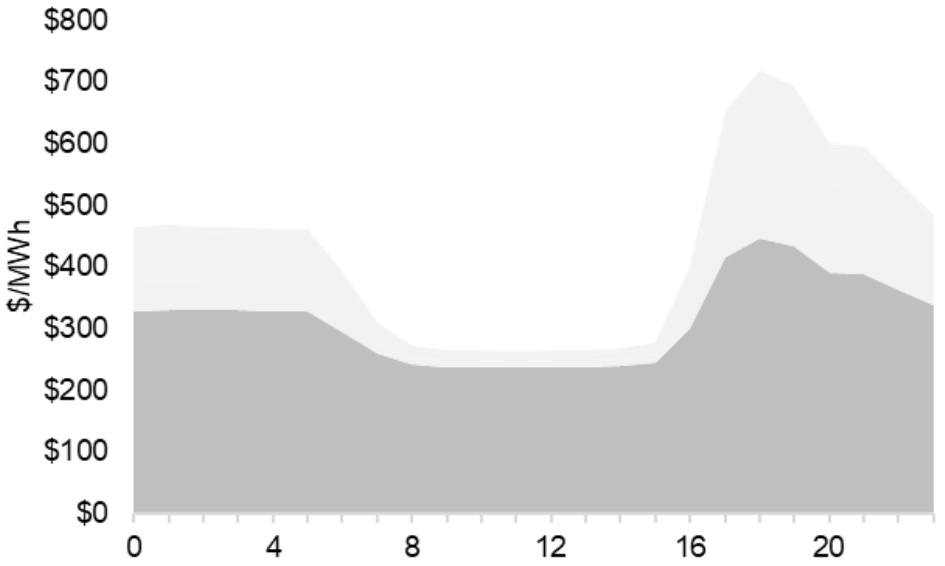


For Climate Zone 9

A large portion of electric LSC also comes from the Revenue Recovery Adder

+ **Revenue Recovery Adder:** This component ensures that the total projected revenue requirement components match the average retail electricity rate. It represents long-term system costs that must be recovered through future customer rates.
  - A portion of the revenue recovery adder is shaped (following marginal cost components) and a portion remains flat
  - The shape of the revenue recovery adder aligns with how TOU rates are shaped

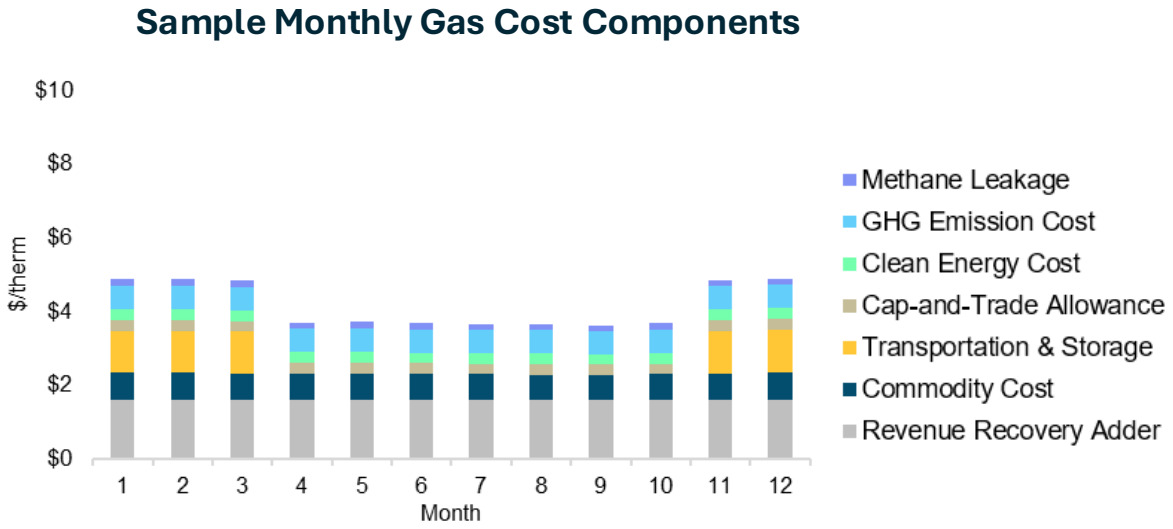
Sample Annual Average Electric Revenue Recovery Adder



For Climate Zone 9

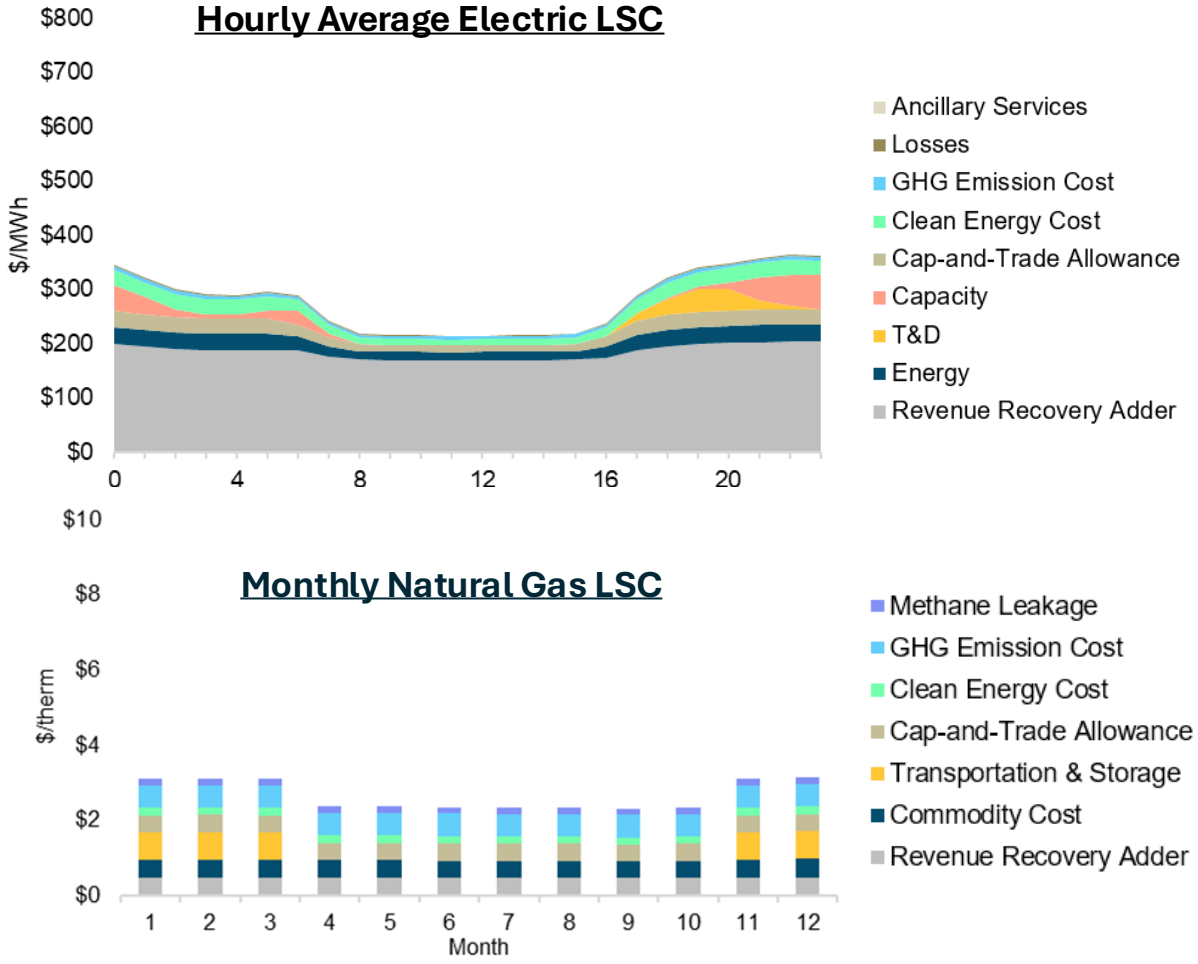
Magnitude of the gas LSC is driven by transportation, storage, and fixed costs

- **Commodity and Clean Energy Cost:** Reflects the forecasted cost of gas delivered to California including the cost of biofuels.
- **Transportation and Storage (T&S) cost:** Costs associated with gas transmission and storage system. This cost only shows up during months with peak gas consumption, and fluctuates with system throughput.
- **Revenue Recovery Adder:** Ensures that the total projected revenue requirement components match the average retail gas rate. It represents gas distribution system costs that remain fixed regardless of gas throughput.

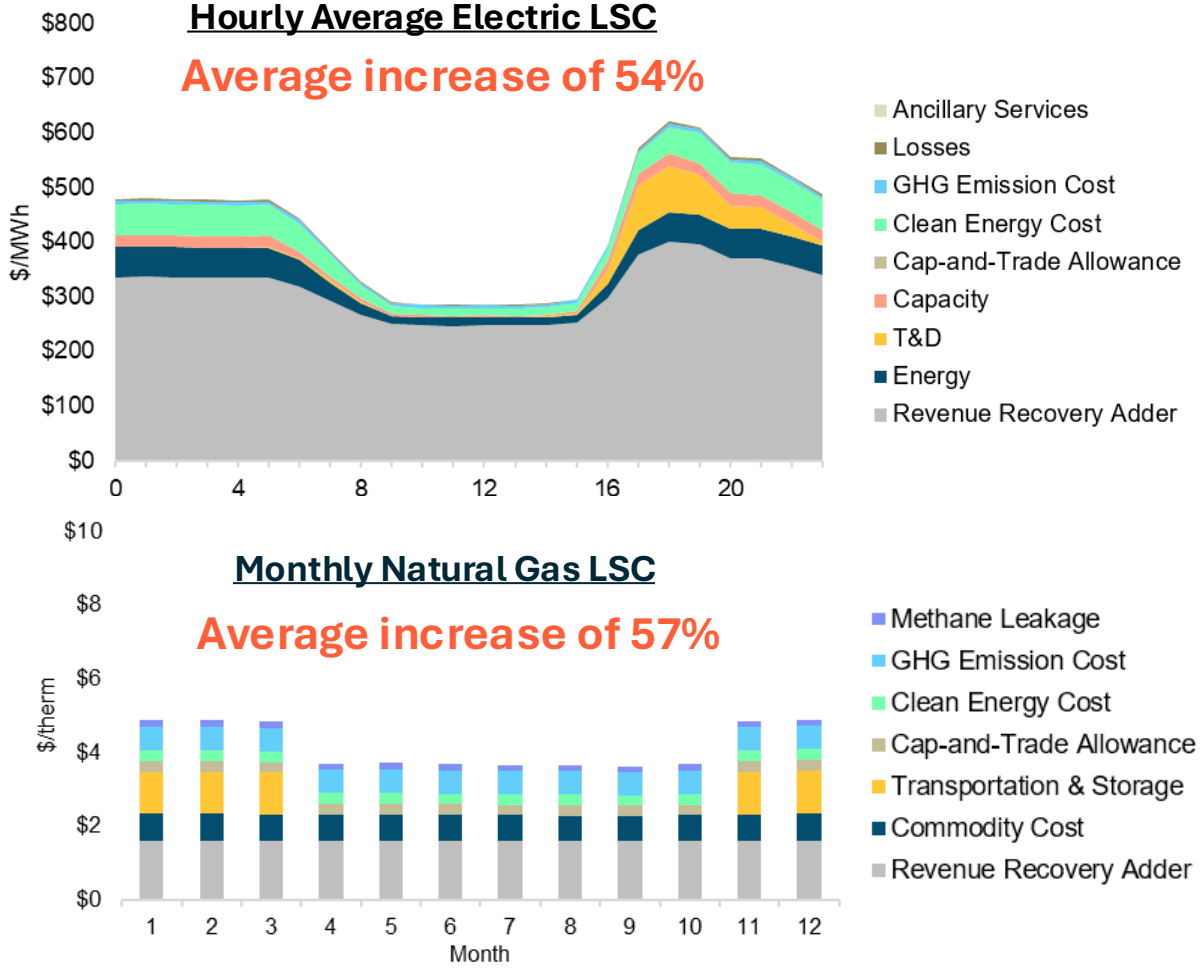


High Level LSC Results – Comparison to 2025 LSC Factors

2025 LSC Factors
Example from CZ9, Average by hour

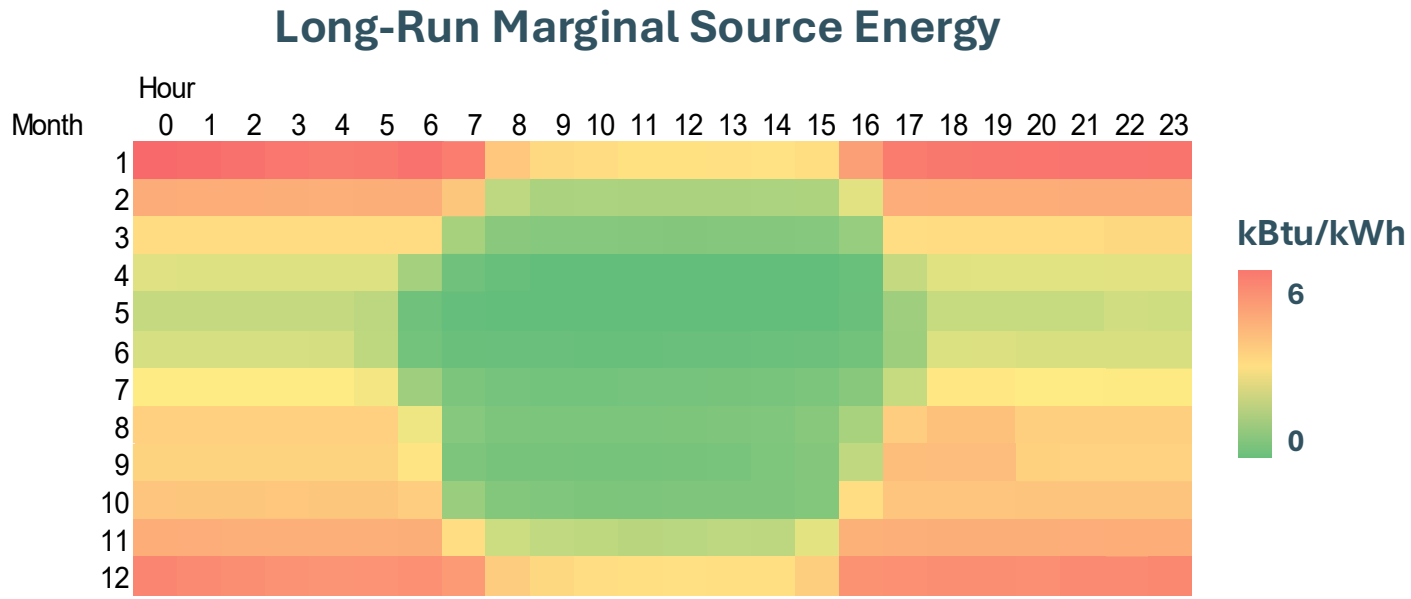


2028 LSC Factors
Example from CZ9, Average by hour



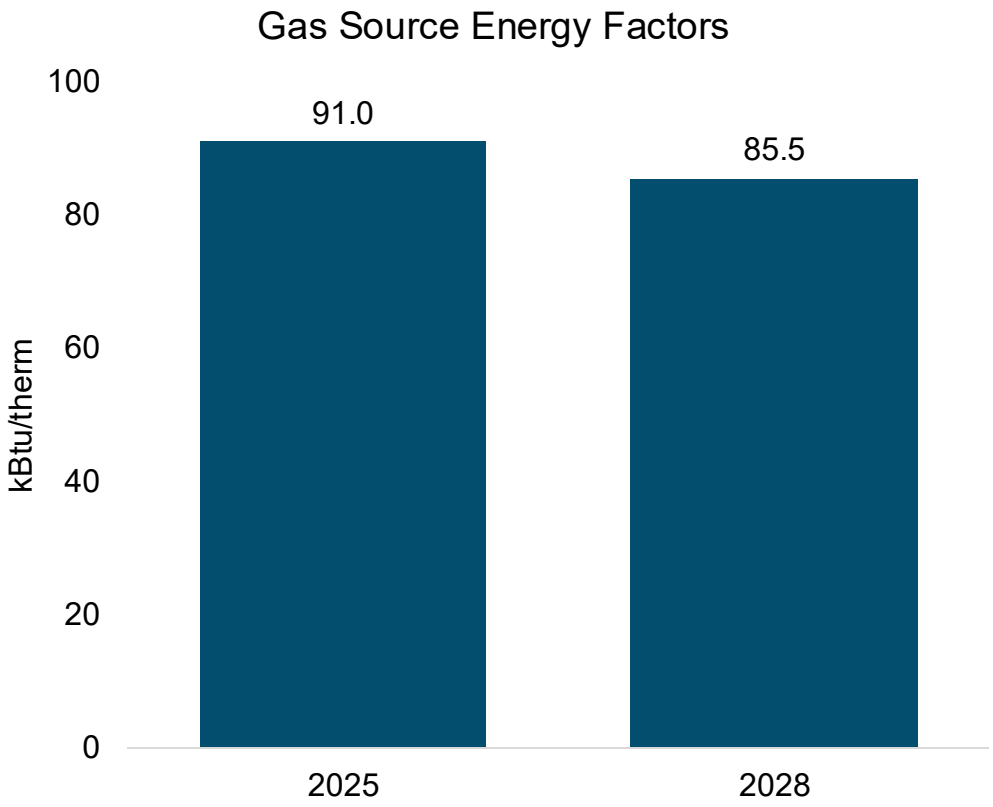
Source energy hourly factors convert site energy to source energy

- **Converts site energy to source energy, defined as the amount of fossil fuels that are combusted in association with demand side energy consumption**
  - Accounts for energy losses incurred in the production, transmission, and delivery of energy to the building
  - Reflects changes in renewable and storage penetration over time
  - Based on the heat rate for the marginal generation resource in each hour
- **Represent lifetime average hourly source energy**
  - Source energy factors are different than emissions factors, but correlated

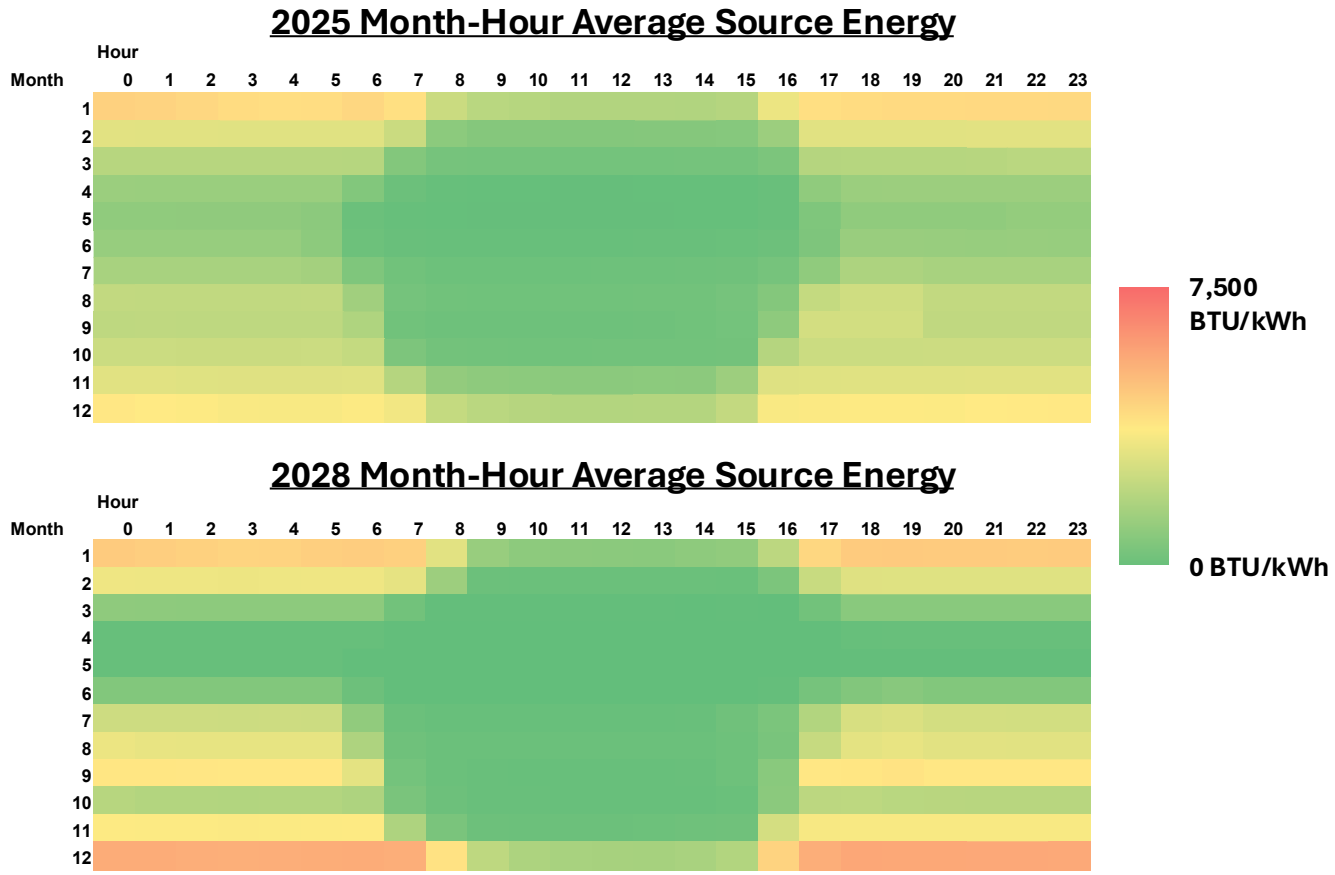


High Level Source Energy Results

Sample Gas Source Energy Metrics



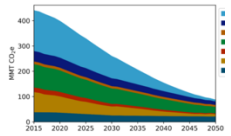
Sample Electric Source Energy Metrics



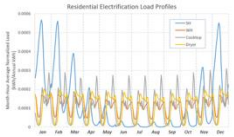
Modeling overview

Development of 2028 electric metrics

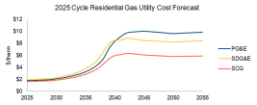
Inputs



Demand Scenario Selection

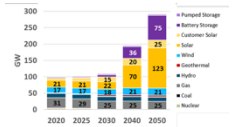


Hourly Load & Renewable Shaping

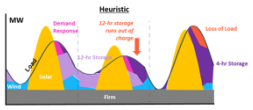


Retail Rate Forecast

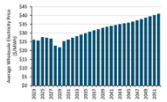
Electric System Modeling



Capacity Expansion Modeling



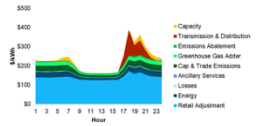
Reliability Modeling



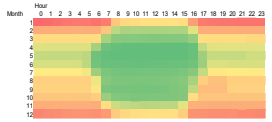
Production Cost Simulation

T&D Modeling

Outputs



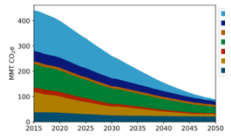
Long-term System Costs



Hourly Source Energy

Development of 2028 electric metrics

Inputs



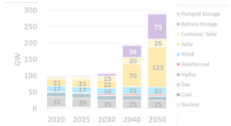
Demand Scenario Selection

Set policy requirements necessary to reach economy-wide GHG targets and select an associated load forecast

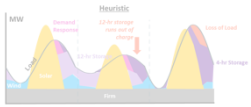
Hourly Load & Renewable Shaping

Retail Rate Forecast

Electric System Modeling



Capacity Expansion Modeling

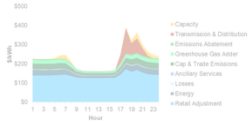


Reliability Modeling

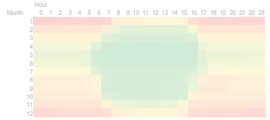
Production Cost Simulation

T&D Modeling

Outputs



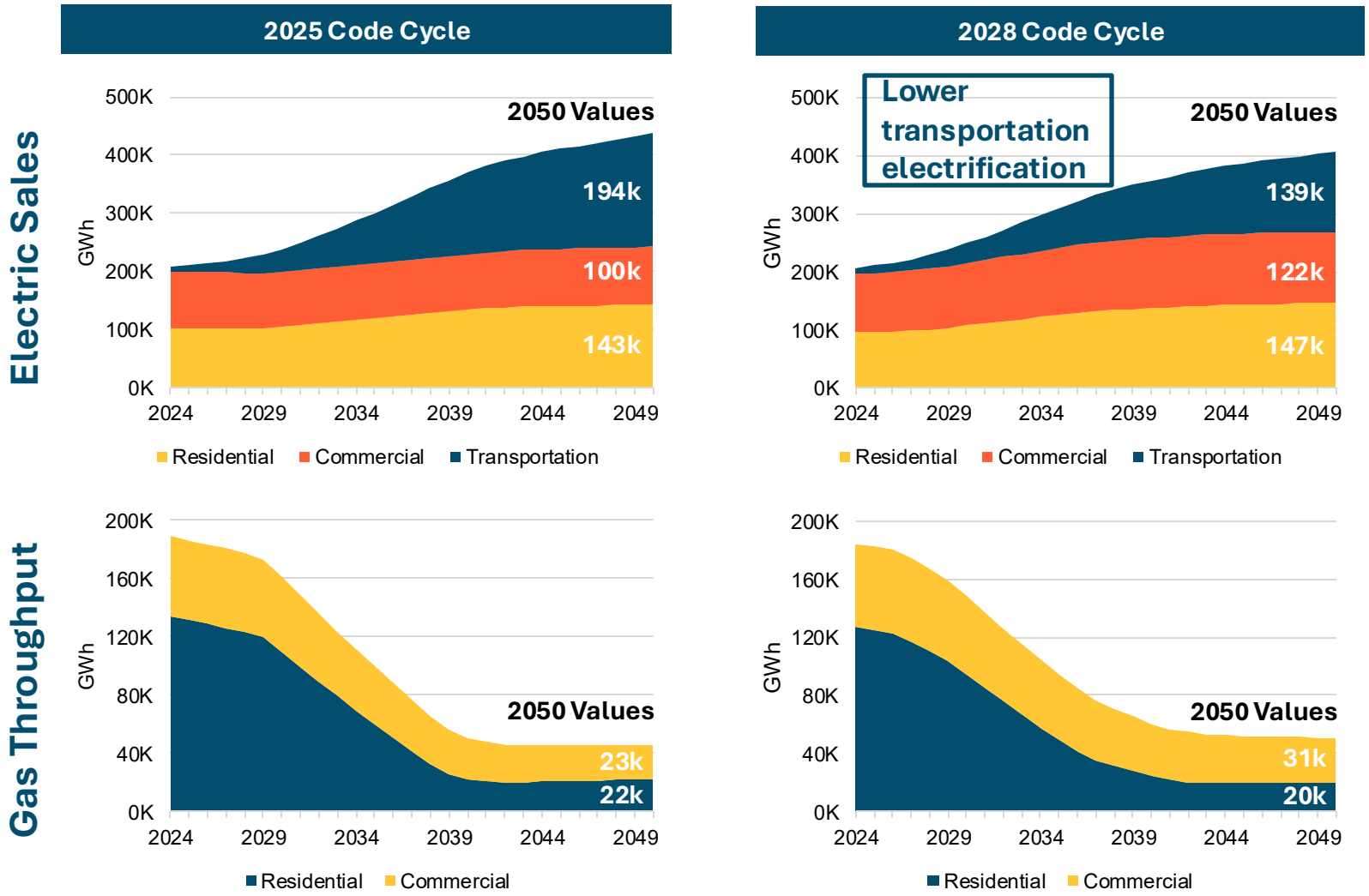
Long-term System Costs



Hourly Source Energy

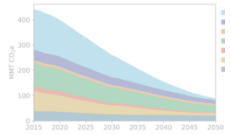
New demand scenario for the 2028 code cycle

- **Demand scenarios represent potential futures with varying strategies to achieve economy-wide decarbonization**
  - Dictates sectoral emissions budgets and policy landscape
- **Demand Scenario for the 2028 LSC factors comes from the 2023 CEC Demand Scenarios Project (aligned with IEPR)**
  - Annual demand reflects additional cooling and reduced heating due to future climate

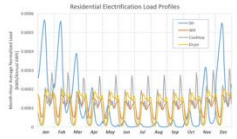


Development of 2028 electric metrics

Inputs



Demand Scenario Selection

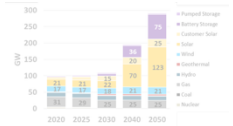


Hourly Load & Renewable Shaping

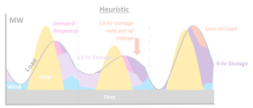
Develop hourly load shapes & renewable generation shapes to align with weather files (provided by Bruce Wilcox)

Retail Rate Forecast

Electric System Modeling



Capacity Expansion Modeling

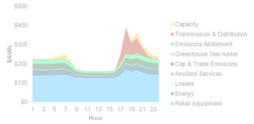


Reliability Modeling

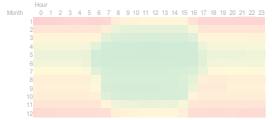
Production Cost Simulation

T&D Modeling

Outputs



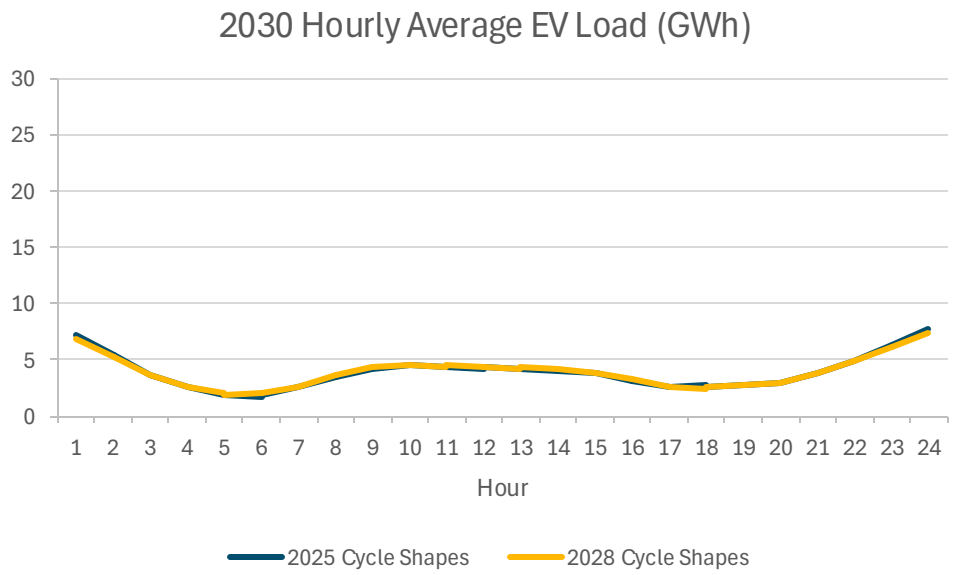
Long-term System Costs

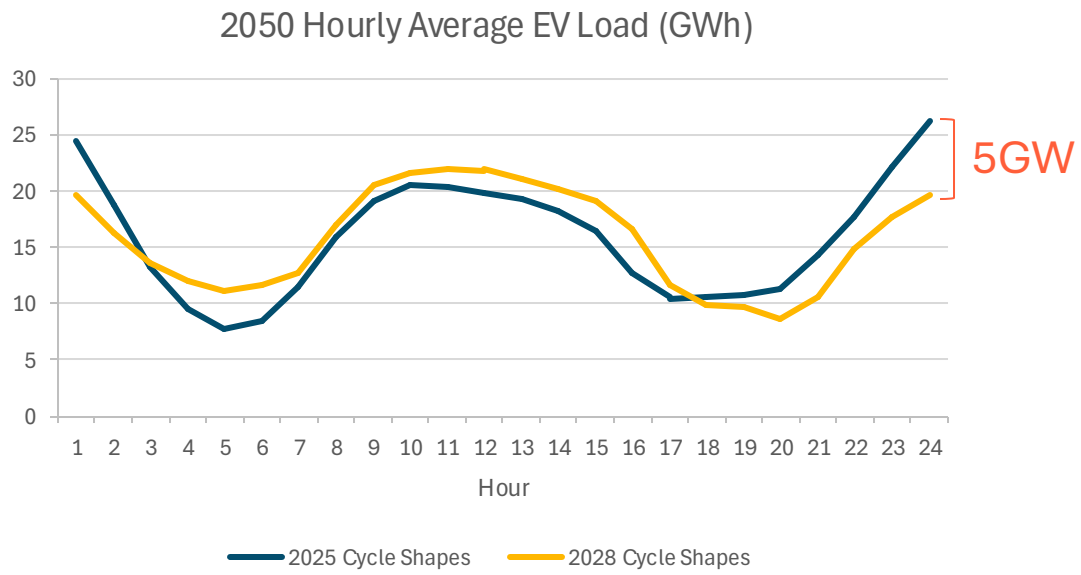


Hourly Source Energy

Updated EV load shapes

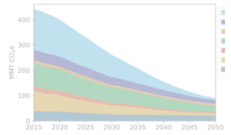
- The EV shape for the 2025 cycle reflected existing time-of-use (TOU) retail rates but might not represent the changing patterns with future TOU rates
- A new EV shape has been developed for the 2028 cycle to incorporate more charging in the mid-day when solar generation is abundant
- The final EV shape has been adopted as the Policy Scenario with Managed Charging Sensitivity as part of the CEC Energy Assessment Division Demand Scenario Project





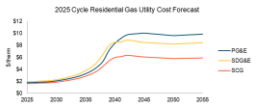
Development of 2028 electric metrics

Inputs



Demand Scenario Selection

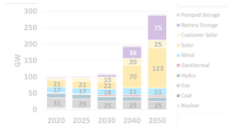
Hourly Load & Renewable Shaping



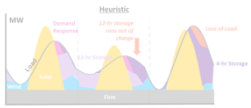
Retail Rate Forecast

Build an annual retail rate forecast aligned with selected demand scenario and revenue requirements

Electric System Modeling



Capacity Expansion Modeling

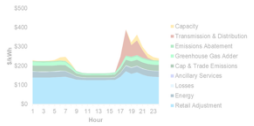


Reliability Modeling

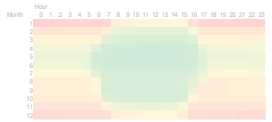
Production Cost Simulation

T&D Modeling

Outputs



Long-term System Costs



Hourly Source Energy

Retail rate forecasts are developed to align with the demand scenario

- Both gas and electric retail rate forecasts are developed bottom-up to align with high electrification demand scenario
- New methodology implemented to better capture class allocation of gas utility revenue requirement

$$\textit{Gas Rates}\ (\$/\textit{therm}) = \frac{\textit{Gas Utility Rev Req}\ (\$)}{\textit{Gas Demand}\ (\textit{therm})} + \textit{Gas Commodity Cost}\ (\$/\textit{therm}) + \textit{Cap and Trade}\ (\$/\textit{therm}) + \textit{Clean Energy Cost}\ (\$/\textit{therm})$$

$$\textit{Electric Rates}\ (\$/\textit{kWh}) = \frac{\textit{Electric Utility Rev Req}\ (\$)}{\textit{Electric Demand}\ (\textit{kWh})} + \textit{Cap and Trade}\ (\$/\textit{kWh}) + \textit{Clean Energy Cost}\ (\$/\textit{kWh})$$

Retail rate forecasts are developed to align with the demand scenario

- Both gas and electric retail rate forecasts are developed bottom-up to align with high electrification demand scenario
- New methodology implemented to better capture class allocation of gas utility revenue requirement

$$\textit{Gas Rates}\ (\$/\textit{therm}) = \frac{\textit{Gas Utility Rev Req}\ (\$)}{\textit{Gas Demand}\ (\textit{therm})} + \textit{Gas Commodity Cost}\ (\$/\textit{therm}) + \textit{Cap and Trade}\ (\$/\textit{therm}) + \textit{Clean Energy Cost}\ (\$/\textit{therm})$$

New Data for 2028 code cycle

2023 IEPR & IOU General Rate Cases

2023 Demand Scenarios Project

NYMEX Forwards

2023 IEPR

RNG procurement per SB1440

$$\textit{Electric Rates}\ (\$/\textit{kWh}) = \frac{\textit{Electric Utility Rev Req}\ (\$)}{\textit{Electric Demand}\ (\textit{kWh})} + \textit{Cap and Trade}\ (\$/\textit{kWh}) + \textit{Clean Energy Cost}\ (\$/\textit{kWh})$$

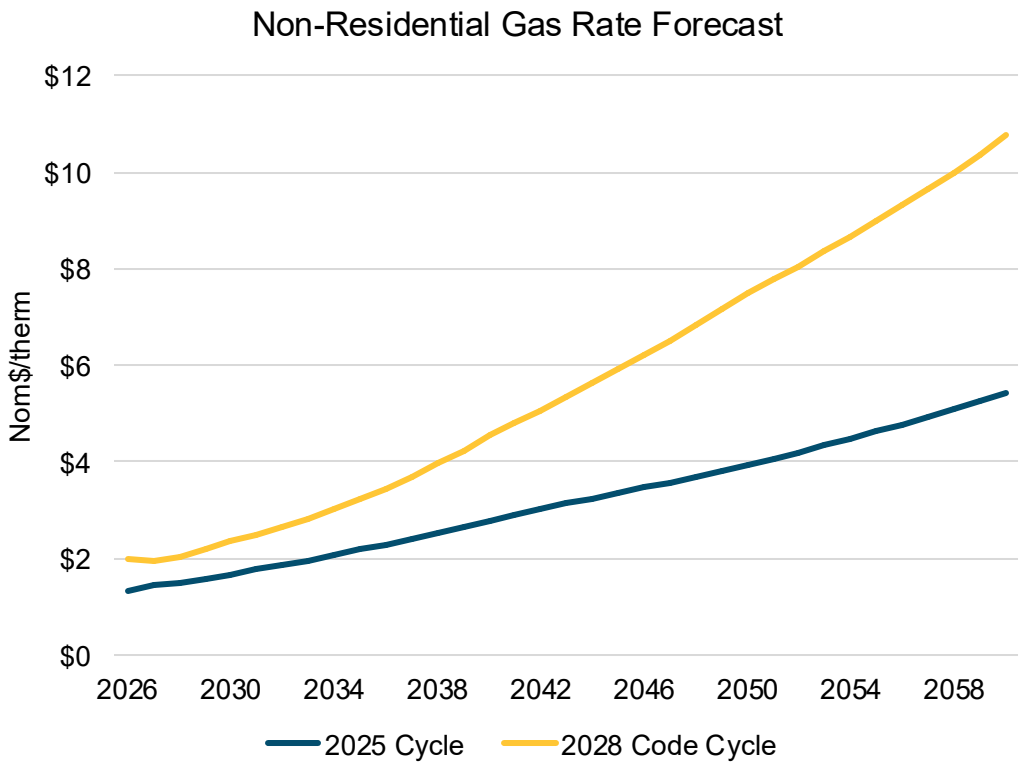
2023 IEPR, CA IRP, 2023 DGEM Report

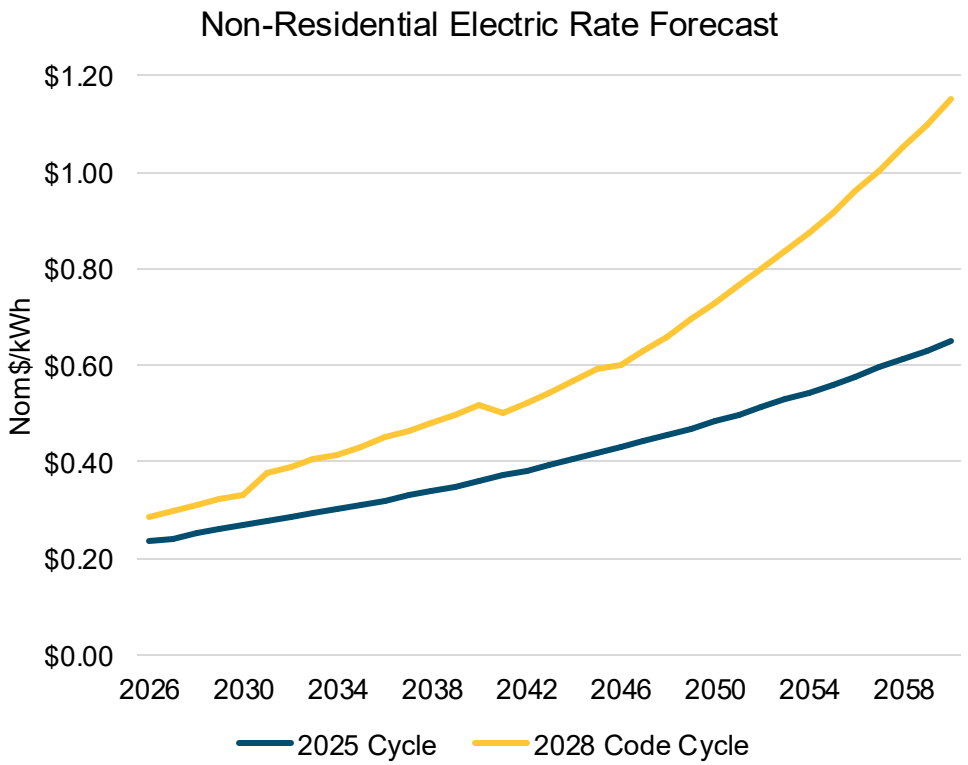
2023 Demand Scenarios Project

2023 IEPR

2023 IEPR

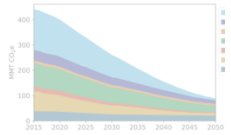
Resulting retail rate forecasts for the 2028 cycle





Development of 2028 electric metrics

Inputs

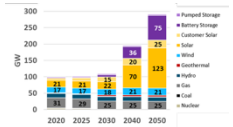


Demand Scenario Selection

Hourly Load & Renewable Shaping

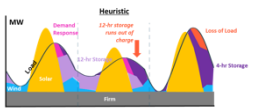
Retail Rate Forecast

Electric System Modeling



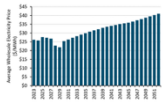
Capacity Expansion Modeling

Identify optimal electricity resource portfolio to achieve electricity sector goals (SB 100)



Reliability Modeling

Study reliability dynamics of high-renewable electric systems and identify hours with highest capacity constraints

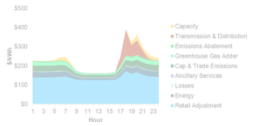


Production Cost Simulation

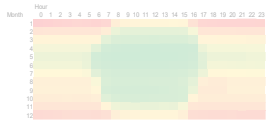
Calculate hourly energy price across WECC to reflect impacts of interzonal trade, transmission constraints, and available resources

T&D Modeling

Outputs



Long-term System Costs



Hourly Source Energy

Reliability Modeling

We assign generation capacity costs ($/kW-yr) to hours in which load reduction is valuable to help improve system reliability

x500 weather years

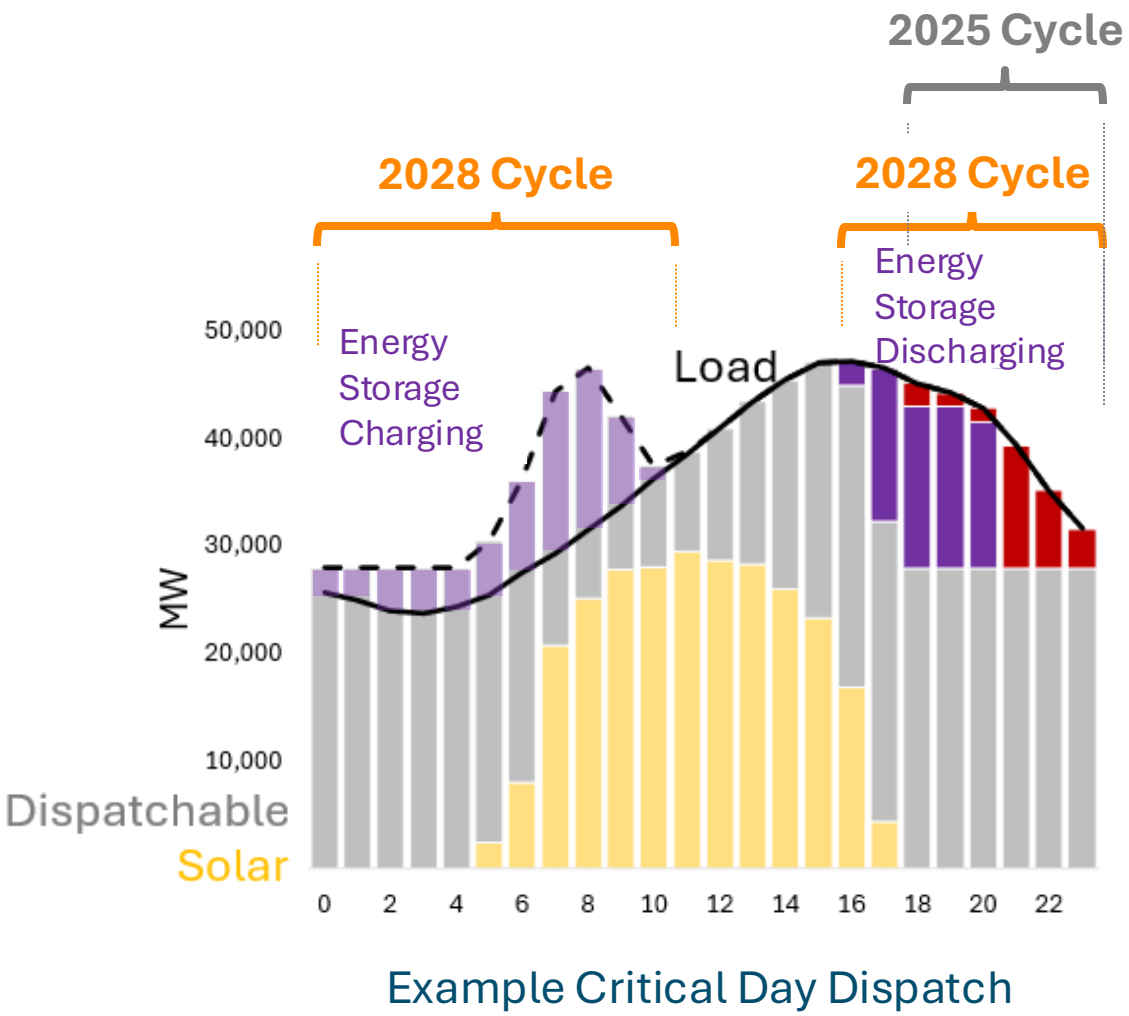
New! EV shapes with more charging in middle of the day
New! Increased cooling load from AC/HP adoption

- Customer Load
- Weather Conditions
- Resource Generation & Operation

New! More granular & robust solar generation profiles

→ Reliability Modeling (RECAP) → **Hourly system operation on days with loss-of-load (LOL)** → **Re-mapped allocation factors to match TMY weather data**

Updated allocation of generation capacity cost



Example Critical Day Dispatch

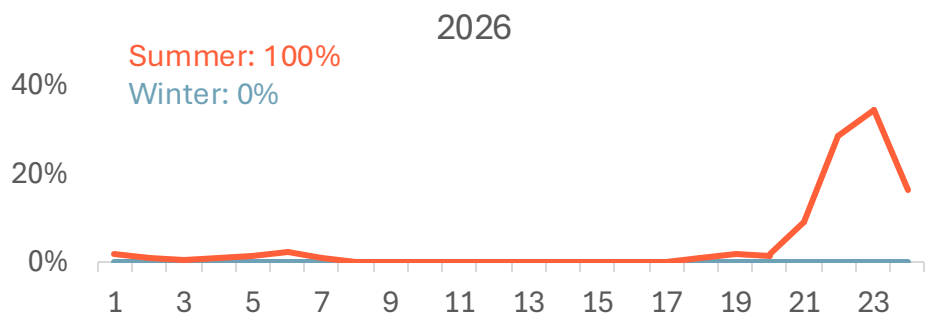
2025 (Traditional) Approach: Define critical hours as **loss-of-Load** hours

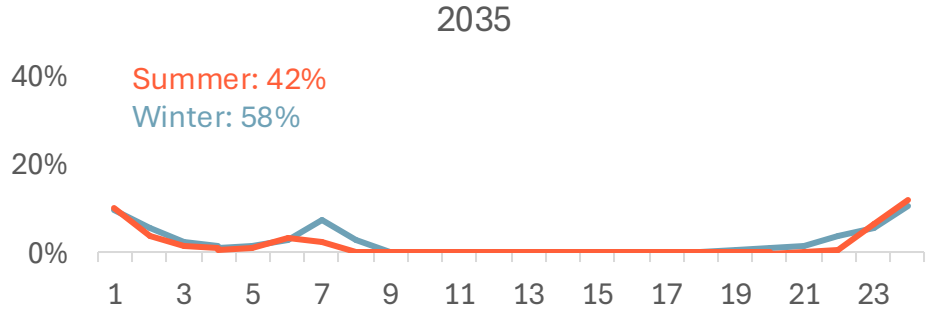
2028 Approach: Define critical hours as **energy storage charging & discharging** hours and **loss-of-load** hours

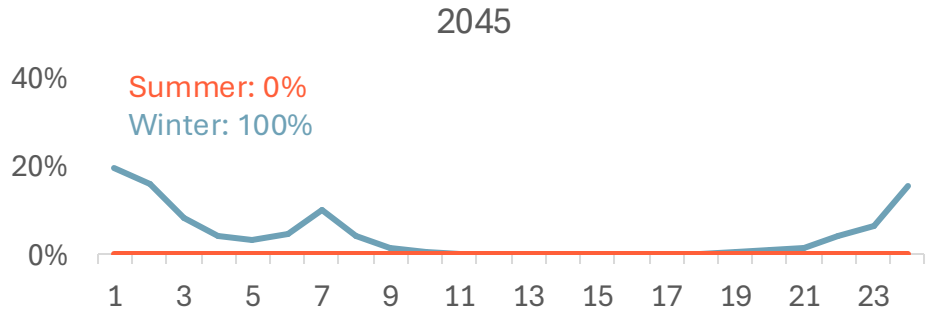
The new approach is necessary to capture critical hours in a system with large amount of storage

Updated allocation of generation capacity cost

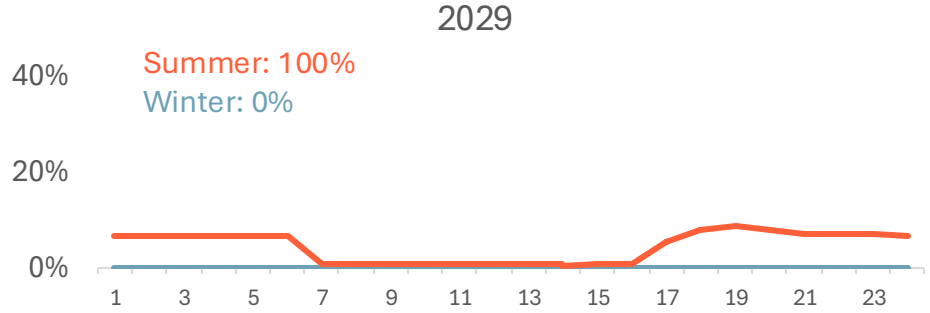
2025 Code Cycle

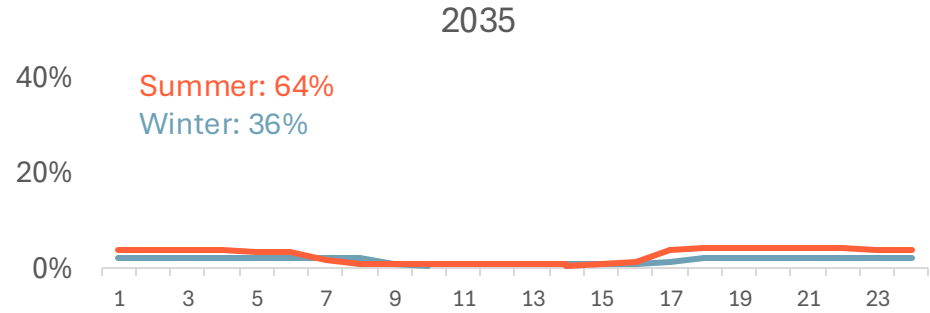


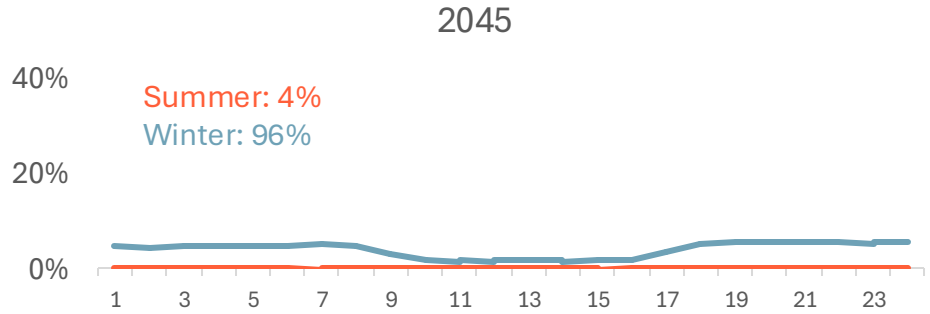




2028 Code Cycle

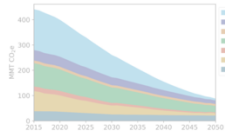






Development of 2028 electric metrics

Inputs

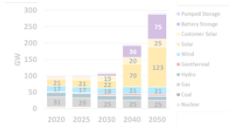


Demand Scenario Selection

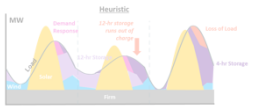
Hourly Load & Renewable Shaping

Retail Rate Forecast

Electric System Modeling



Capacity Expansion Modeling



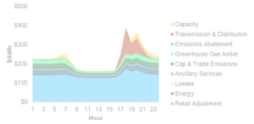
Reliability Modeling

Production Cost Simulation

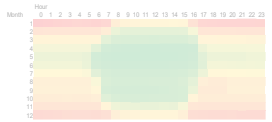
T&D Modeling

Identify hours during which the transmission and distribution system will be most constrained

Outputs



Long-term System Costs



Hourly Source Energy

T&D cost allocation is driven by local distribution loads & behind-the-meter solar adoption

CZ 3 (Oakland) T&D Cost Allocation

2025 Cycle

2028 Cycle

Near-term

Long-term

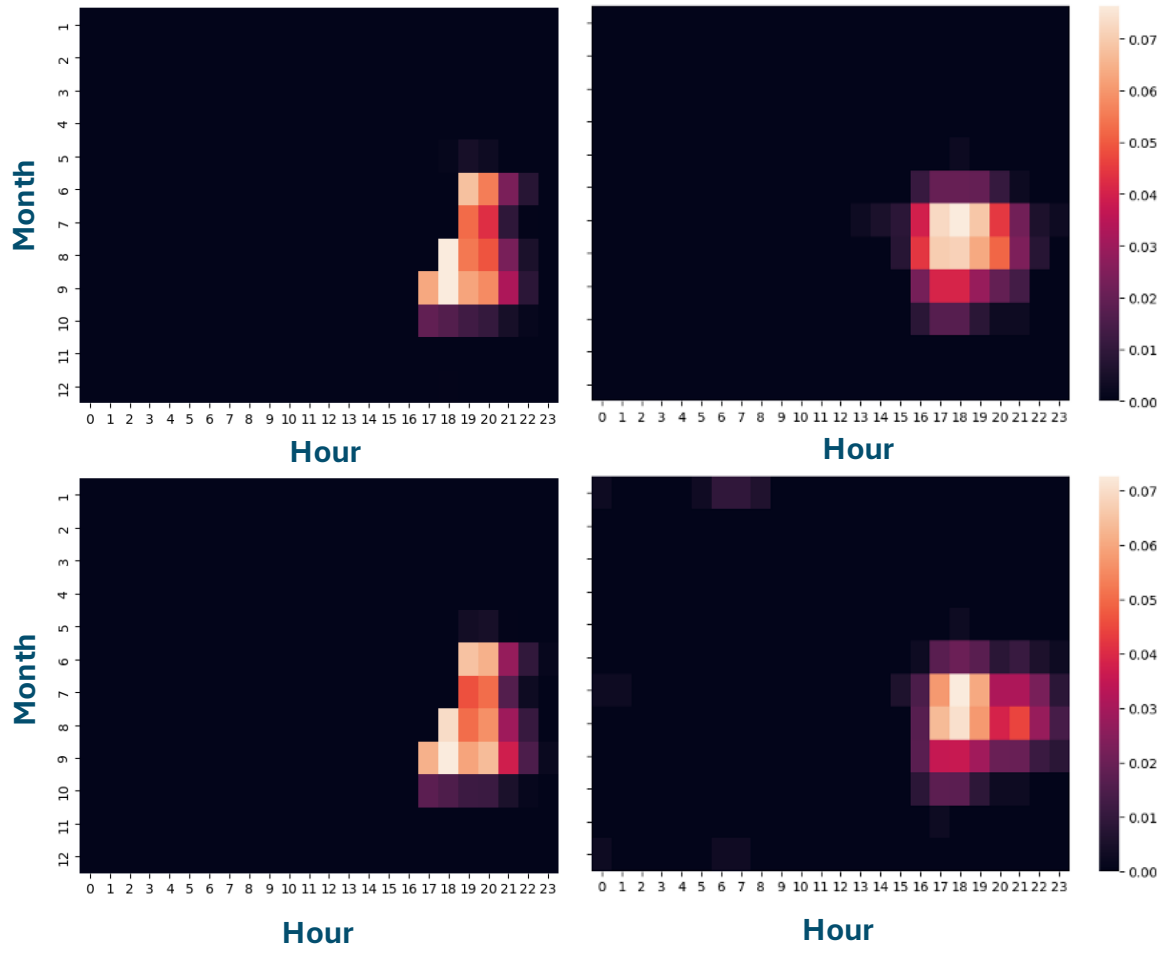
CZ 9 (Burbank) T&D Cost Allocation

2025 Cycle

2028 Cycle

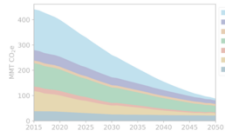
Near-term

Long-term



Development of 2028 electric metrics

Inputs

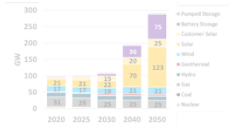


Demand Scenario Selection

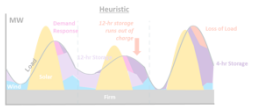
Hourly Load & Renewable Shaping

Retail Rate Forecast

Electric System Modeling



Capacity Expansion Modeling

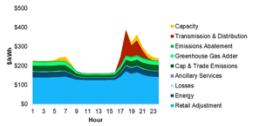


Reliability Modeling

Production Cost Simulation

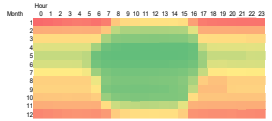
T&D Modeling

Outputs



Long-term System Costs

Aggregate marginal costs and other system costs that require revenue to be recovered through retail rates, convert to 30-year net present value to calculate Long-term System Costs (LSC)

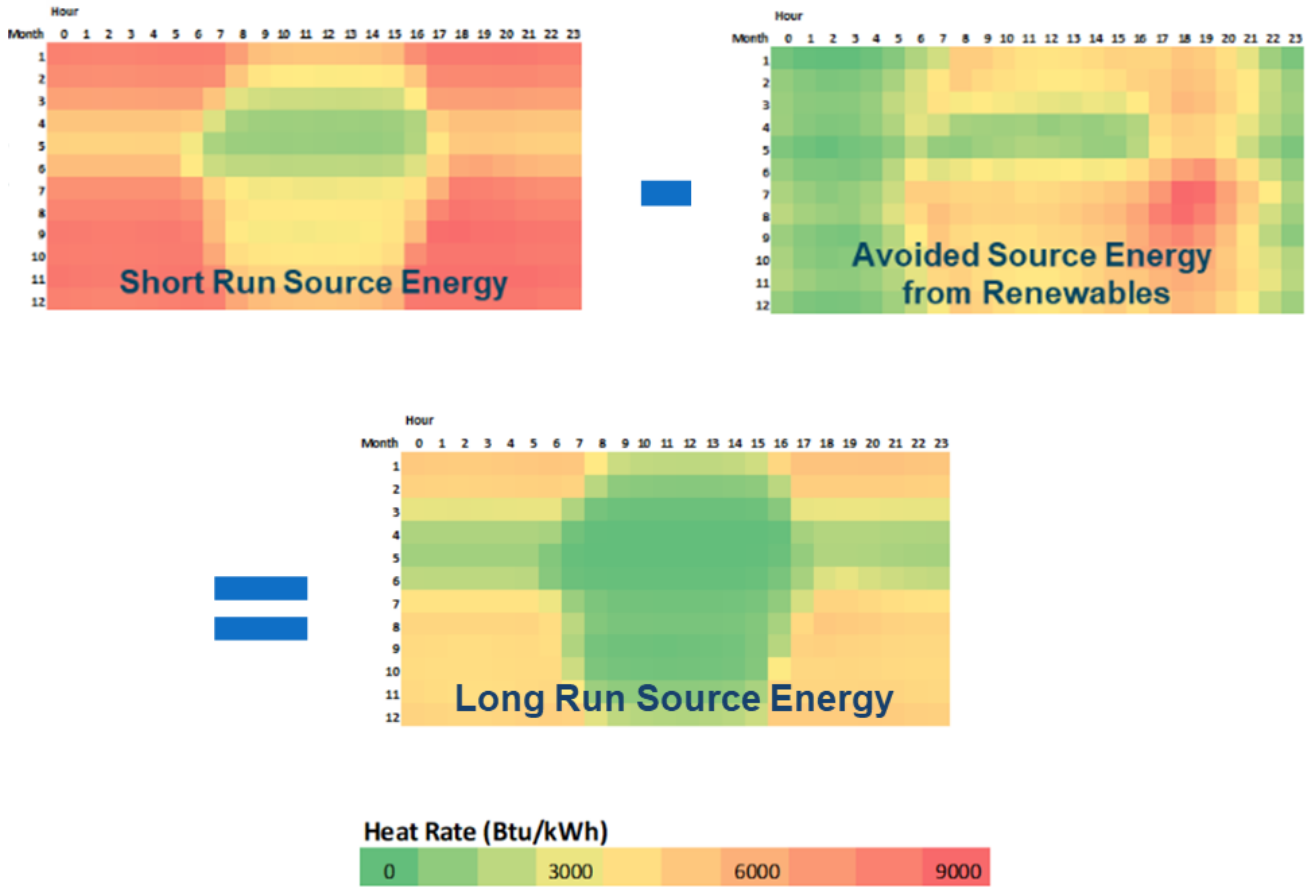


Hourly Source Energy

Average 30-year long-run marginal source energy to calculate Hourly Source Energy (HSE)

Calculating source energy

- **Electric source energy is calculated using**
  - **Short-run marginal energy:** increase in source energy from marginal generator needed to meet change in load
  - **Long-run marginal energy:** Accounts for avoided source energy from incremental renewable generation
  - Calculated using the same methodology as US Department of Energy
- **Gas source energy is calculated using RNG throughput in gas pipeline**
  - CPUC adopted biomethane procurement targets for gas utilities of 72.8 billion cubic feet of biomethane per year starting in 2030 (following SB1440)



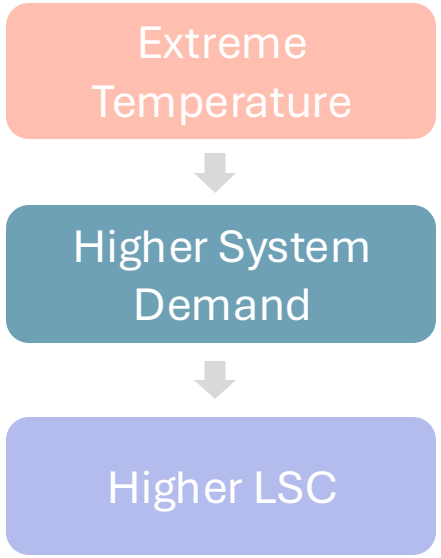
Evolving metrics in the changing grid

Energy+Environmental Economics

As CA incorporates more renewable resources and energy storage, LSCs patterns have evolved

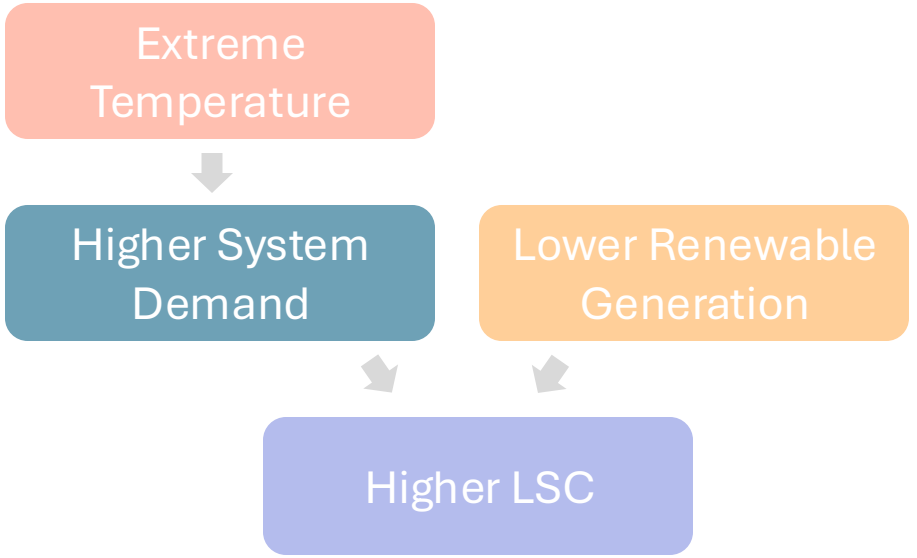
Traditional

LSCs were closely correlated to temperature because the higher the load, the higher the costs to dispatch thermal resources to serve load



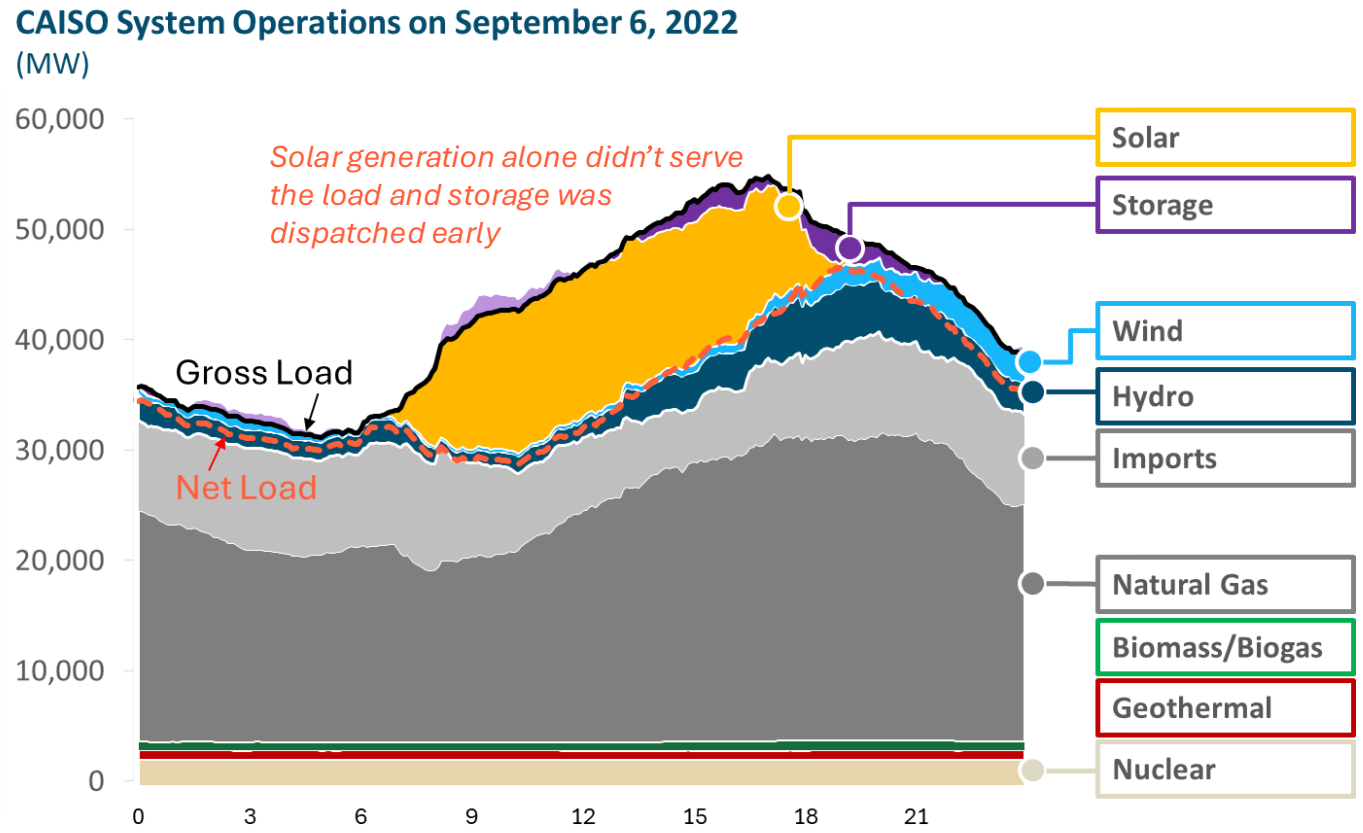
High Renewable Penetration

LSCs are high when both load is higher and renewable generation is low, which don't necessarily coincide with the highest temperature



Real life example

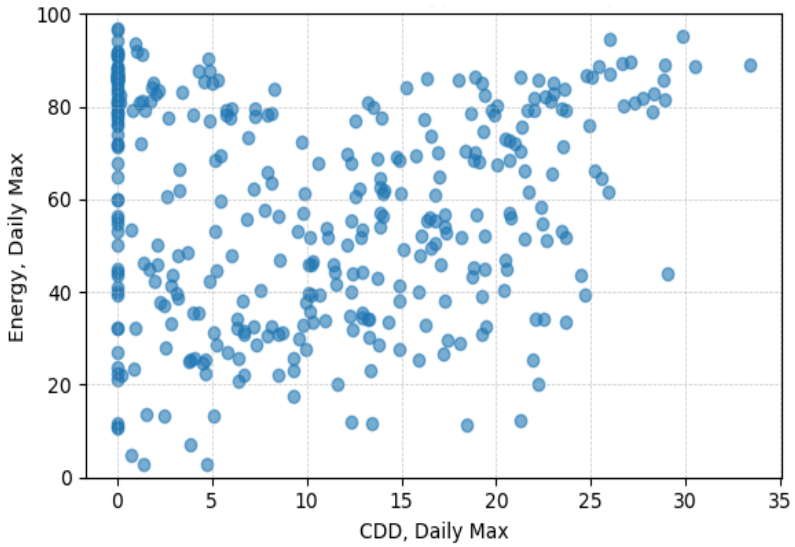
- Net load = Total System Demand – Renewable Generation
- On September 6, 2022, CAISO issued a Flex Alert to request energy conservation
- While the total system demand (gross load) peaked at 5PM, the grid is the most constrained at 7PM, when net load was the highest



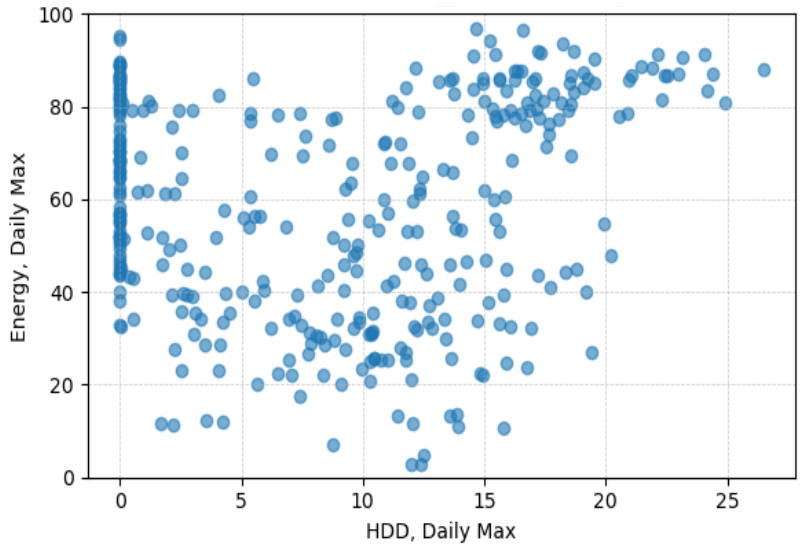
Certain LSC components are more correlated to net load than temperature

- For example, marginal energy avoided costs are closely correlated to net load
- Other components such as T&D are still correlated to temperature and total system demand

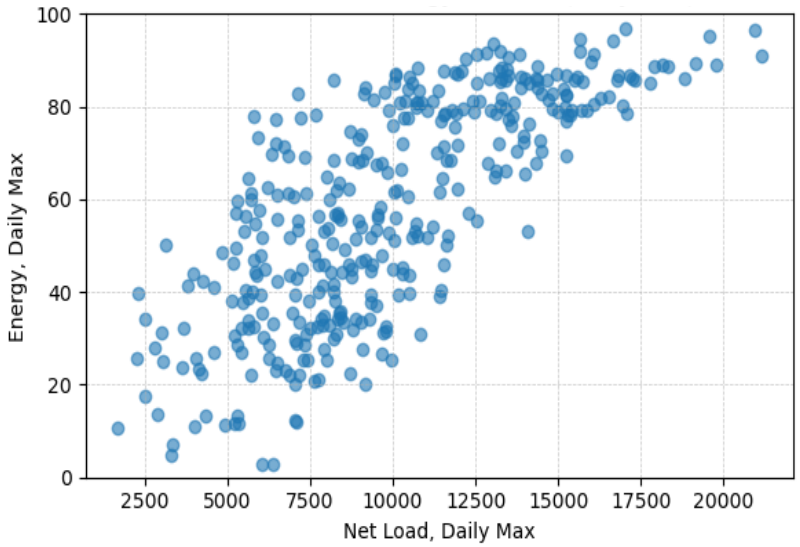
CZ9 Energy vs Daily Max CDD



CZ9 Energy vs Daily Max HDD



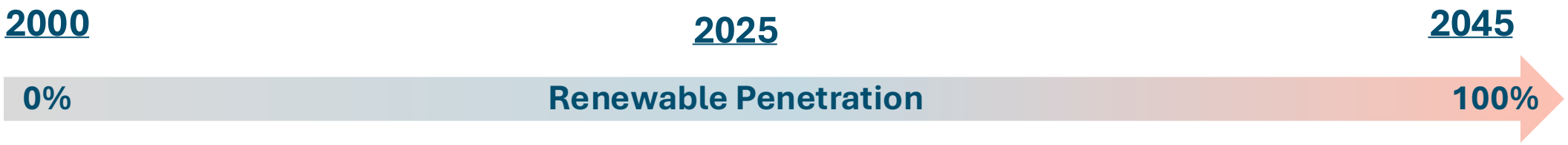
CZ9 Energy vs Daily Max Net Load



Evolving grid challenges at increasing renewable penetrations

+ **Increasing levels of renewables will cause the timing of reliability challenges to shift to different times of day – and eventually to different times of year**

Drivers of Reliability Need Over Time



Summer Peak

In the absence of renewables, the periods of highest demand present the greatest challenge to reliability

Summer Net Peak

At moderate penetrations of renewables, solar shifts "net peak" to evening, which becomes the primary challenge

Extended Periods of Low Renewable Production in Winter

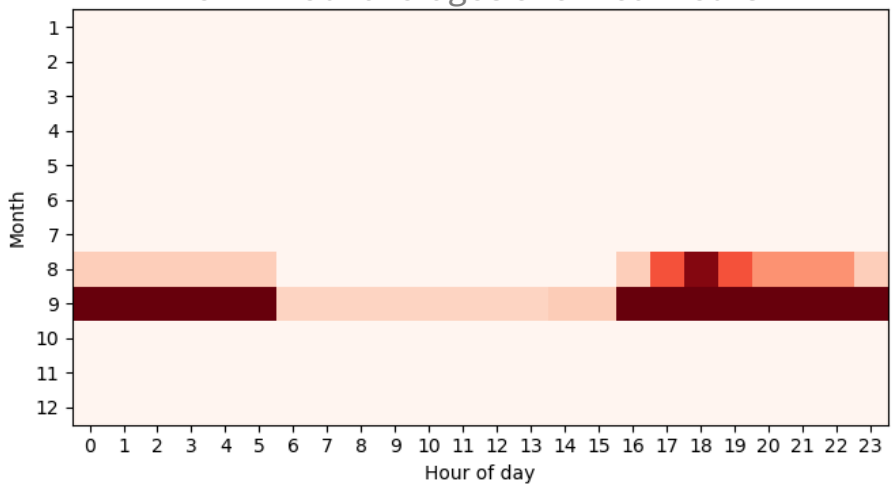
At high penetrations of renewables, periods of sustained low renewable production – most often in the winter - present the greatest challenge to operations

Decarbonization will eventually shift timing of critical hours into winter months

+ **Critical hours represent hours in which load reduction is the most valuable to help reduce loss of load events. These hours are used to produce hourly marginal costs of generation capacity**

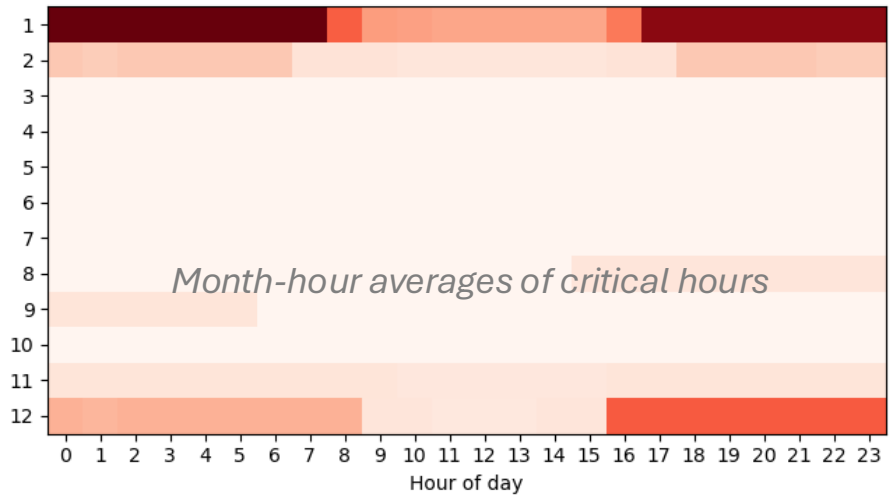
2029

Month-hour averages of critical hours



In the near-term, critical hours are concentrated in summer "net peak" period – after sunset and before sunrise while loads are high and renewable generation is low

2045

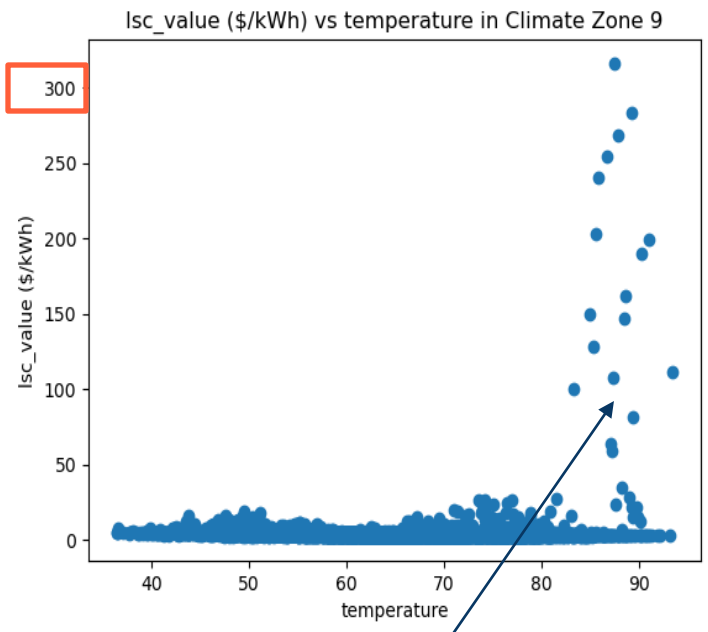


In a deeply decarbonized grid, critical hours will occur in the winter, during sustained periods of low renewable production

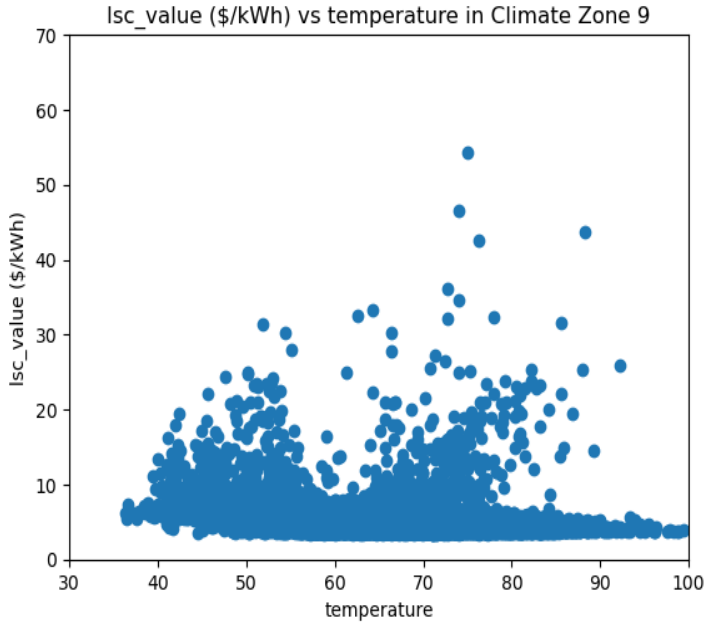
Latest LSCs reflect a "U" shape in relation to temperature

Latest LSCs are flatter, reflecting high storage penetration

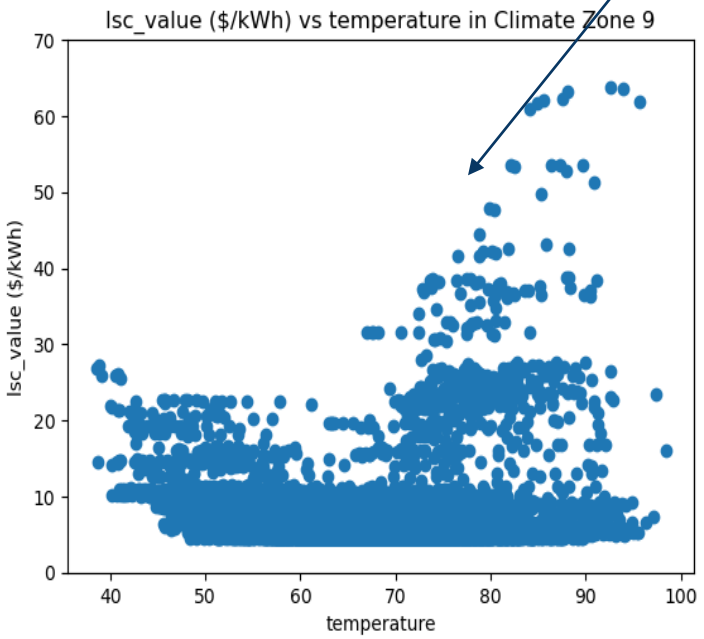
2022



2025



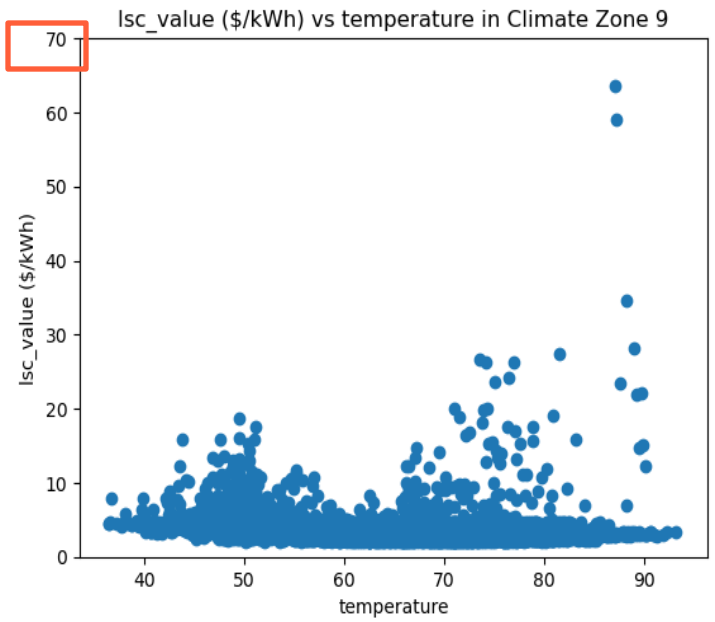
2028



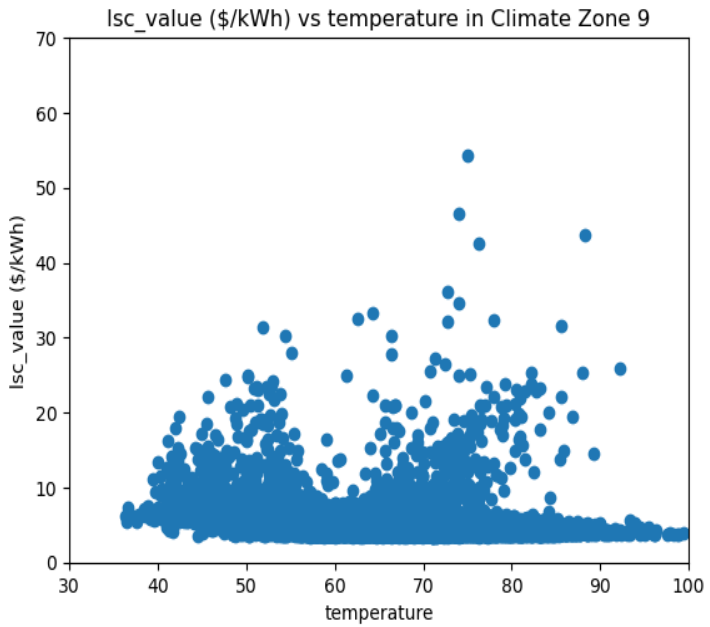
2022 LSC were extremely peaky in summer

Latest LSCs reflect a "U" shape in relation to temperature

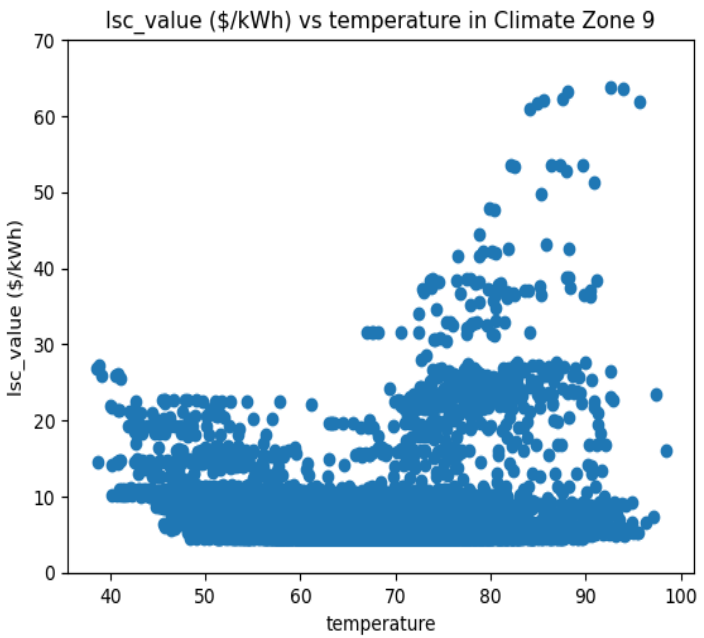
2022



2025



2028



LSCs are higher in summer and winter

2028 code cycle metrics results

Energy+Environmental Economics

High Level takeaways

Electric LSCs

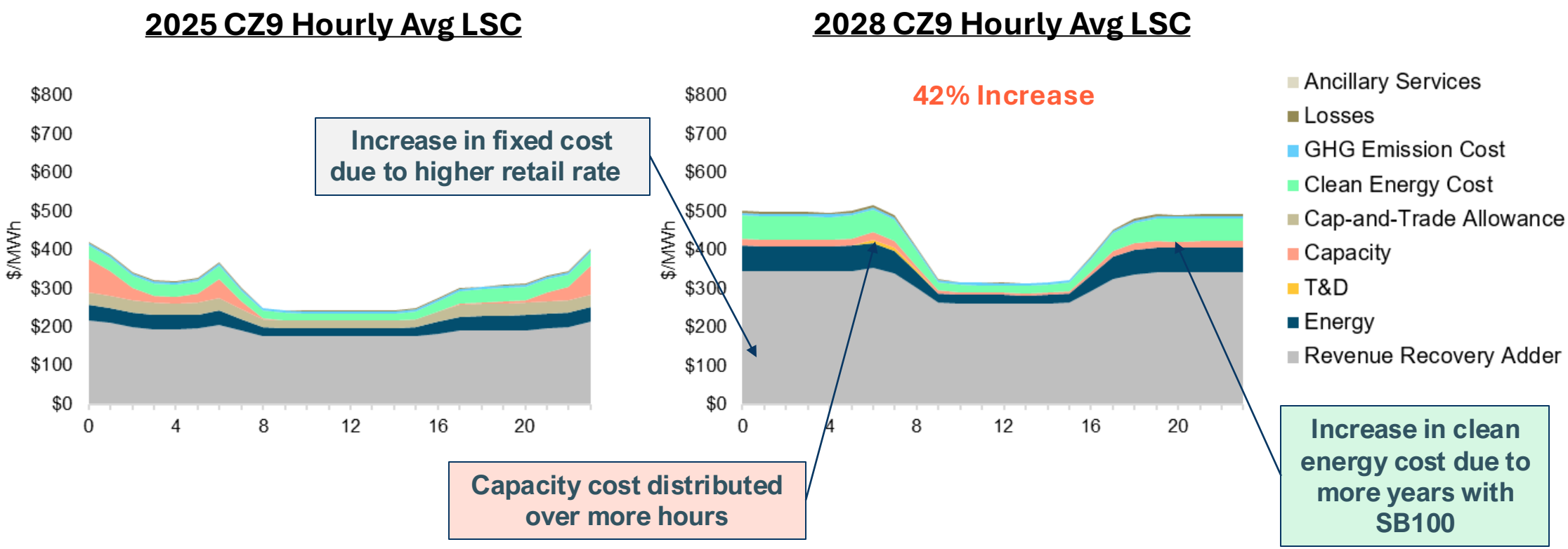
+ **2028 Electric LSCs have increased since 2025 cycle**
  - Larger revenue recovery adder due to higher rate forecast
  - Larger clean energy cost due to more years with SB100
  - More value during winter mornings from heating electrification
  - More value during summer evenings from increased cooling in future weather
  - Capacity cost distributed over more hours
  - Larger on-peak to off-peak ratio

Gas LSCs

+ **2028 Gas LSCs have increased since 2025 cycle**
  - Larger revenue recovery adder and T&S costs due to lower gas throughput
  - Future weather further reduces gas throughput beyond impacts of electrification

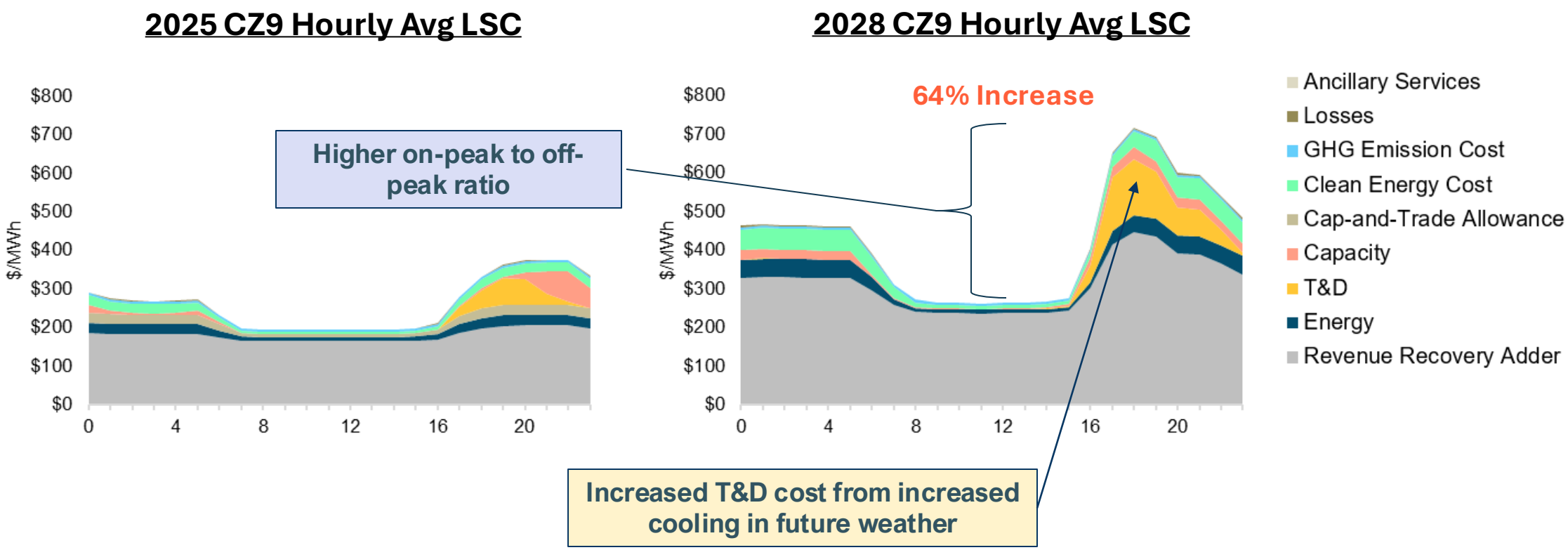
Winter Electricity LSC

Winter electric factors are **26-35% higher** than 2025 cycle, mainly due to increases in fixed costs & clean energy costs

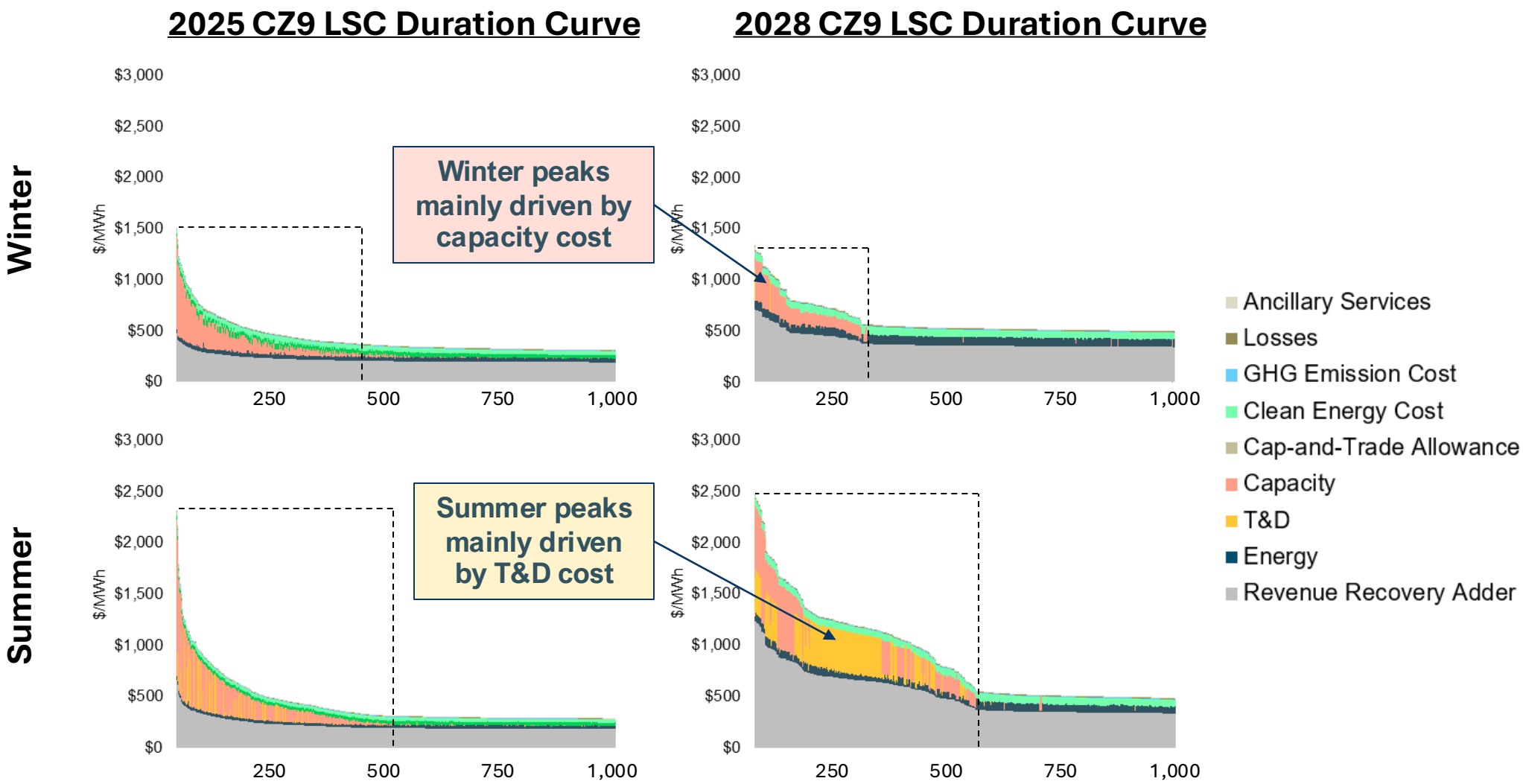


Summer Electricity LSC

Summer electric factors are **36-42% higher** than 2025 cycle, mainly due to increases in fixed costs, clean energy costs, and impacts of future weather

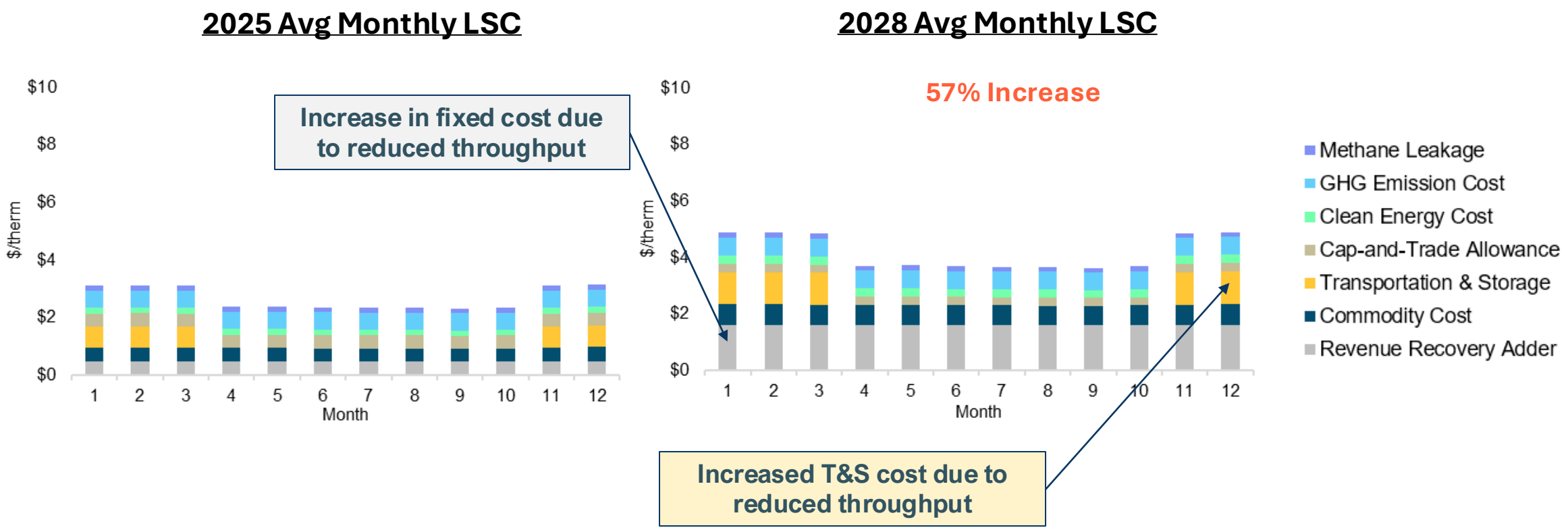


Extreme peaks in electric LSC create opportunities for load flexibility



Natural Gas LSC

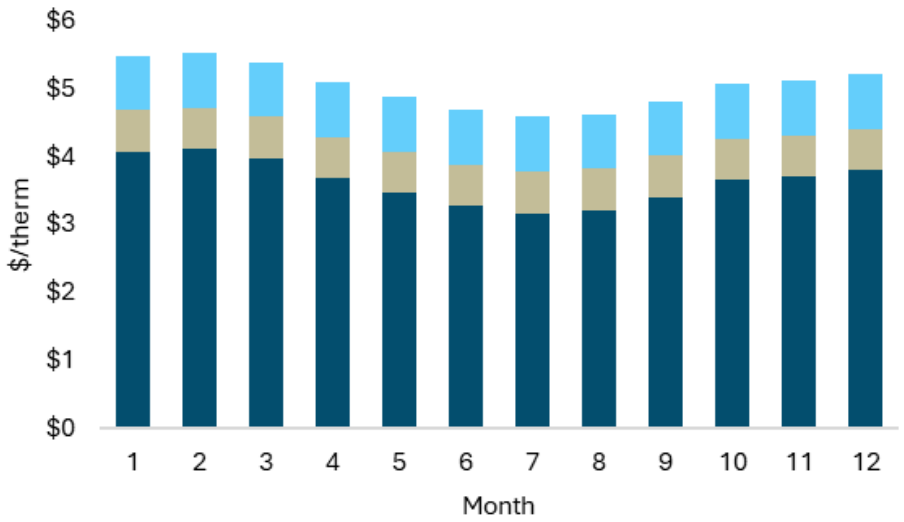
Natural gas LSC factors are **35-36% higher** than 2025 cycle, mainly due to increases in revenue recovery adder and transportation and storage costs



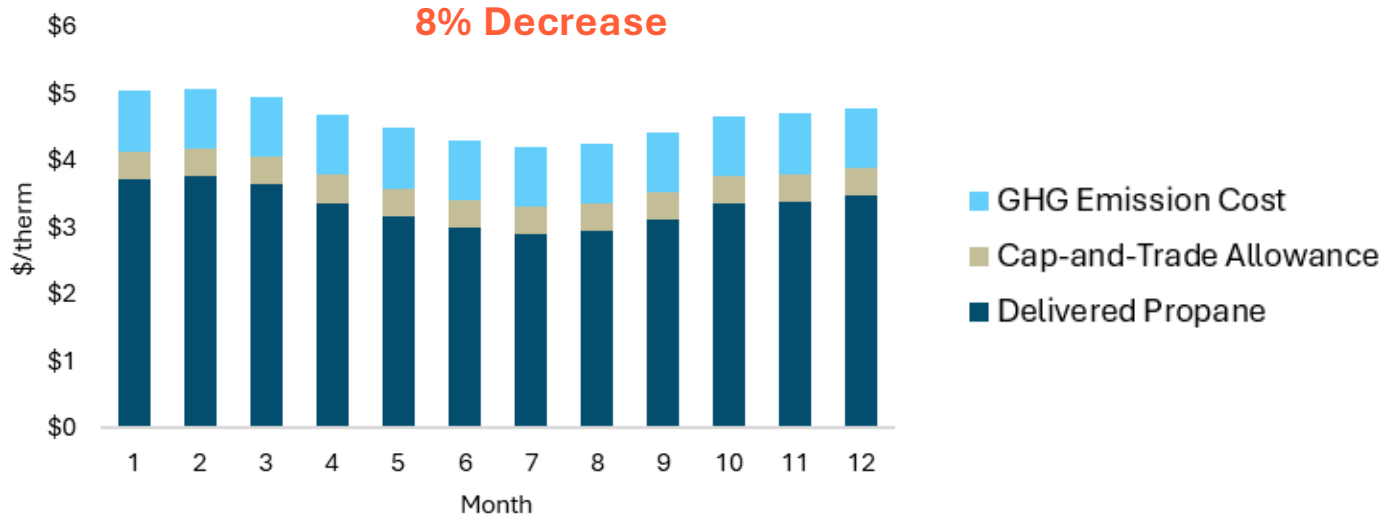
Propane LSC

Propane factors are **8% lower** than 2025 cycle, as a result of a decrease in delivered propane costs due to milder weather and more robust propane inventories

2025 Avg Monthly LSC

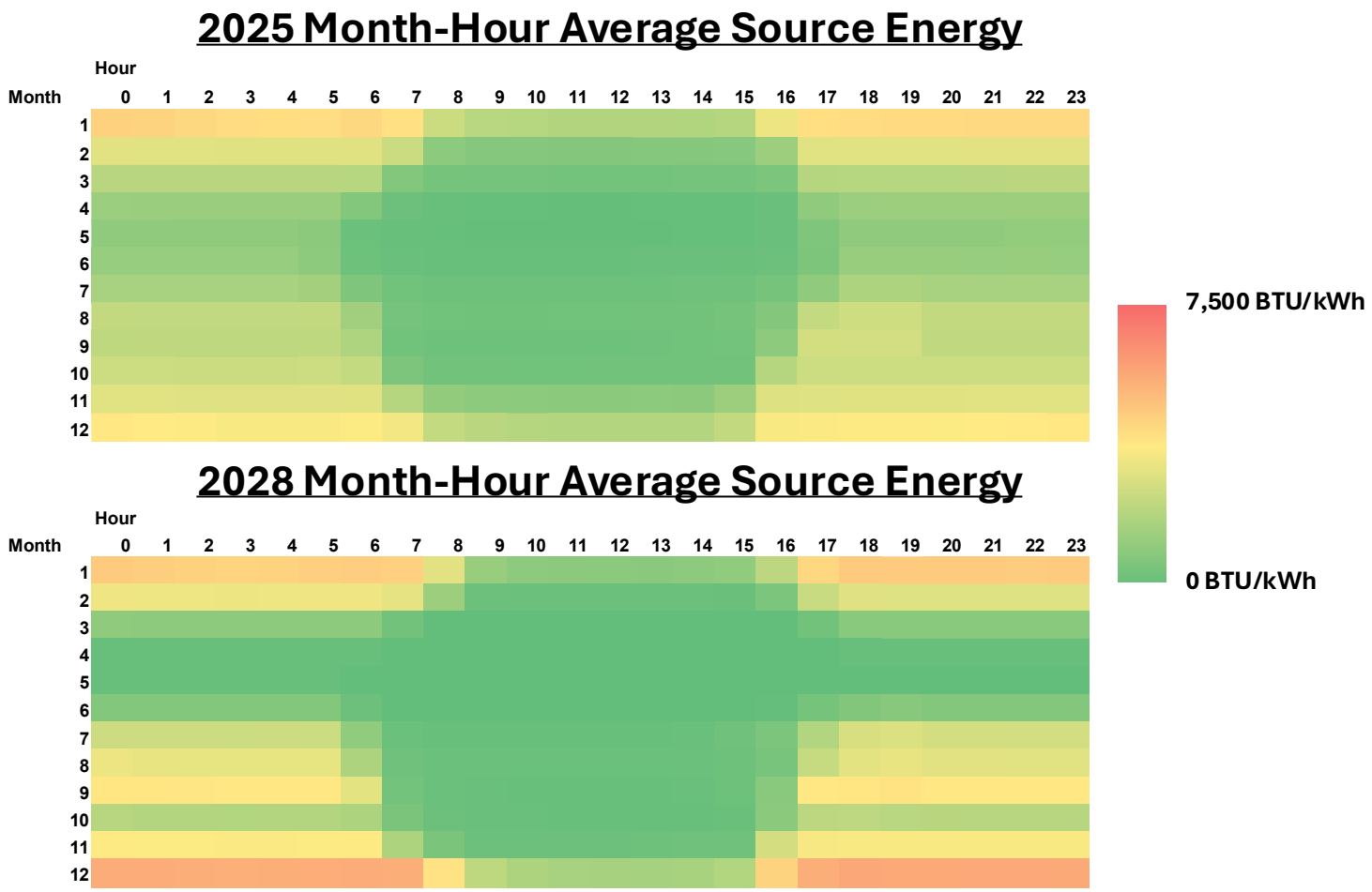


2028 Avg Monthly LSC



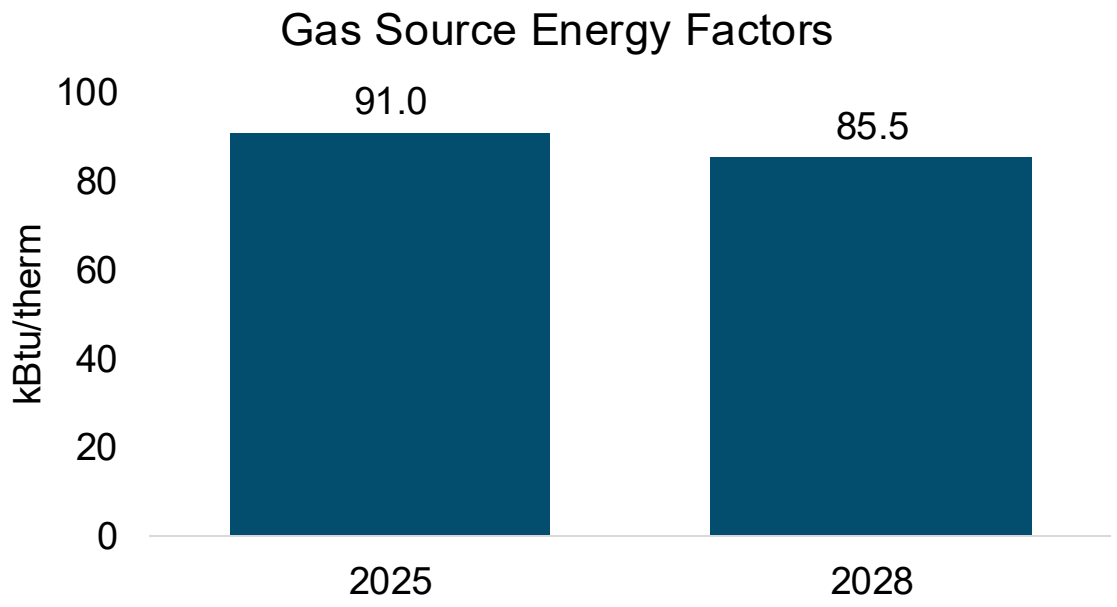
Electric Source Energy

- Electric source energy is LOWER than 2025 cycle during daytime hours, due to more years with high renewable penetration
- Electric source energy is HIGHER than 2025 cycle in Winter and Summer nighttime hours, due to more accurate representation of marginal units



Gas Source Energy

+ **Gas source energy is about 7% LOWER than 2025 cycle, as a result of more years with renewable gas in the pipeline**
  - CPUC adopted biomethane procurement targets for gas utilities of 72.8 billion cubic feet of biomethane per year starting in 2030 (following SB1440)



Thank You

Jared.Landsman@ethree.com

Fanxing.Liu@ethree.com

Snuller@ethree.com

Energy+Environmental Economics

Title 24 2028 Code Cycle

Nonresidential LSC Factors Sensitivity Analysis

August 28, 2025

Mohammad Dabbagh
Nasim Miriam
Rahul Athalye

NORESCO

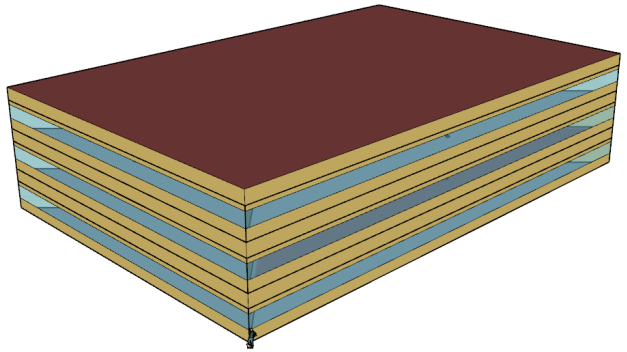
AGENDA

- Prototypes Selected for Analysis
- Impact on LSC and Source Energy
- Measures Selected for Analysis
- Results
- Summary of Observations

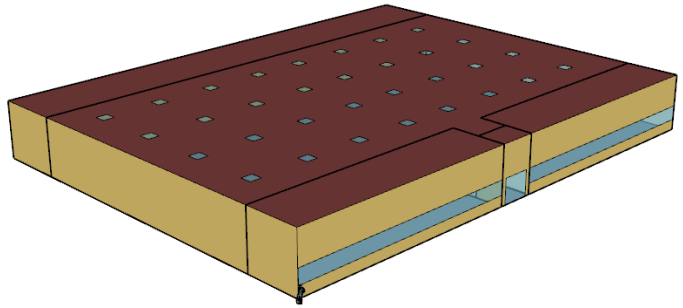
PROTOTYPES SELECTED FOR ANALYSIS

Characteristics	Medium Office	Medium Retail
Conditioned Floor Area, sf	53,600	24,000
Number of Stories	Three	One
Occupied Hours	M-F, 9 am – 5 pm Sat, unoccupied Sun, unoccupied	M-F, 7am – 9 pm Sat, 7am – 10 pm Sun, 9 am – 7 pm
Window-to-Wall Ratio Skylight-to-Roof Ratio	33% 0%	7% 2%
HVAC System Used	VRF	Packaged single zone heat pump

Medium Office



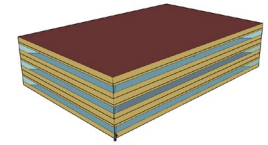
Medium Retail



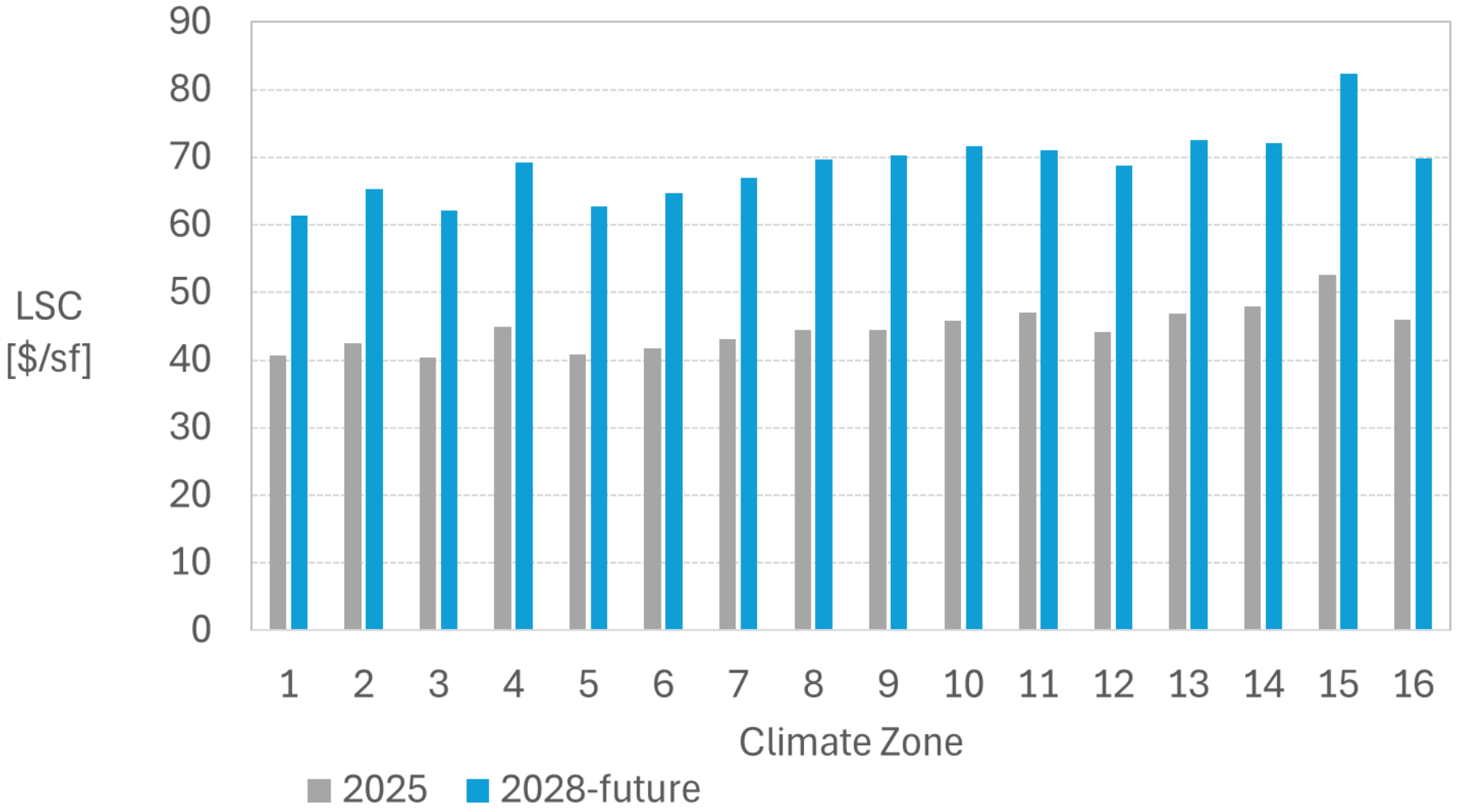
NORESCO

IMPACT ON LSC AND SOURCE ENERGY

LSC COMPARISON



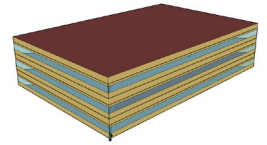
Medium Office



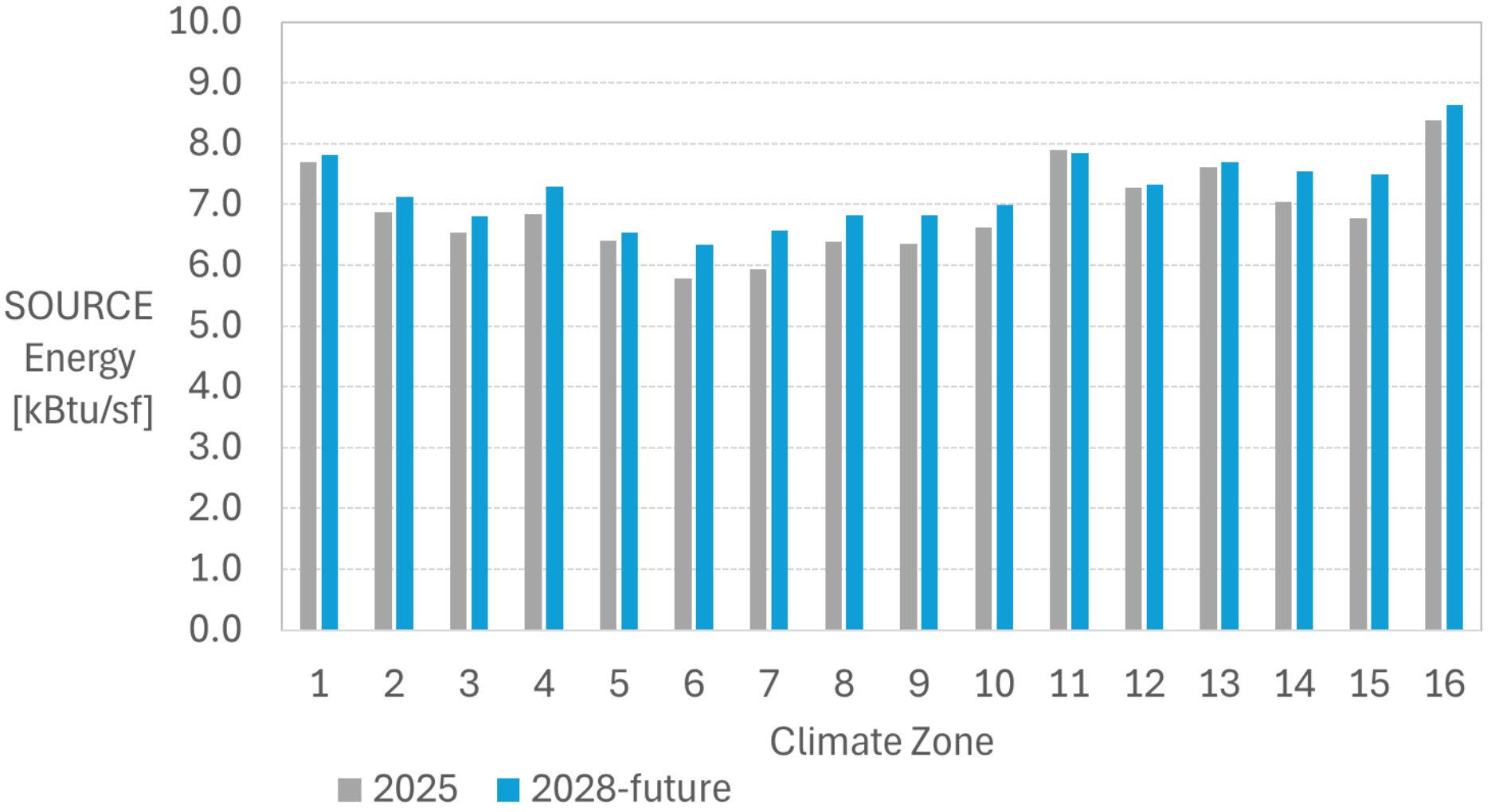
2028 LSCs are approximately 50% higher than 2025 LSCs

NORESCO

SOURCE ENERGY COMPARISON



Medium Office



2028 Source energy is about the same or slightly higher than 2025

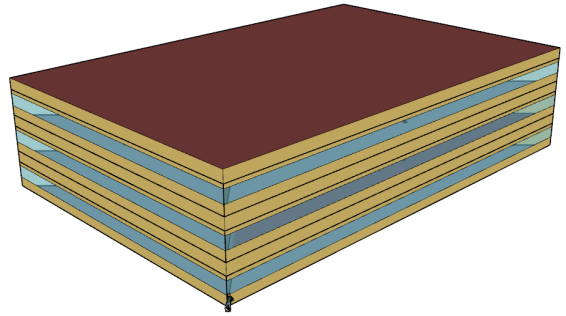
NORESCO


MEASURE ANALYSIS

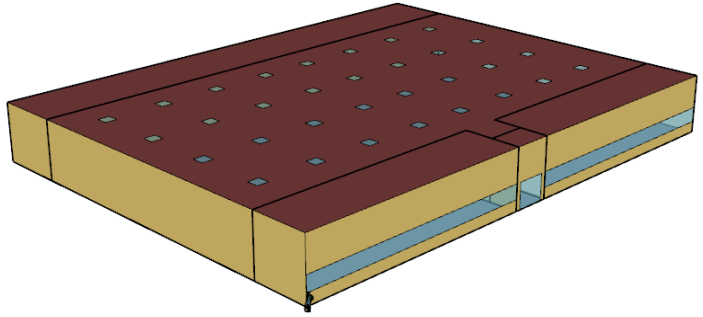
TEST CASES

Prototype	Measure
Medium Office (3-story, 53,000 sf, VRF system)	Increase window SHGC by 10%
	Decrease envelope R-value by 10%
	Increase cooling EER by 20%
Medium Retail (1-story, 24,000 sf, Packaged SZ HP)	Increase roof reflectance by 10%
	Decrease interior lighting power by 15%
	Increase cooling EER by 20%

Medium Office



Medium Retail



MEASURE RESULTS

- Measure savings are calculated as:

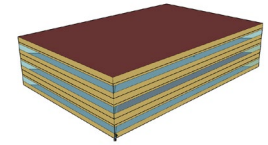
$$Measure\ Savings\ (Percent)\ =$$

$$\left(\frac{Standard\ Design\ Performance\ (LSC\ or\ Source) - Proposed\ Design\ Performance\ (LSC\ or\ Source)}{Standard\ Design\ Performance\ (LSC\ or\ Source)}\right) \times 100$$

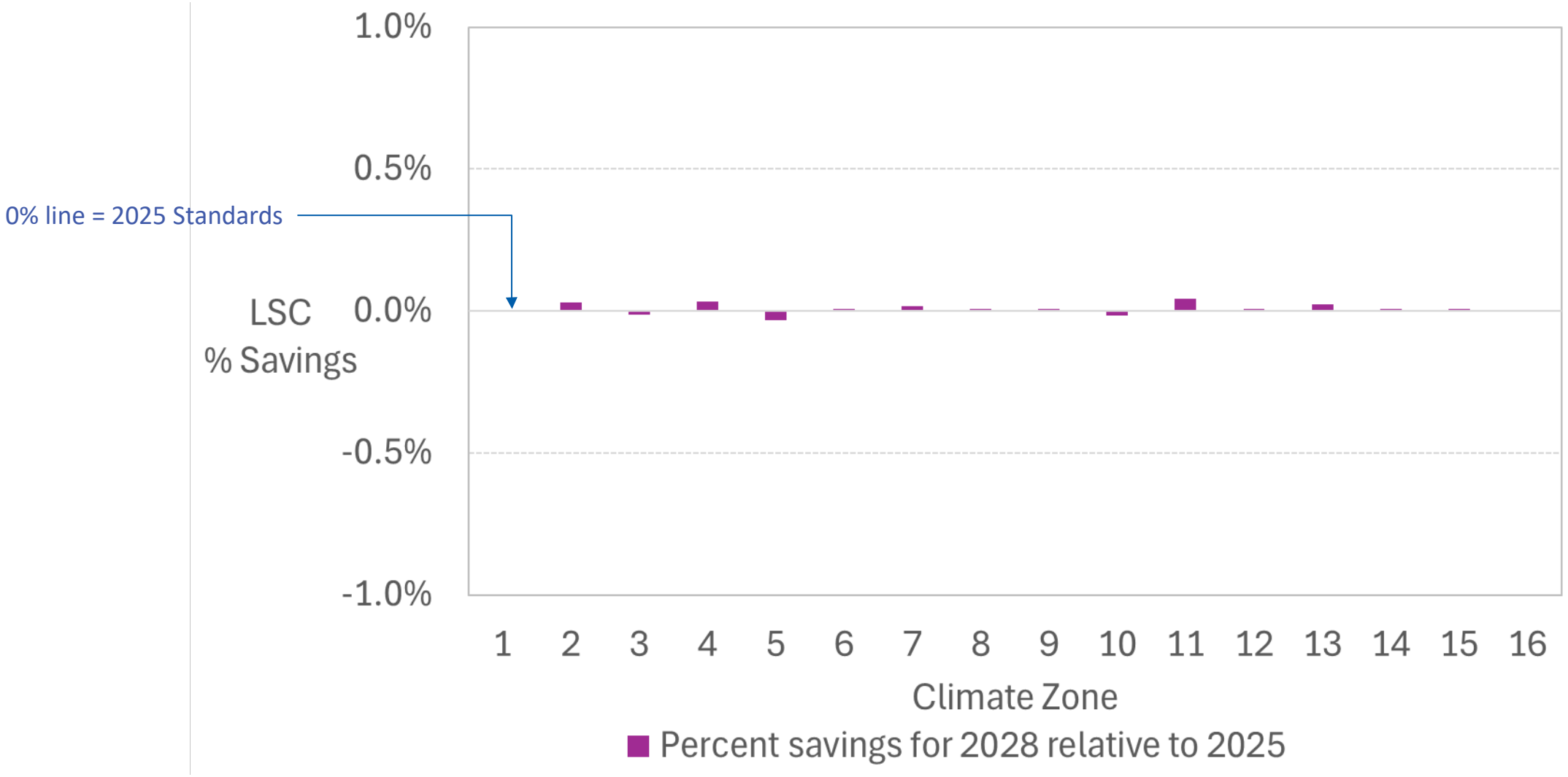
- In slides that follow, measure impact in each climate zone is reported as:

Percent savings for 2028 relative to 2025 = 2028 Measure savings – 2025 measure savings

INCREASE WINDOW SHGC BY 10%

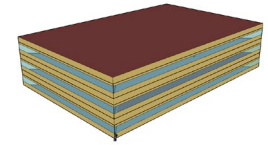


Medium Office

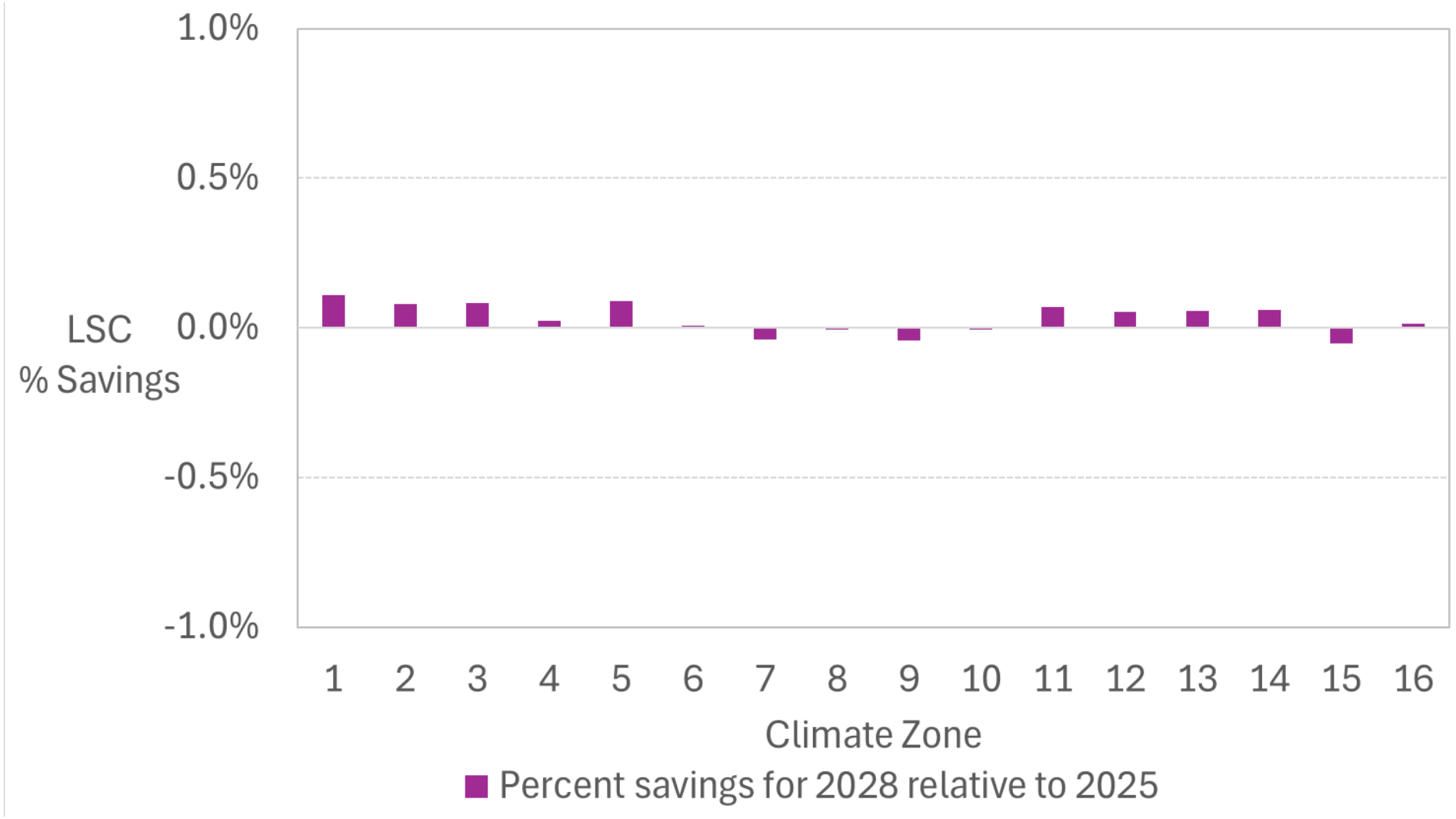


NORESCO

DECREASE WALL AND ROOF R-VALUE BY 10%

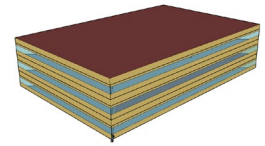


Medium Office

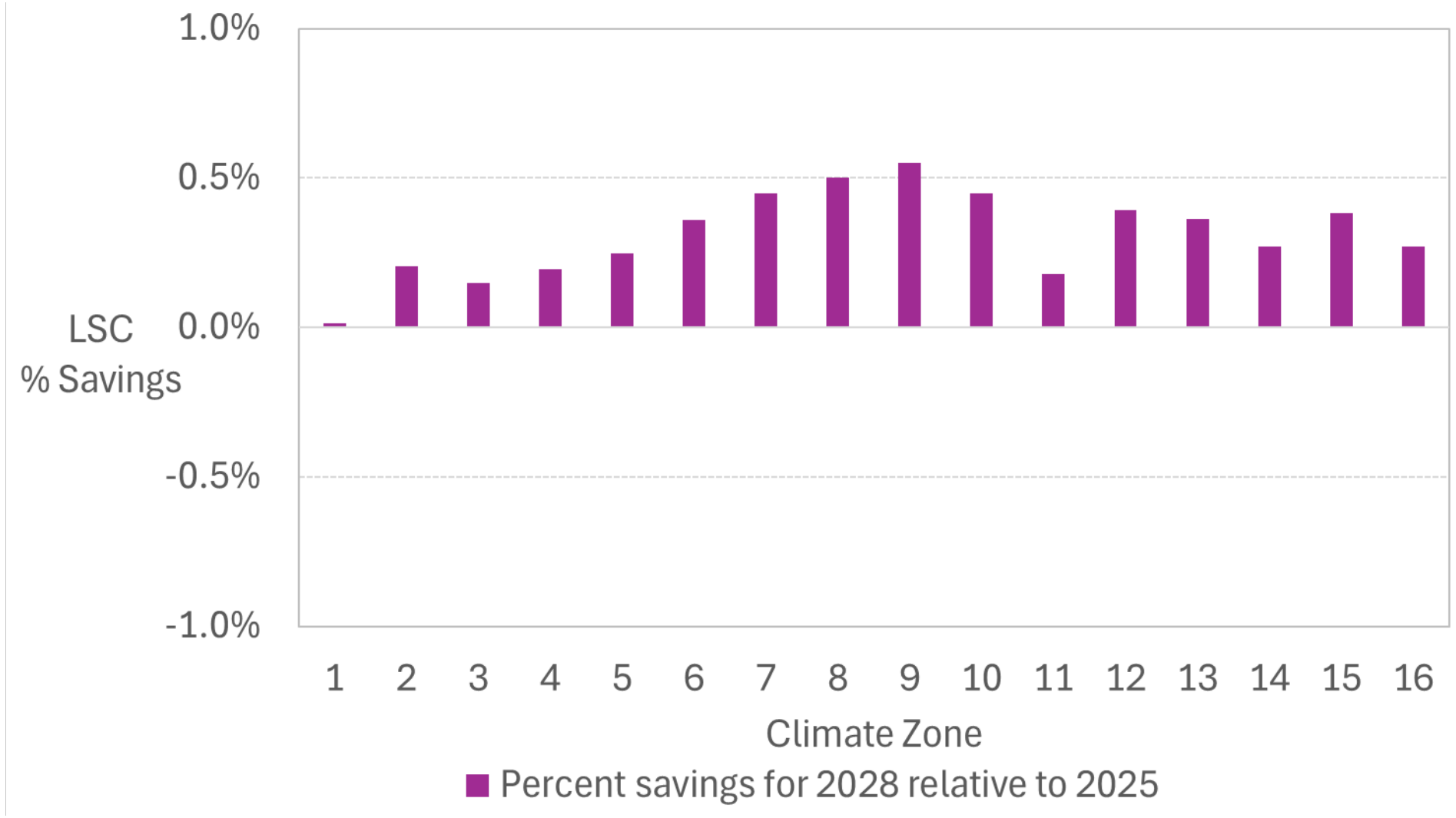


NORESCO

INCREASE COOLING EFFICIENCY BY 20%

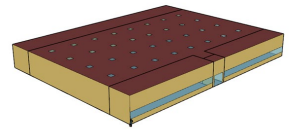


Medium Office

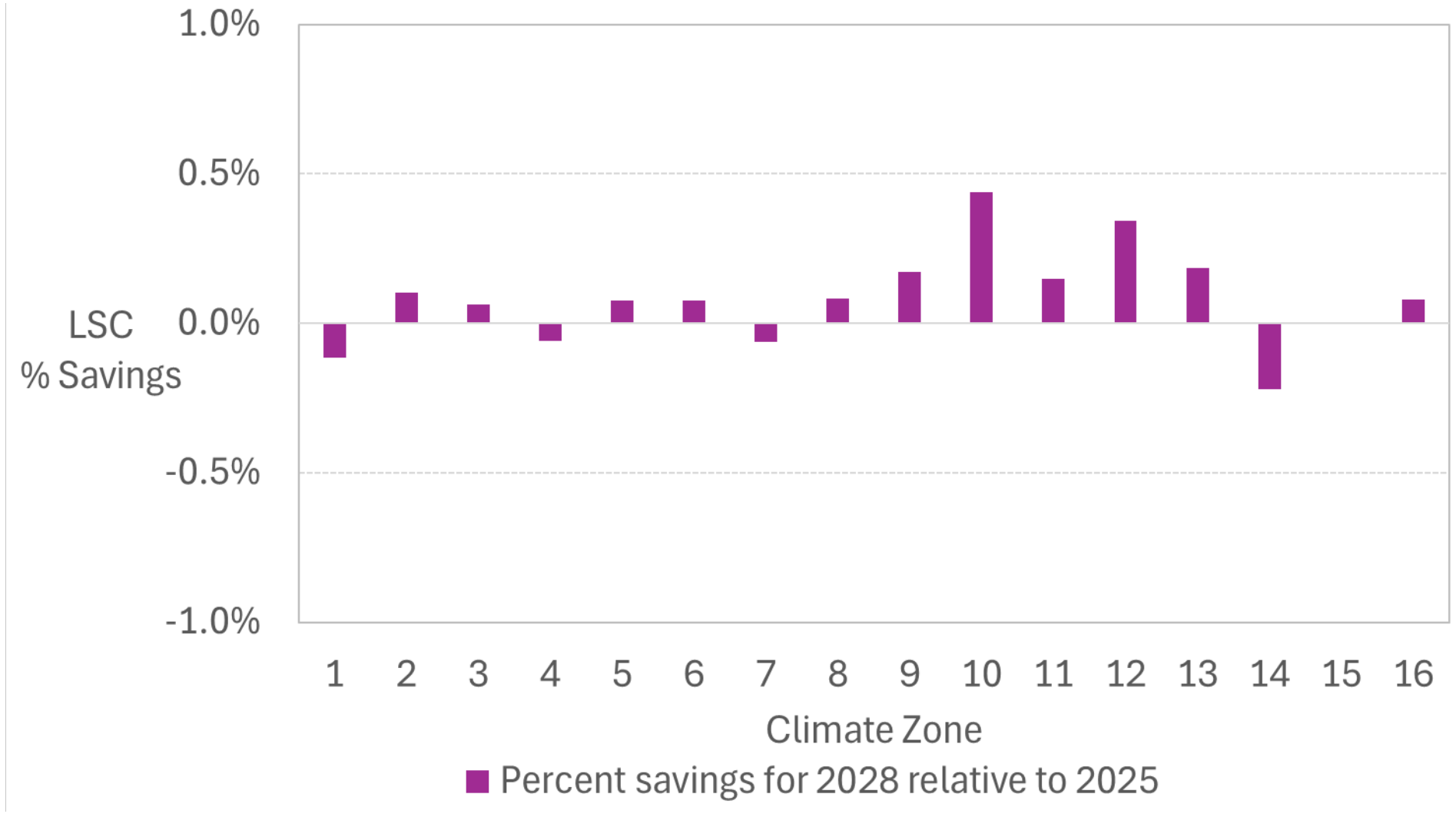


NORESCO

INCREASE COOL ROOF REFLECTANCE BY 10%

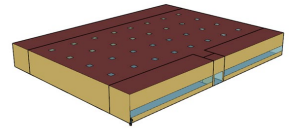


Medium Retail

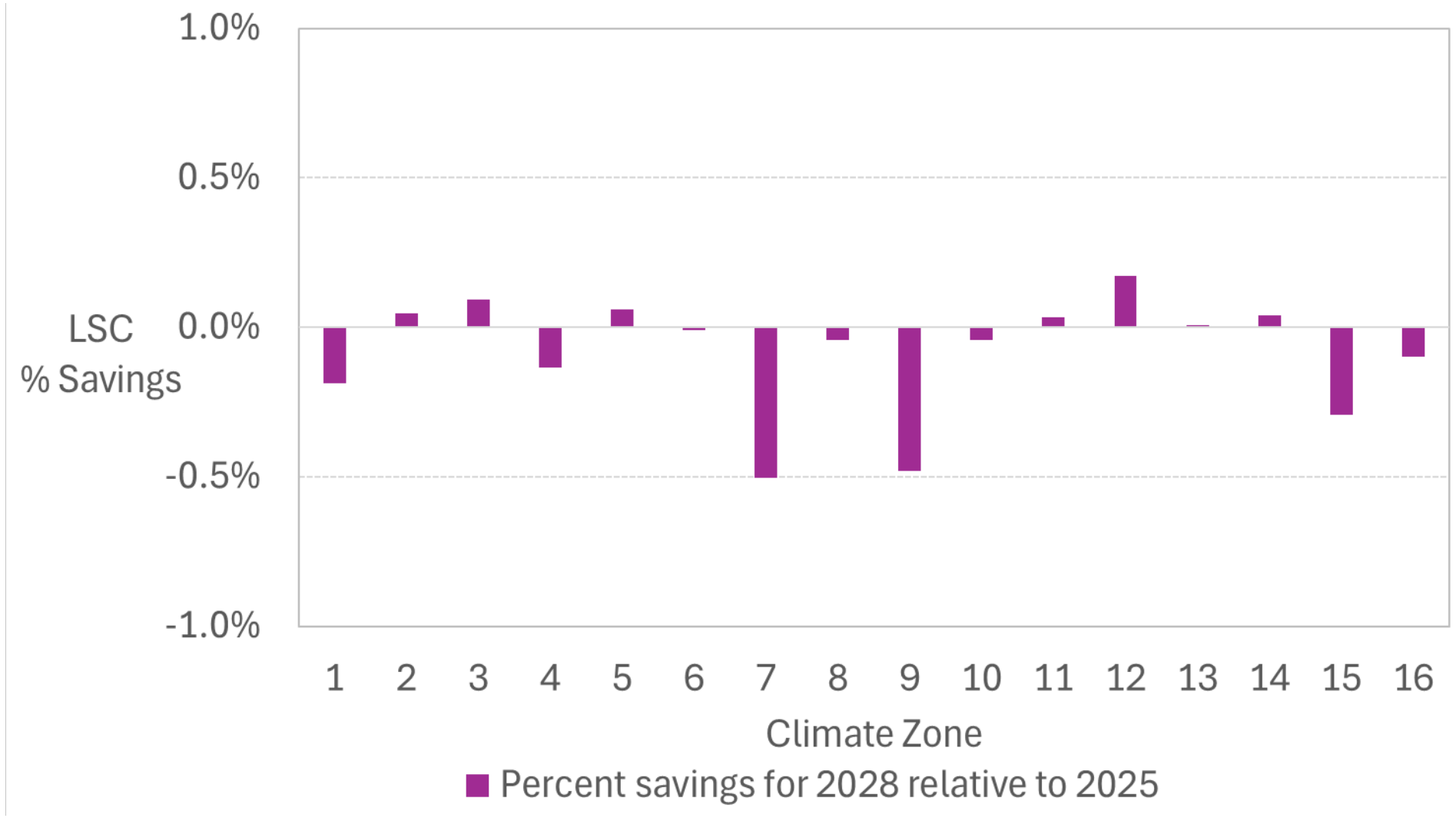


NORESCO

DECREASE INTERIOR LIGHTING POWER BY 15%



Medium Retail



NORESCO

SUMMARY OF OBSERVATIONS

- 2028 LSC factors result in about 50-60% higher LSCs than 2025, and will likely result in more absolute savings from measures
- 2028 Source Energy factors result in about the same amount of source energy in 2028 as that in 2025
- Measure impacts resulting from the 2028 factors are about the same as those from the 2025 factors


THANKS!

2028 Nonresidential Prototype Proposals

August 8, 2025

Eric Shadd, Mohammad Dabbagh, Nasim Miriam

NORESCO

AGENDA

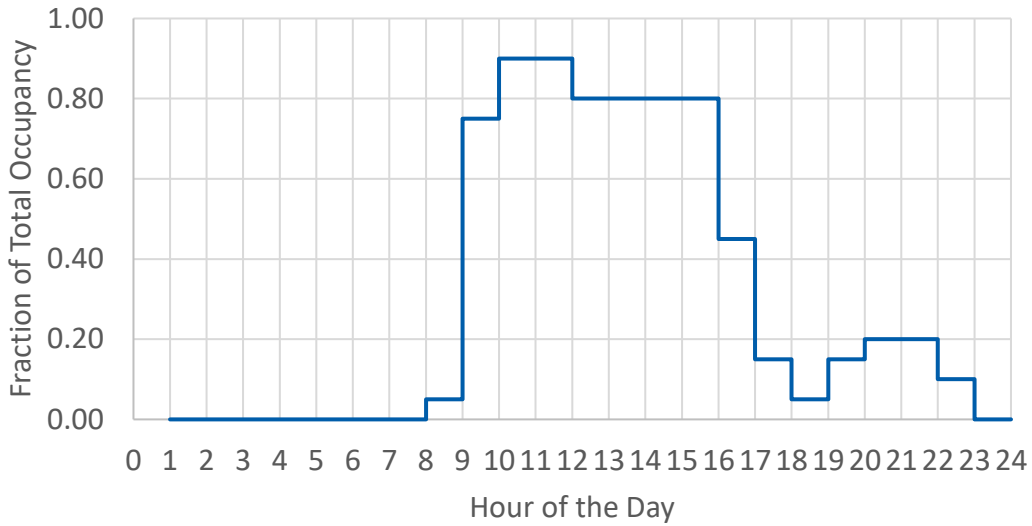
- Kindergarten through 8th Grade School
- High School
- Assembly Spaces
- Hotels & Motels

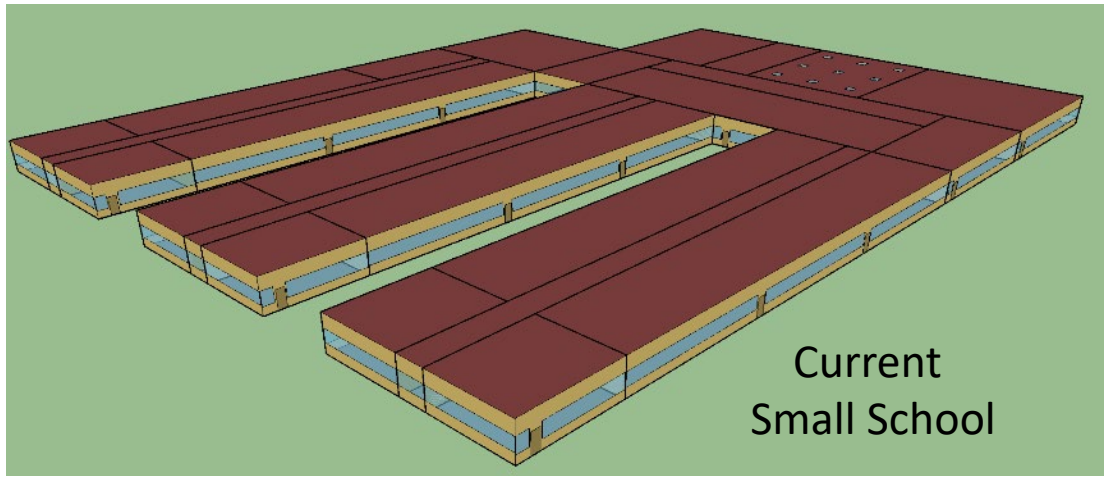
NORESCO

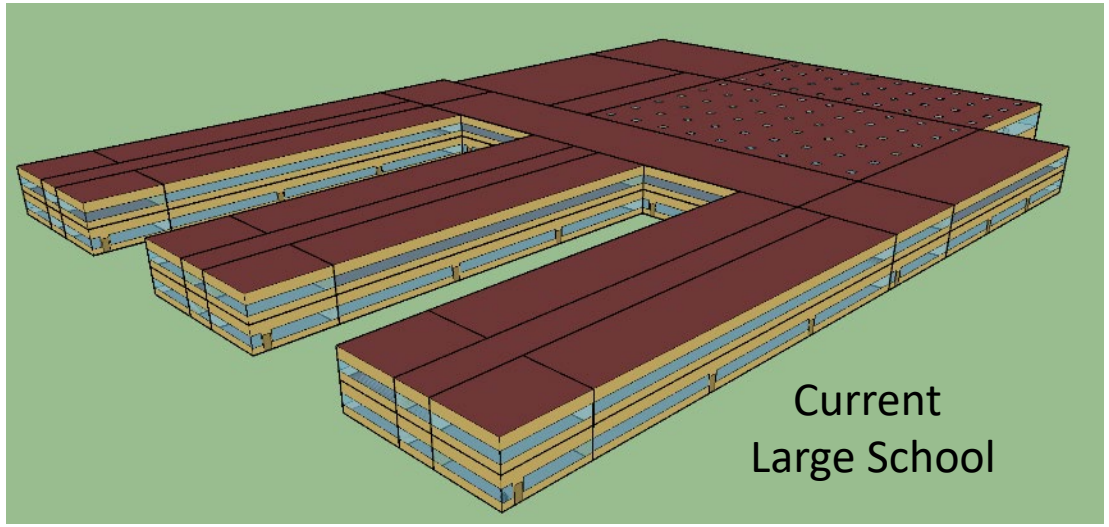

KINDERGARTEN THROUGH 8TH GRADE SCHOOLS

SCHOOL PROTOTYPE DEVELOPMENT RATIONALE

- Layout: Finger-style single-building is not typical
- Schedules: Schools not a year-round, single-activity like office

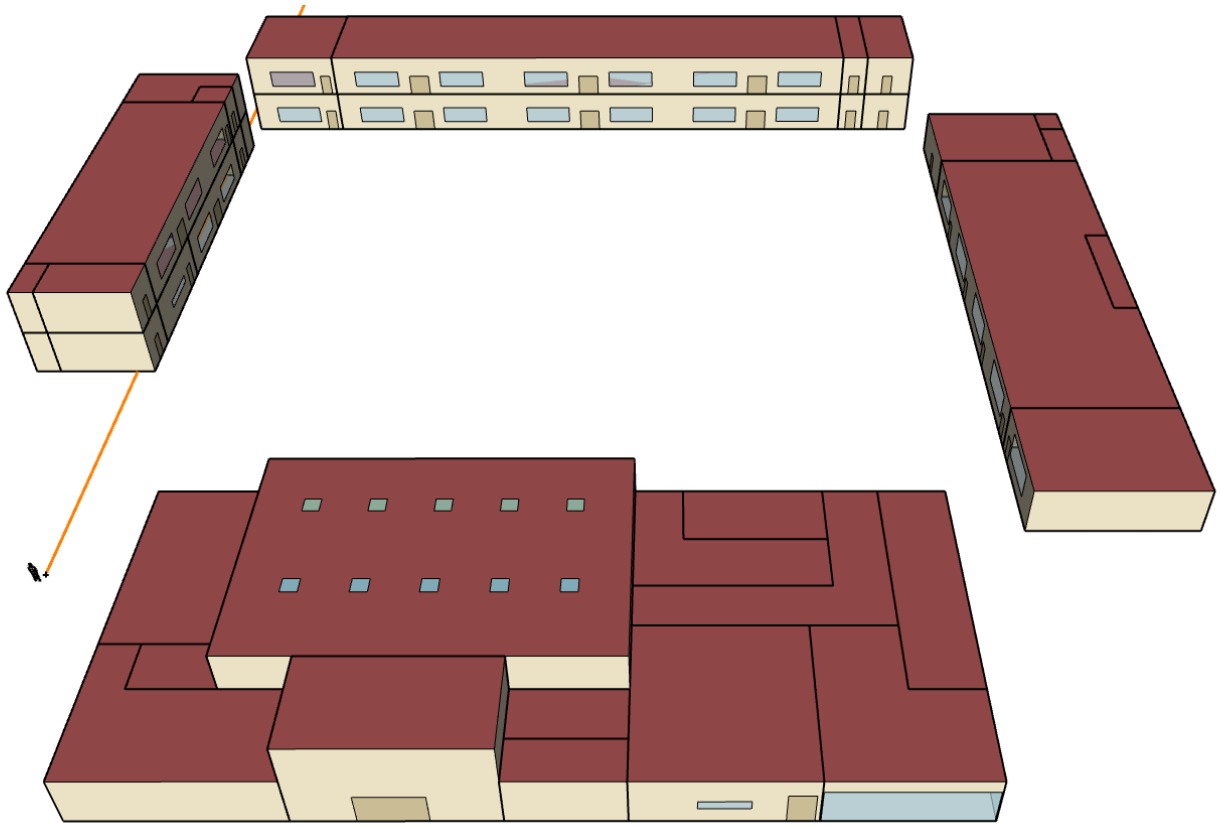






NORESCO

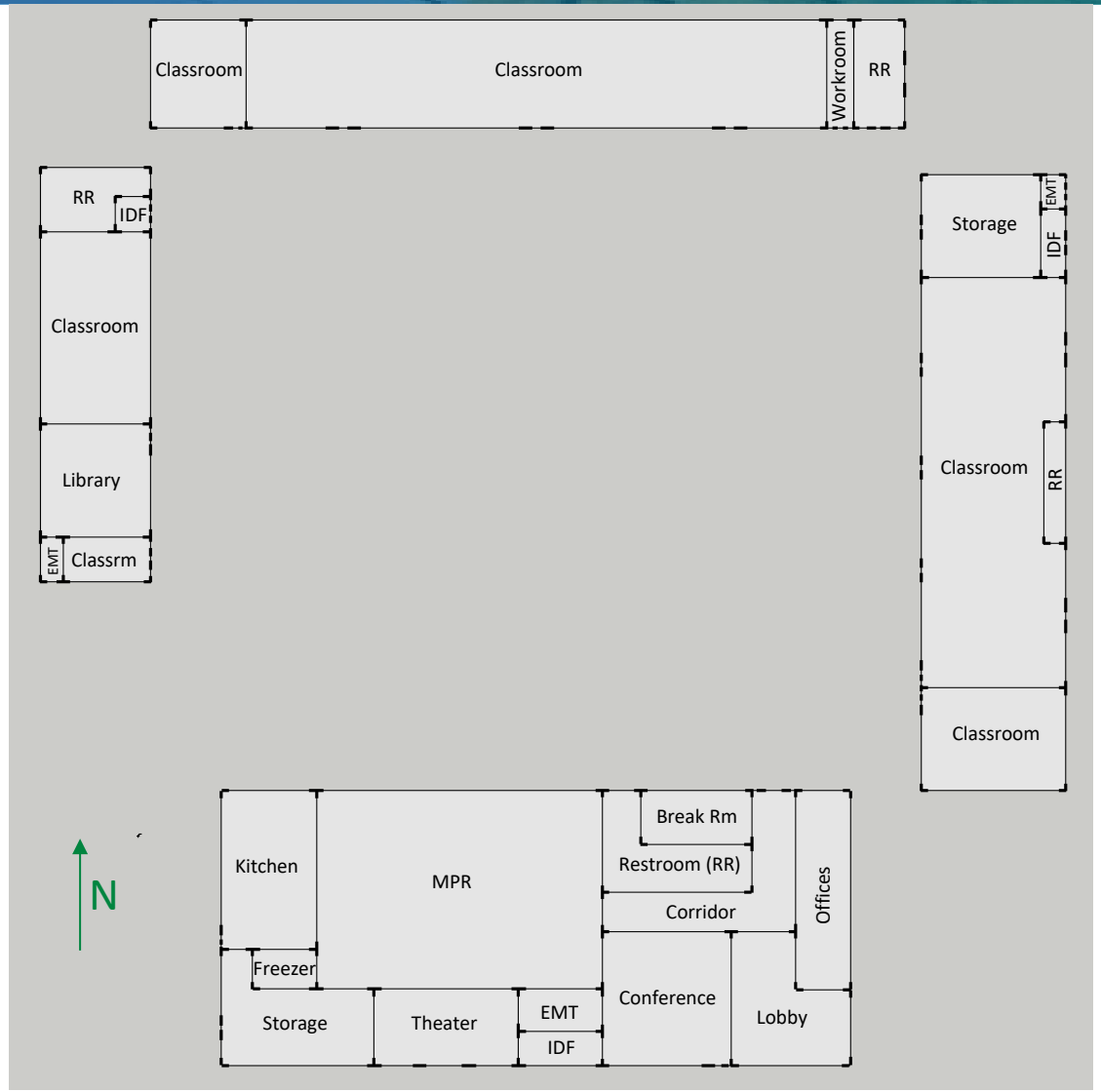
PROPOSED KINDERGARTEN – 8TH GRADE (K – 8)



- Based on newly constructed schools from DSA
- West, North, East classrooms
- South
  - Administrative: offices, conference, breakrooms, etc.
  - Multipurpose Room (MPR): cafeteria, gym, theater
- 41,500 square feet
- Single-zone heat pumps

NORESCO

LAYOUT & SPACES

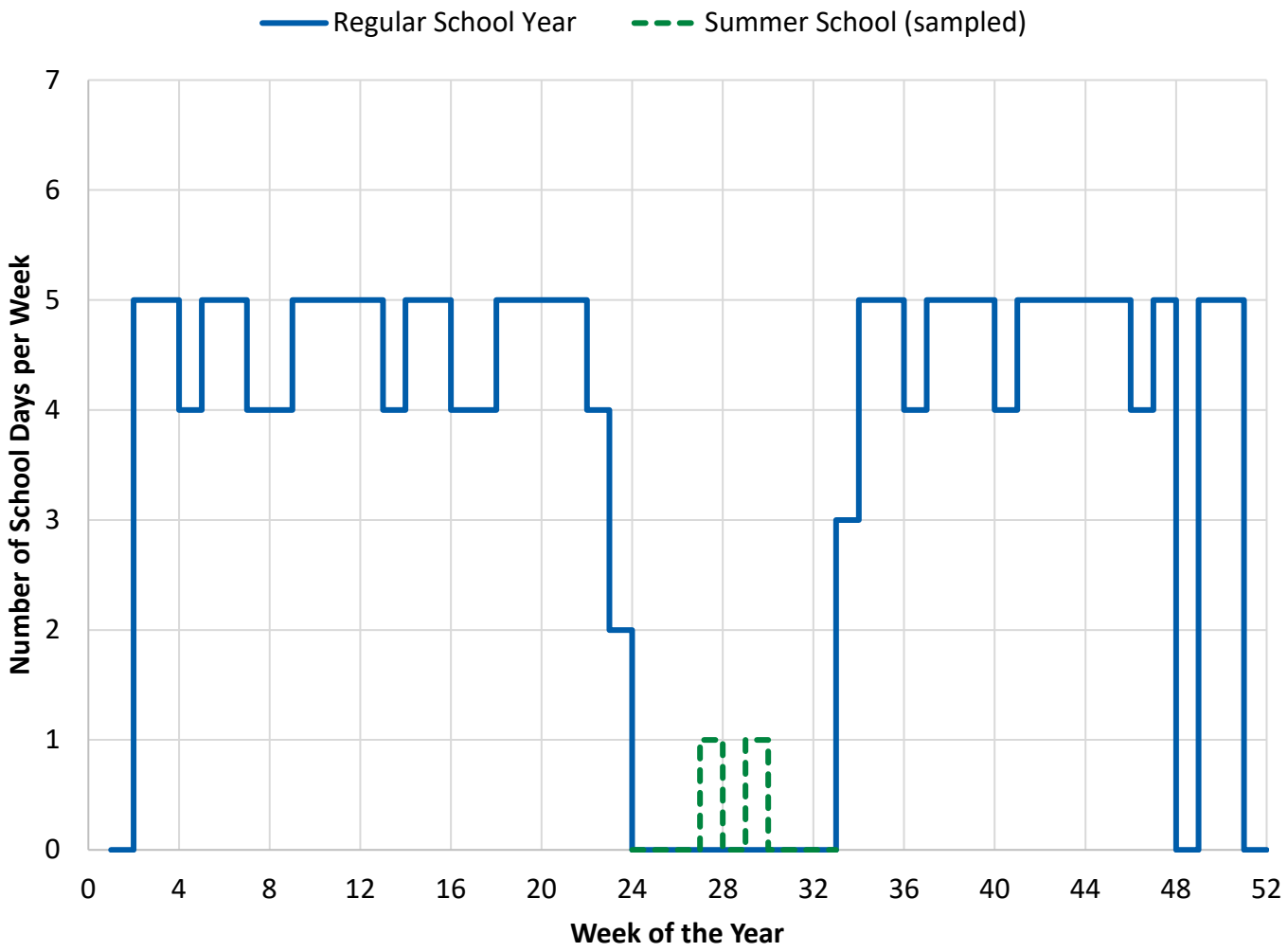


- Simplification
  - Combined similar spaces
  - Number of walls minimized
  - Windows were merged
- < 1% difference: design examples vs prototype
  - Total campus floor area
  - Ratio of space type to total area
  - Window-to-floor area & Daylit area-to-floor area ratio by space type and orientation

NORESCO

ANNUAL SCHEDULE

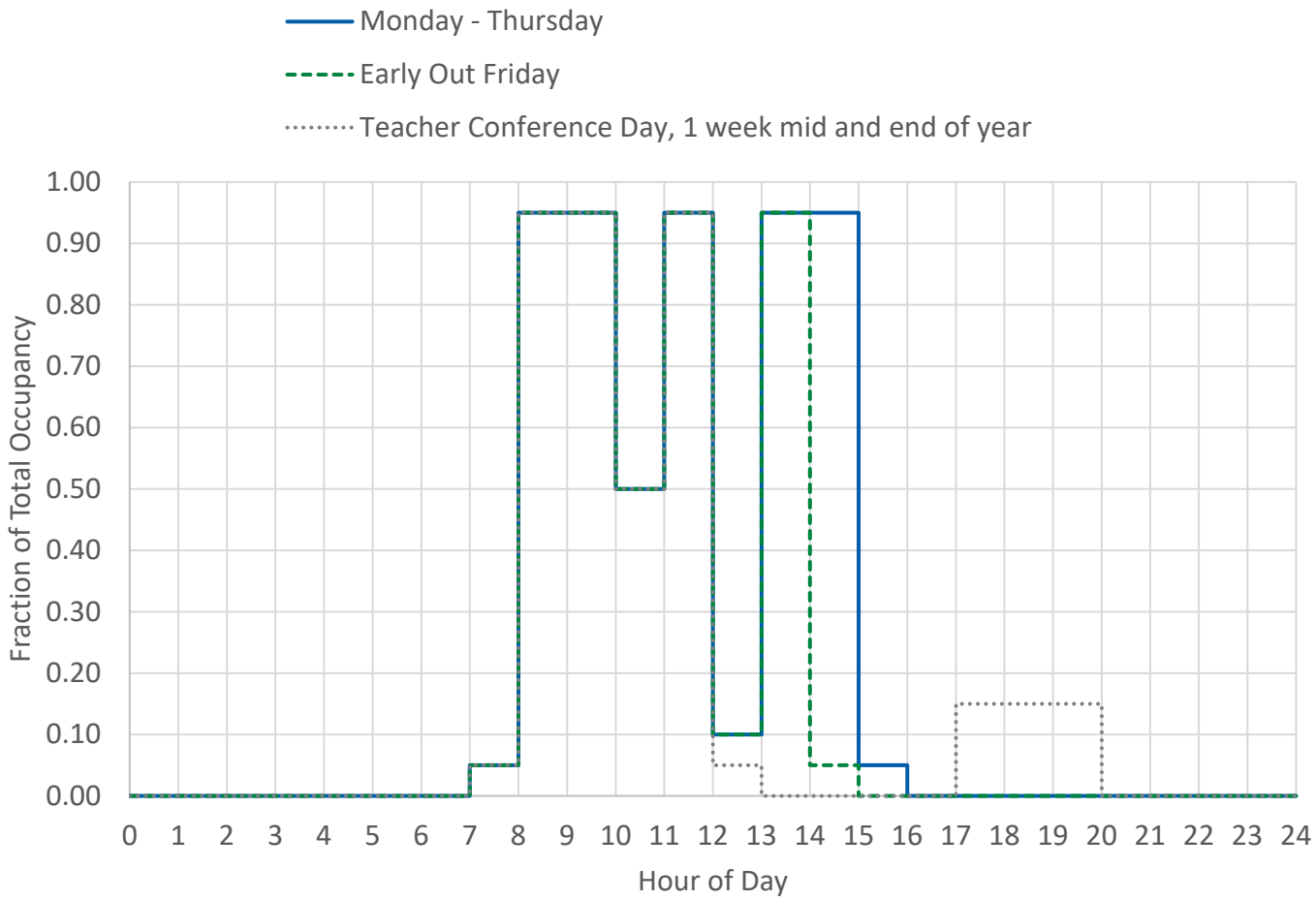
- School Year
  - Median of 17 school districts
  - Matches typical 180-day school year
- Summer School
  - 25% of classrooms in 30% of schools → Four days of class.
  - All classrooms on two representative days of summer
  - Captures vacancy
- Weighted by elementary vs middle school floor area (4:1)
  - # of times/year
  - Level of occupancy



NORESCO

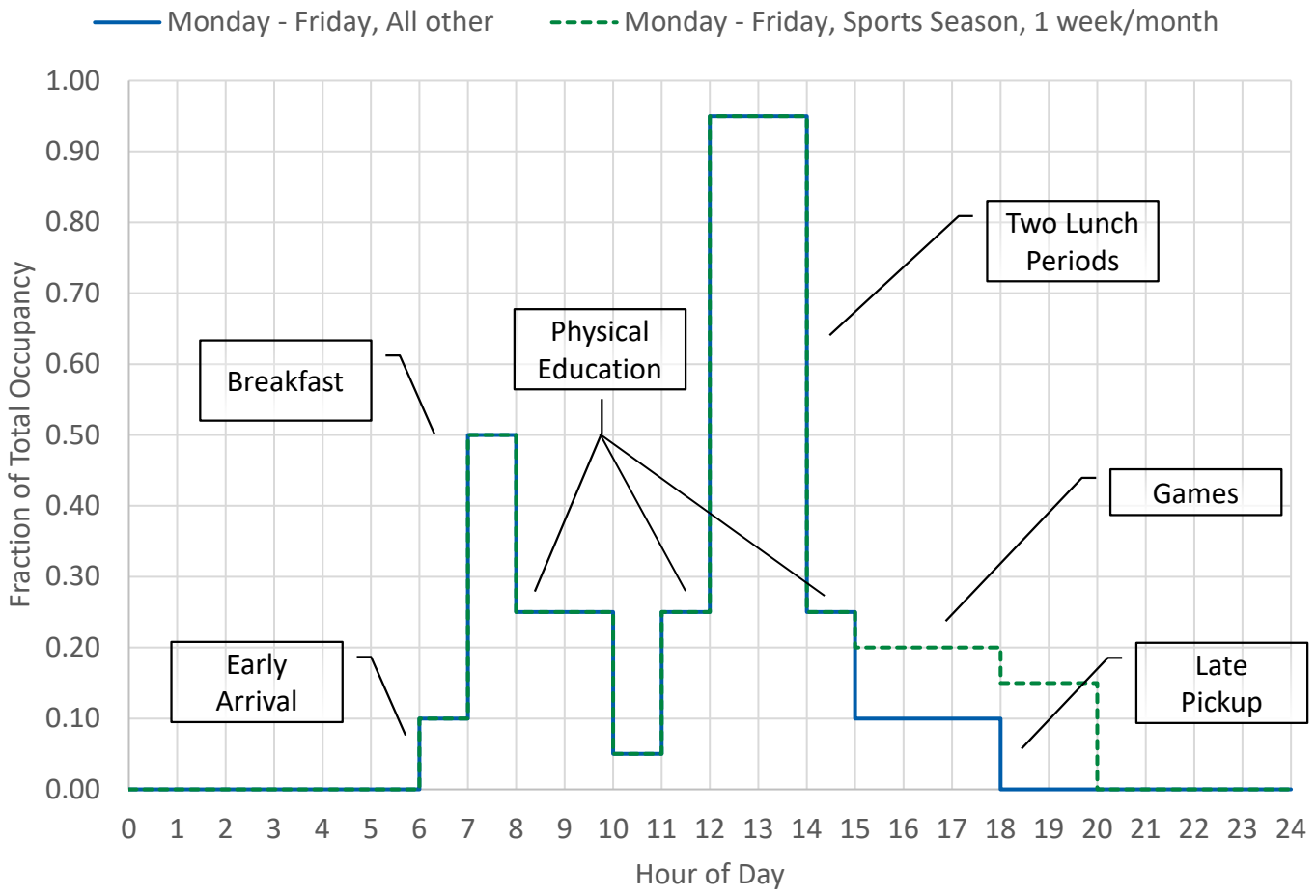
CLASSROOM SCHEDULES

- Classes 8 am – 3 pm
- ½ hour recess 10 – 11 am
- Early out on Fridays
- Teacher Conference: two weeks per year
- Summer school same as school year except
  - 50% occupancy
  - no recess
  - out at noon



NORESCO

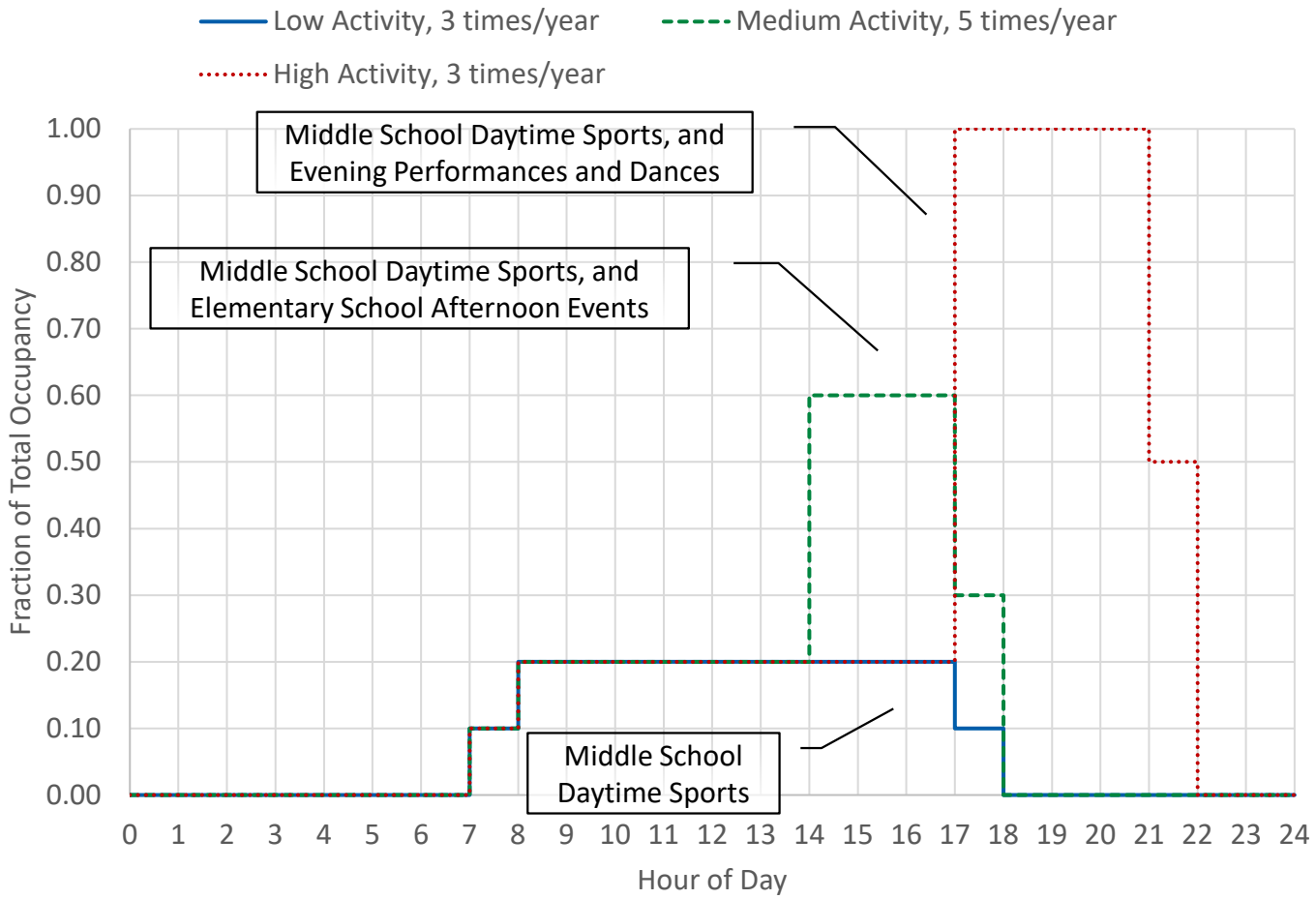
MPR WEEKDAY SCHEDULES



- Sports season (Nov – Feb): after-school indoor games
- Research revealed two lunch periods

NORESCO

MPR SATURDAY SCHEDULES



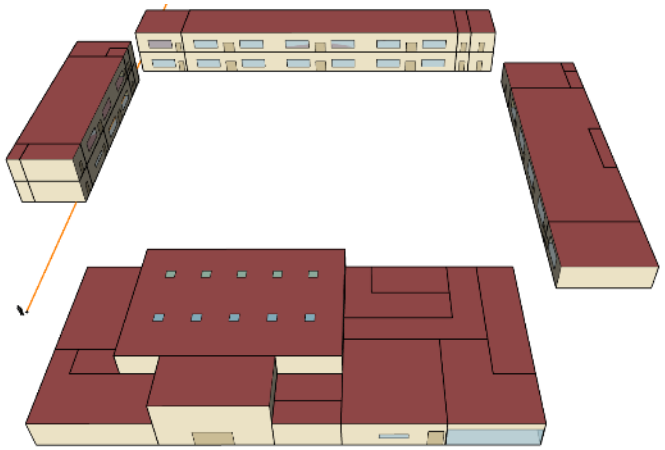
- Daytime activity is consistent with occasional afternoon and/or evening events

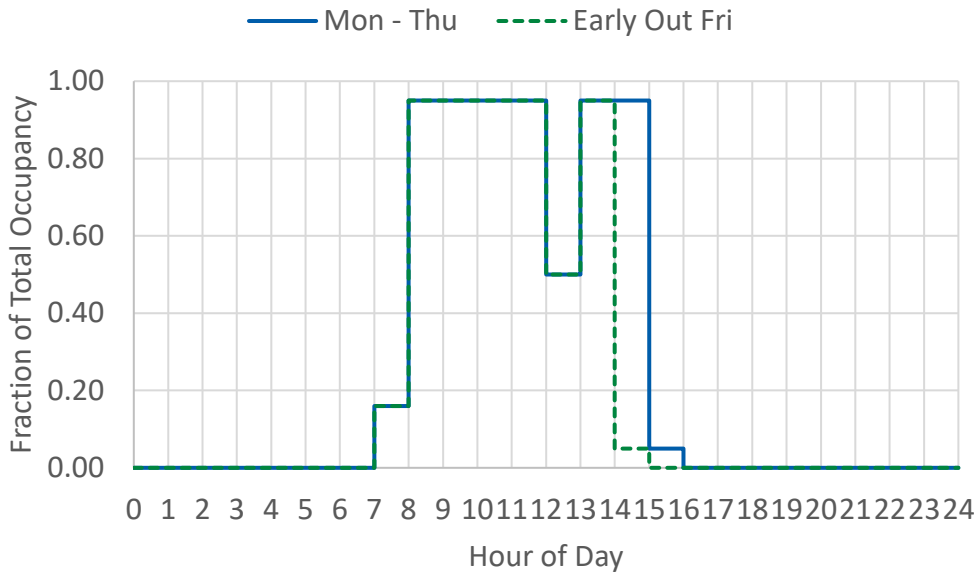
NORESCO


HIGH SCHOOL
Dividends
41%
$839.60
$733.40
2009
2008

PROPOSED HIGH SCHOOL CHARACTERISTICS

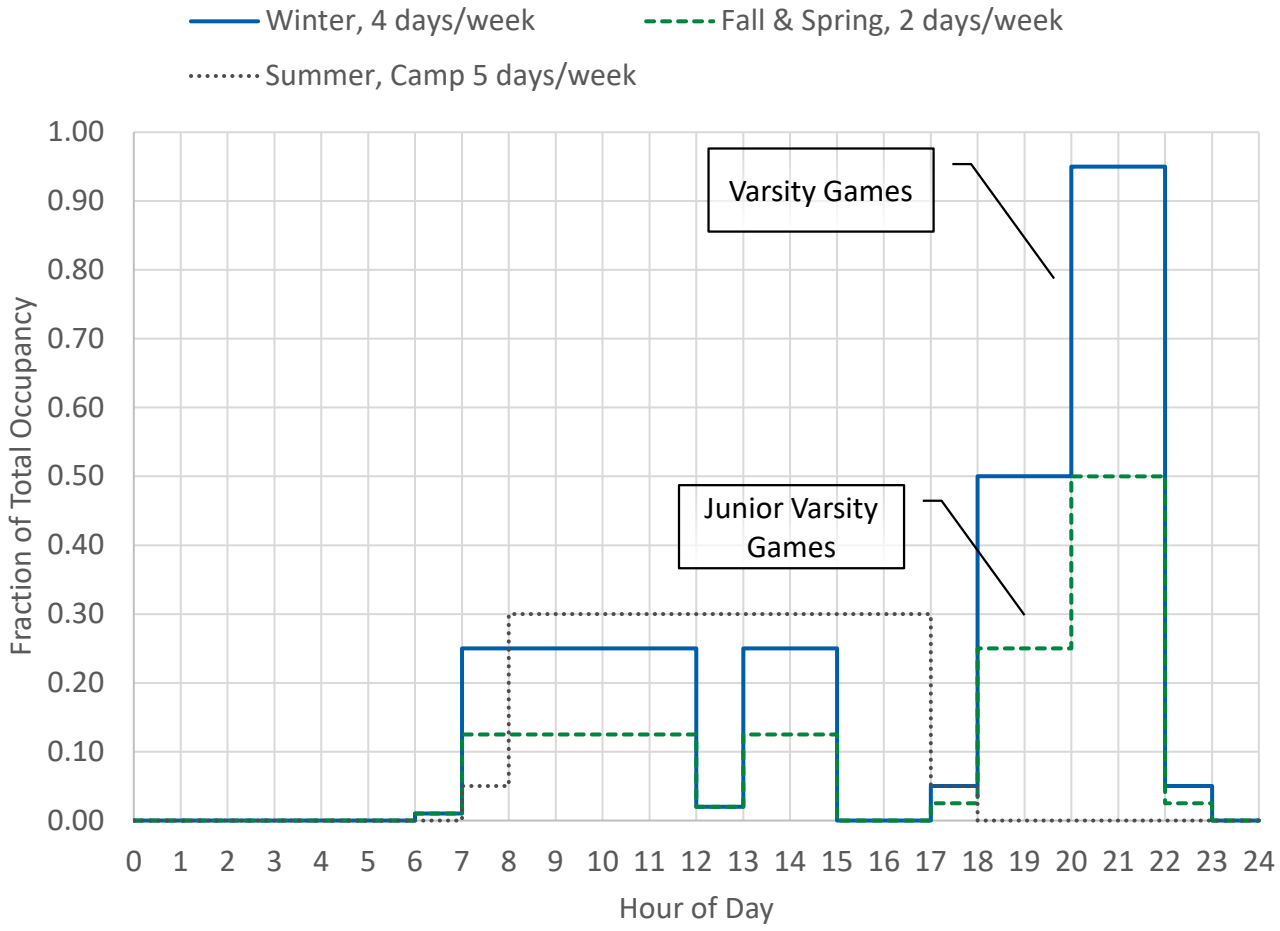
- K – 8 Basis
- Layout: 190,000 sf
  - Multipliers to match typical High School size and proportions
  - MPR converted to Cafeteria
  - Gymnasium would be added
  - Convert some classrooms: Science Labs, Art & Shop
- Schedules
  - Annual same except 4 representative Summer days
  - Class: zero period, no recess, no parent-teacher conference





NORESCO

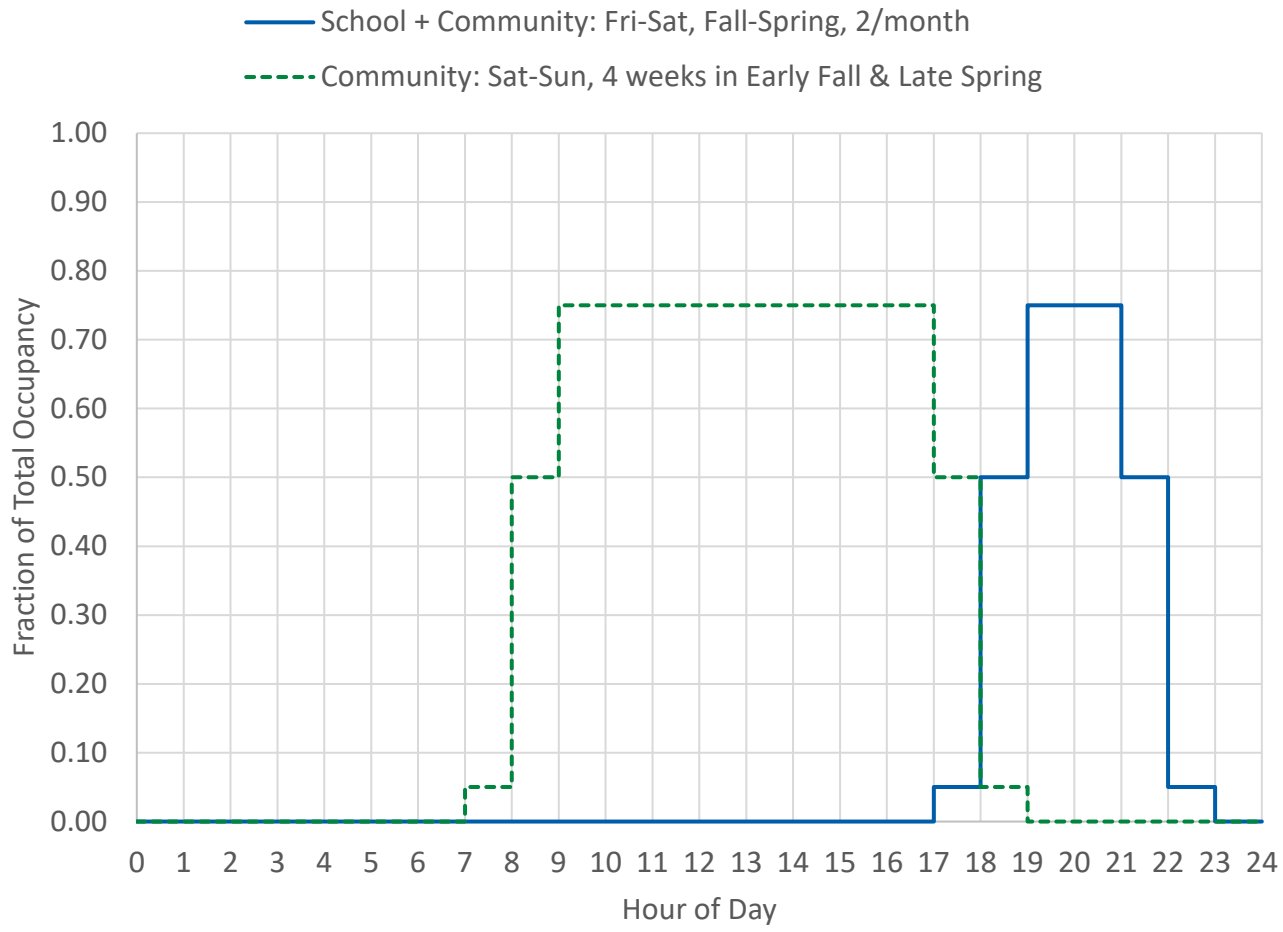
GYM WEEKDAYS: CLASSES AND TEAM GAMES



- Indoor sports are more frequent during winter
- When no games, there is practice until 8 pm

NORESCO

THEATER WEEKENDS



School + Community

- **School**: Drama, Musical, Band, Orchestra, Choir, Graduation.
- **Community**: Org gatherings, Performances.

Community

- Rehearsal, Performances, Academic Competitions, Org Gatherings.

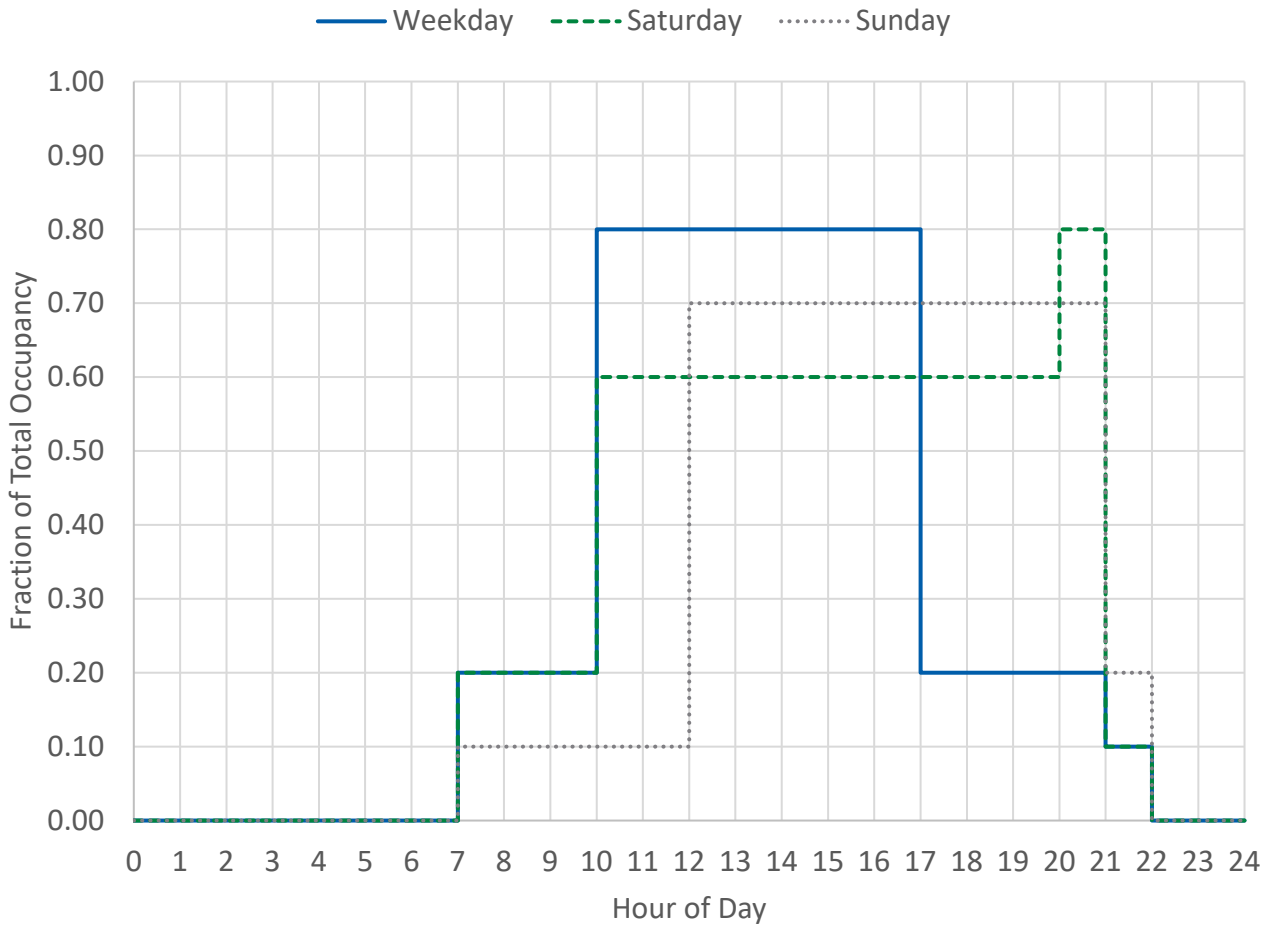
Low weekday use in actual theater

- few class-time students
- some seasonal after-school rehearsal

NORESCO

ASSEMBLY SPACES

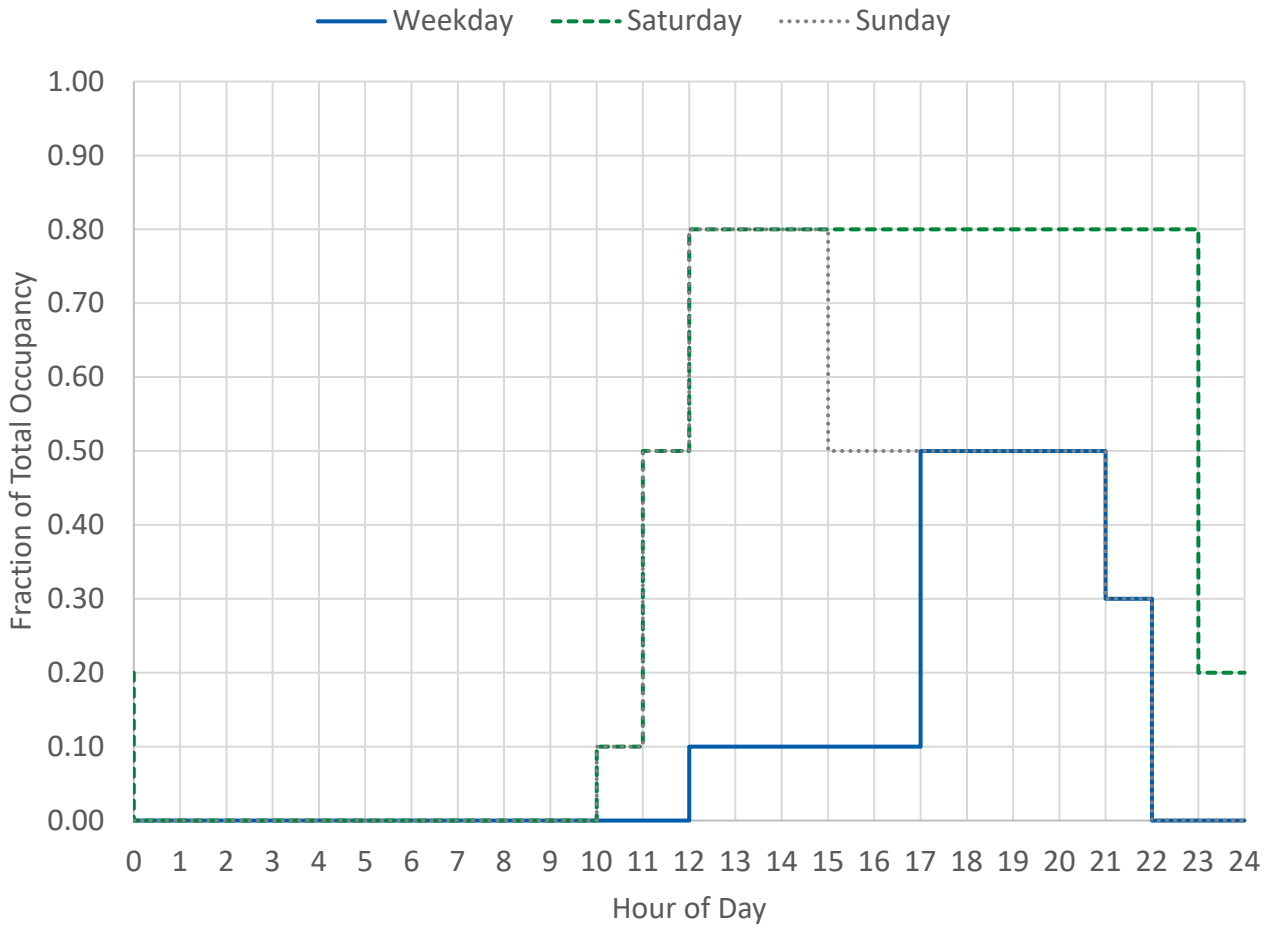
CURRENT OCCUPANCY SCHEDULES – ALL ASSEMBLY SPACES



- Weekdays high load during business hours, lower load before/after
- Weekend high load until late, earlier start on Saturday
- Very generic and not typical for many space types
- Upcoming proposed schedules represent specific assembly spaces and not associated administrative spaces, etc.

NORESCO

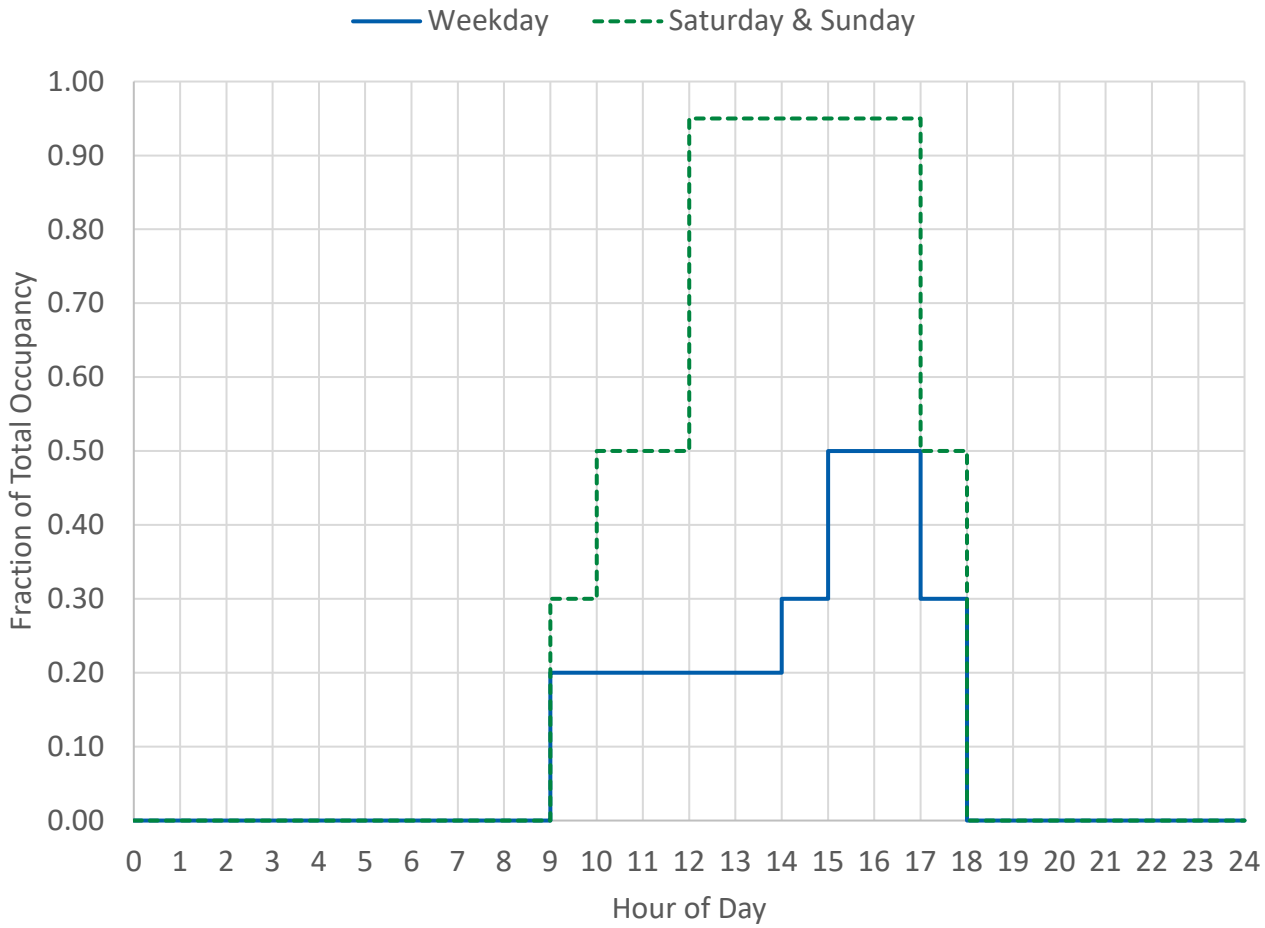
PROPOSED MOTION PICTURE AND LIVE PERFORMANCE SPACES



- Weekdays: low during the day, higher in the evening
- Saturday: highest occupancy lasts all day until later.
- Sunday: highest during day, lowering to weekday level in evening
- Based on research into ticket availability and showtimes

NORESCO

PROPOSED MUSEUMS AND PUBLIC LIBRARY SPACES

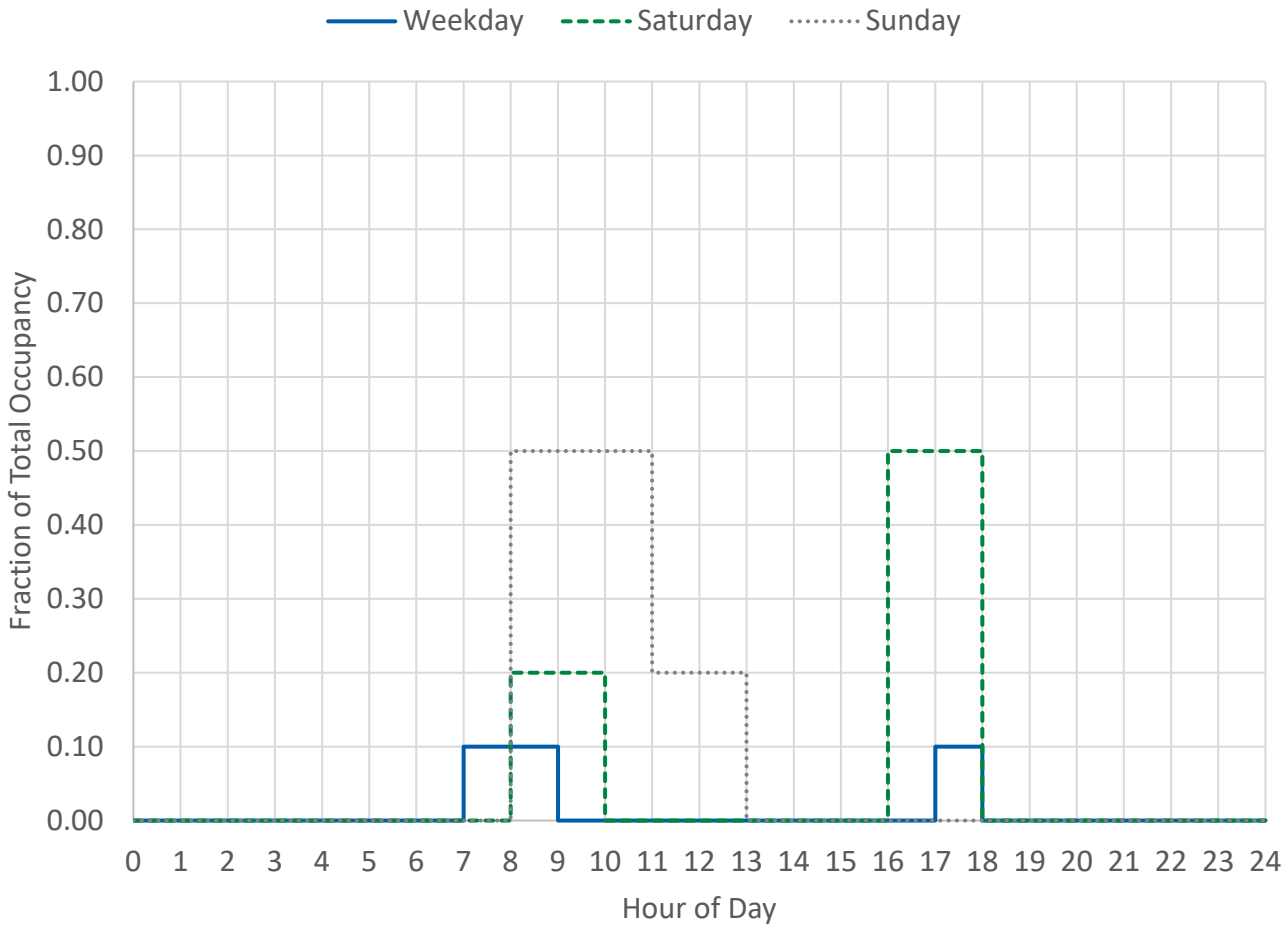


- Weekdays: low, but not empty, peaking in the afternoon
- Saturday & Sunday: peaking in early to late afternoon
- Opening and closing hours based on survey of buildings

NORESCO

PROPOSED RELIGIOUS WORSHIP SPACES

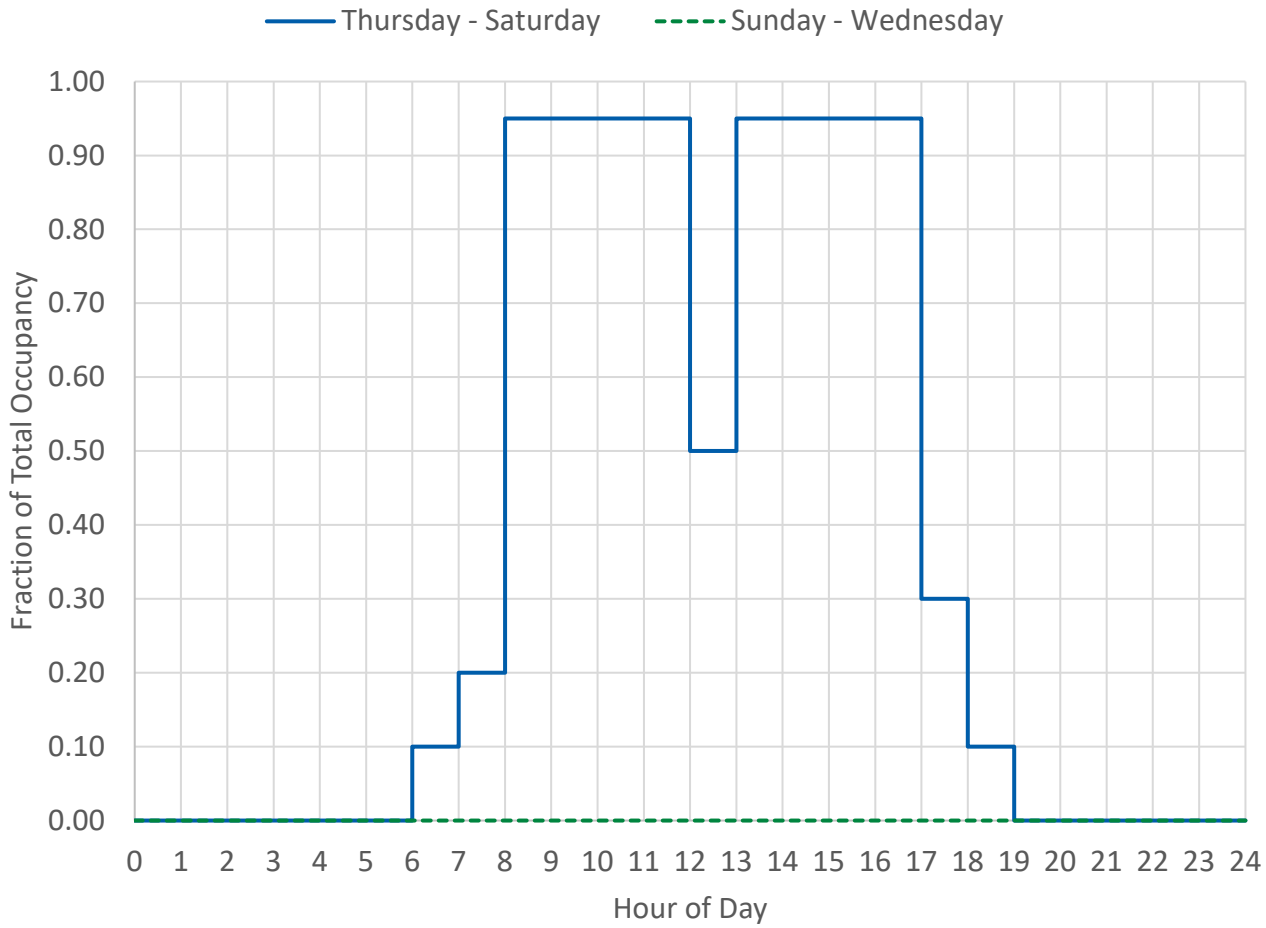
- Weekdays: some morning and evening services
- Saturday: many evening services for a couple of hours
- Sunday: many morning services throughout morning
- Based on the number of worship services offered in an area for a given time period for religions with the highest percentage of California's population.



NORESCO

PROPOSED CONVENTION CENTER SPACES

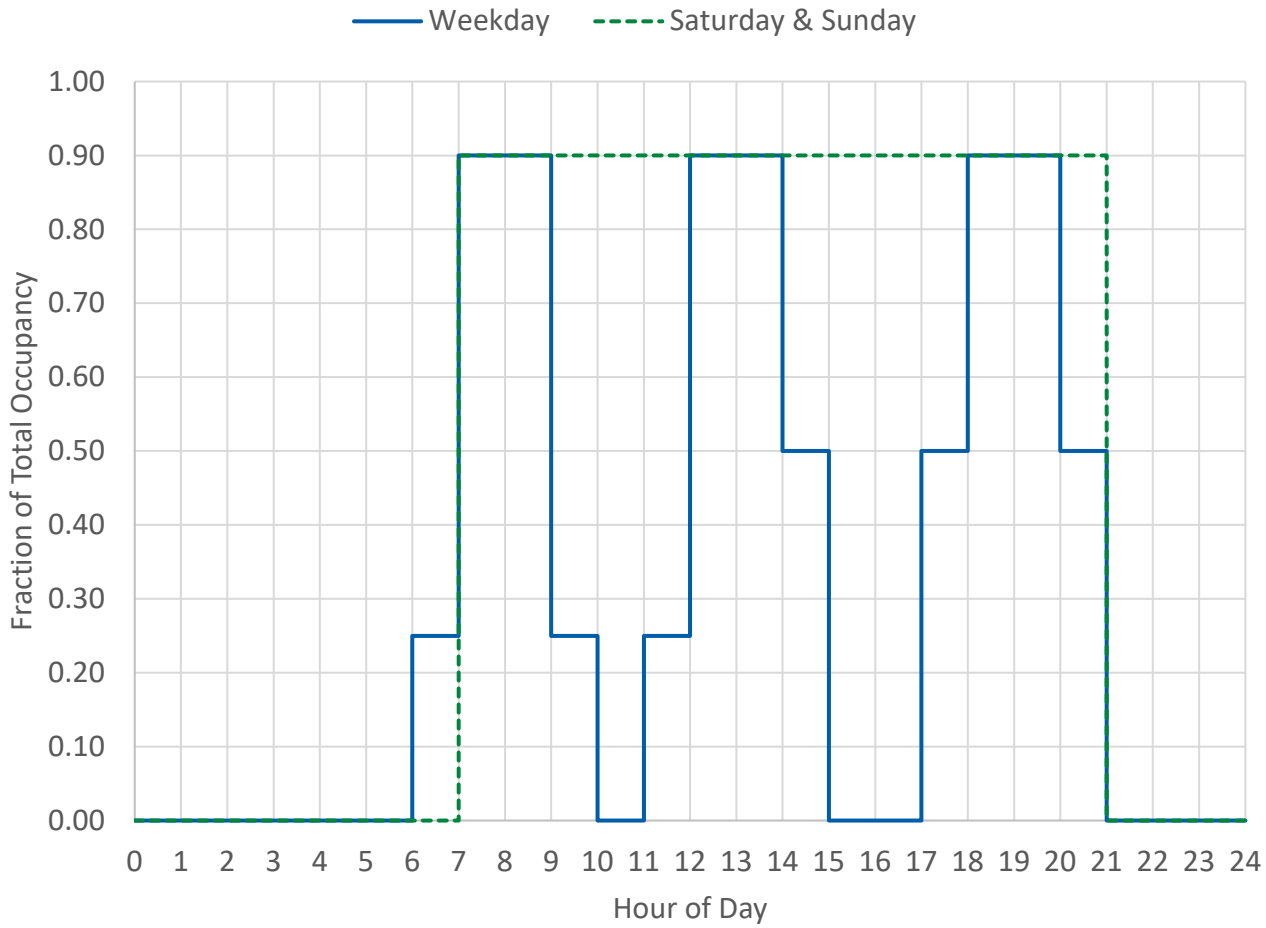
- Two weekday and one weekend day of occupancy.
- Rest of the week is empty
- Based on published event schedules



NORESCO

PROPOSED EXERCISE, FITNESS, AND GYMNASIUM SPACES

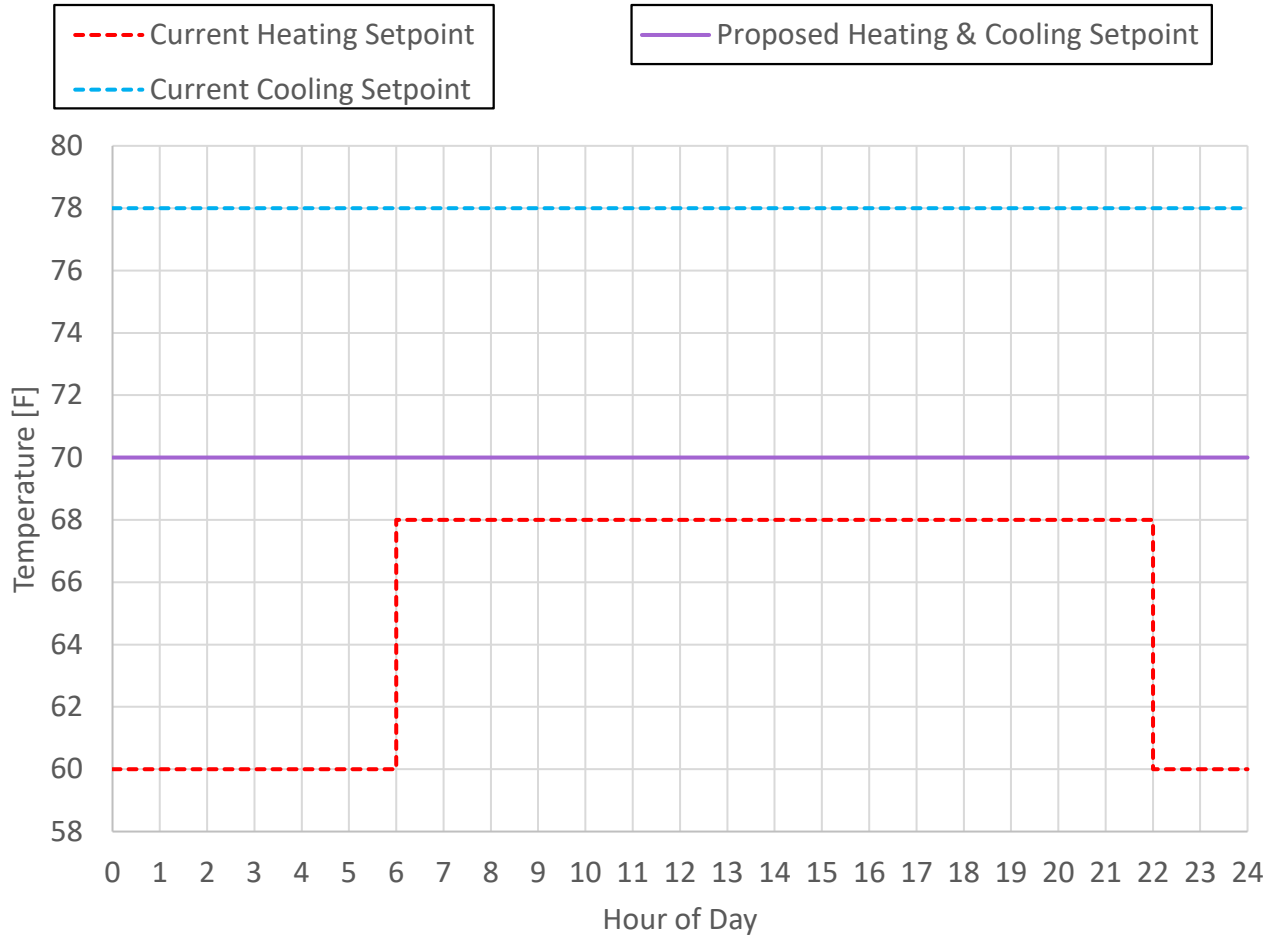
- Weekdays: typically full but with mid-morning and afternoon vacancies
- Weekend: full early morning until night
- Based on PNNL research for COMNET schedule



NORESCO

HOTELS & MOTELS

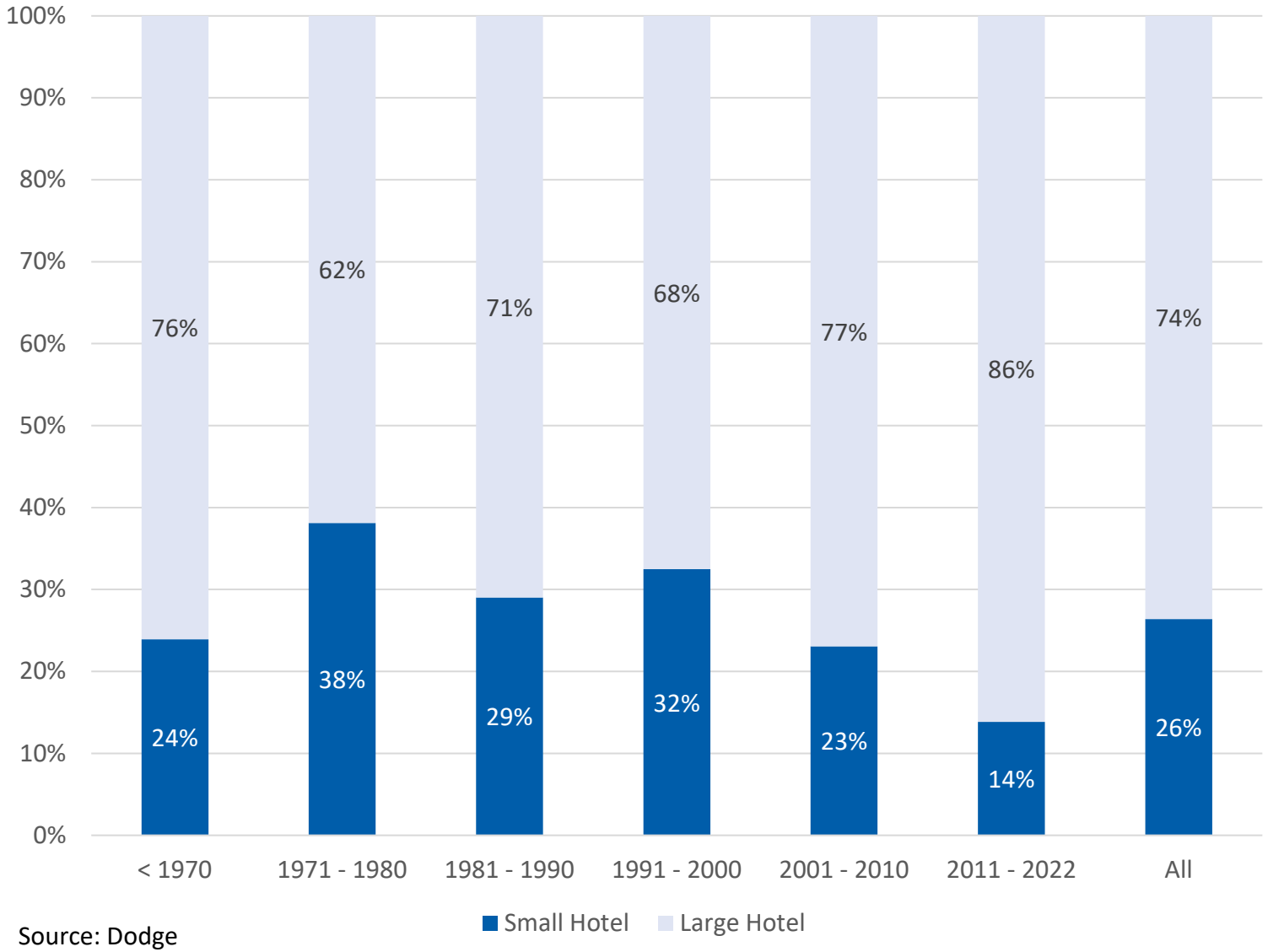
PROPOSED HOTEL THERMOSTAT SETPOINTS



- Current based on residential method: 8 days of prior weather
  - Guests not there for extended periods
- Proposed constant 70°F based on DOE prototype
  - Guests set the comfort, regardless of energy cost, season, in the room, sleeping
- Subject to AB 130 determination

NORESCO

HOTEL STATEWIDE CONSTRUCTION BY SIZE

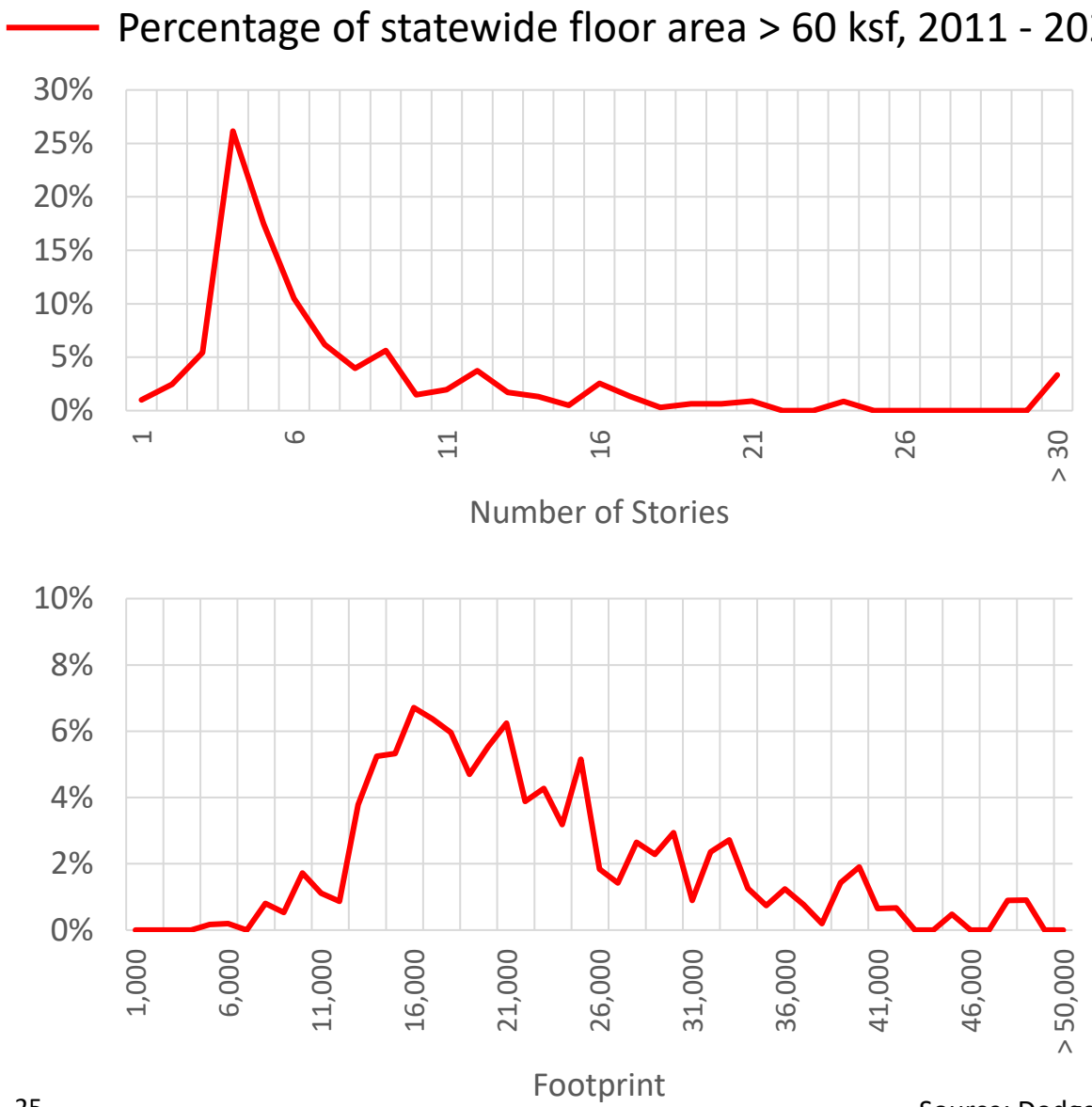


Source: Dodge

- Large Hotels (> 60 ksf) have always been, and remain, a larger portion of the statewide floor area

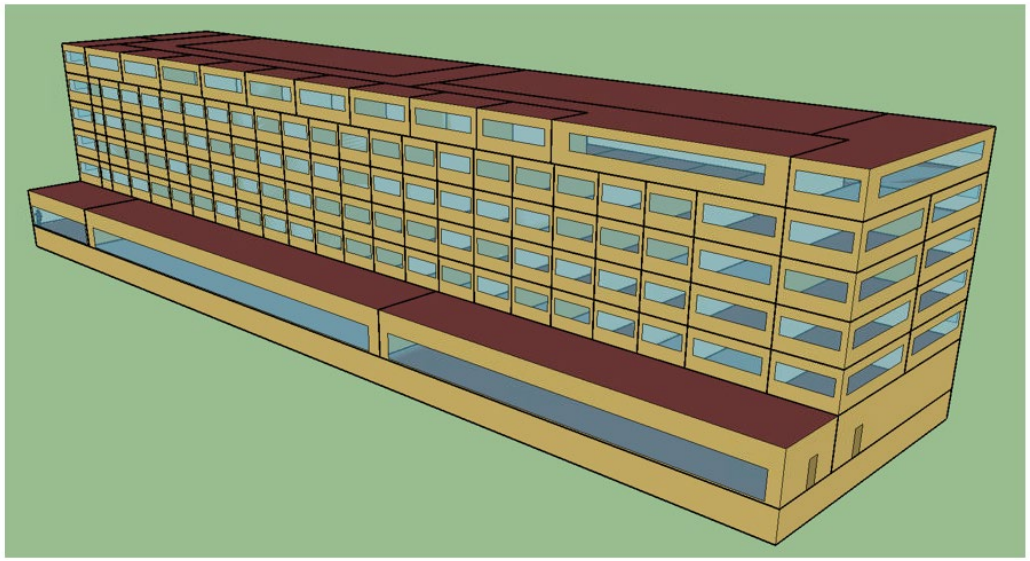
NORESCO

PROPOSED LARGE HOTEL HEIGHT & FOOTPRINT



Source: Dodge

PNNL Large Hotel: 122,132 sf



Source	# of Stories	Footprint [sf]
PNNL Prototype	6	20,400
Dodge 2011 - 2022	8.1	22,500

The PNNL footprint follows recent construction

Proposal: Use the PNNL Prototype

NORESCO


THANKS FOR LISTENING

Plug Loads and Schedules

Proposed Updates for the 2028 Energy Code

Introduction

- Plug loads and schedules are “prescribed” by the Alternative Calculation Method (ACM) as inputs for compliance software
- Plug loads and their schedules of operation are not regulated, but they impact HVAC loads and energy consumption, and sizing and performance of solar photovoltaic and battery storage systems
- Prescribed values for nonresidential buildings have not been updated since the 2013 Energy Code Update

Proposed Updates

- Updates account for advances in equipment technology, and latest available research

- Scope:
  - Plug load updates evaluated for 10 space types
  - Plug load schedule updates for 6 function groups
    - 1 new proposed schedule function group (hotel/motel guest rooms)
  - Refrigeration load updates for 2 space types

Prioritization of Updates

- Schedules:
  - Construction forecast
  - Energy consumption forecast, by building type
  - Analysis to determine which building types accounted for the highest projected statewide plug load energy consumption
- Plug Loads:
  - Frequency Analysis: Analysis of data sources to determine how prevalent space types are across multiple building types
  - Differential Analysis: How much variation is seen between the current EPD values in the Nonresidential and Multifamily ACM (NRMFACM) and other data sources
  - Space type is present in the building types where plug/process loads have the highest statewide impacts

Plug Load Updates

Proposed New Equipment Power Density (EPD) Values, by Space Type

Space Type	Current EPD (W/ft^2)	Proposed EPD (W/ft^2)
Office Area (>250 square feet)	1.5	**0.7**
Office Area (<250 square feet)	1.5	**0.7**
Kitchen/Food Preparation Area	1.5	**1.5** [1]
Retail Sales Area (Grocery Sales)	1.0	**0.4**
Retail Sales Area (Retail Merchandise Sales)	1.0	**0.4**
Retail Sales Area (Fitting Room)	1.0	**0.4**
High-Rise Residential Living Spaces	-	**Reduced by 3.5%** [2]
Hotel/Motel Guest Room	0.5	**0.5** [3]
Classroom, Lecture, Training, Vocational Areas ("Classroom K-8 school") [4]	1.0	**0.8**

1. No change to EPD value, but proposed change to cooking equipment inputs in compliance software
2. Proposed reduction to overall equipment load – will not be implemented due to AB130
3. Proposed to remove "link" to residential equipment load calculations. Change is subject to determination of whether AB 130 applies to these building types
4. Proposed new space type for K-8 school classrooms

Methodology for Plug Load Updates

- "Bottom-up Approach":
  - Estimate the types and quantities of electrical plug load equipment present in each space type
  - Determine power load for each piece of equipment
    - DOE Appliance Efficiency Standards
    - Energy Star equipment database
    - Literature research

$$Space\ EPD = \frac{\sum_i (Load_i \times N_i \times F_i)}{Area}$$

- $Load_i$ is the power load for a single piece of equipment of type i.
- N_i is the quantity of the equipment of type i.
- F_i is the assumed frequency of the equipment of type i, expressed as a fraction of buildings in which the equipment may be present.
- $Area$ is the assumed area for the space type analyzed.

Example for Office Space Type

Equipment Assumptions for Office (<250 square feet)
Note: Analysis assumes office area of 200 square feet.

Equipment	Qty	Frequency	Power Draw (W/unit)	Total Watts
Phones	2	50%	4	4
Computers/ Desktops	1	100%	39	39
Laptops	1	100%	12	12
Printers	1	25%	22	6
Laptop docking station	1	50%	49	25
Screens/monitors	2	100%	25	50
Task lighting	2	100%	2	4
Misc at workstation	2	20%	2.5	1
Total (W)				140
EPD (W/SF)				**0.70**

Full documentation for all space types available in Appendix A of the project report

Schedule Updates

- Updated schedules proposed for 6 function groups:
  - Office
  - Warehouse
  - Restaurant
  - Retail
  - School [1]
  - Assembly [1]

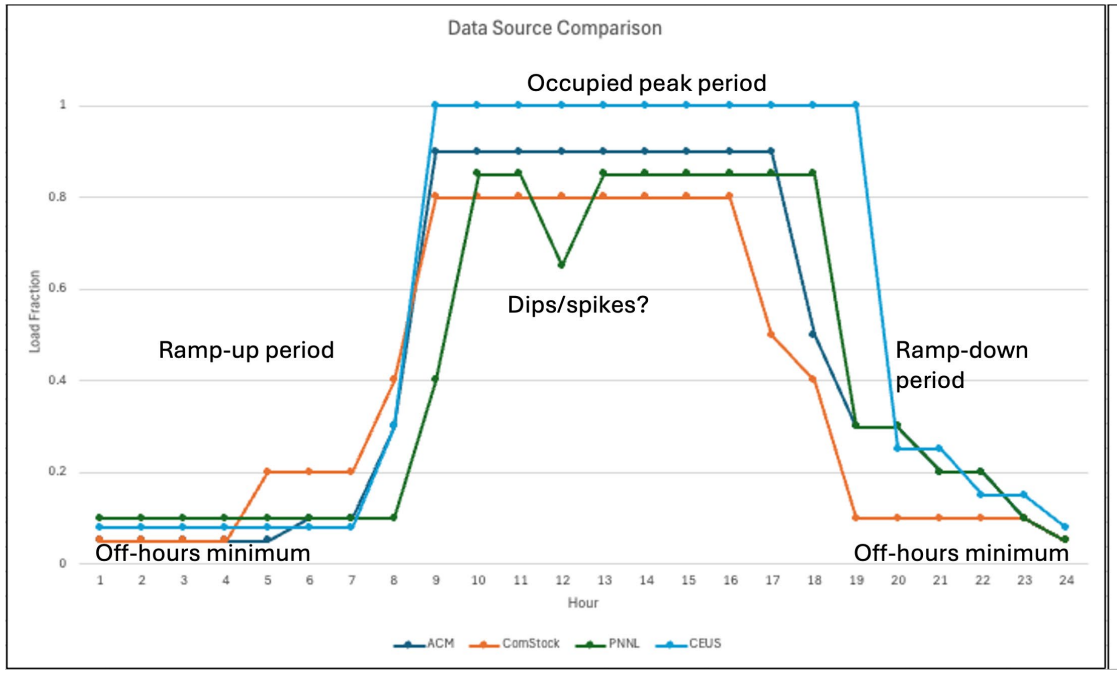
- One new function group is proposed:
  - Hotel Living [2]

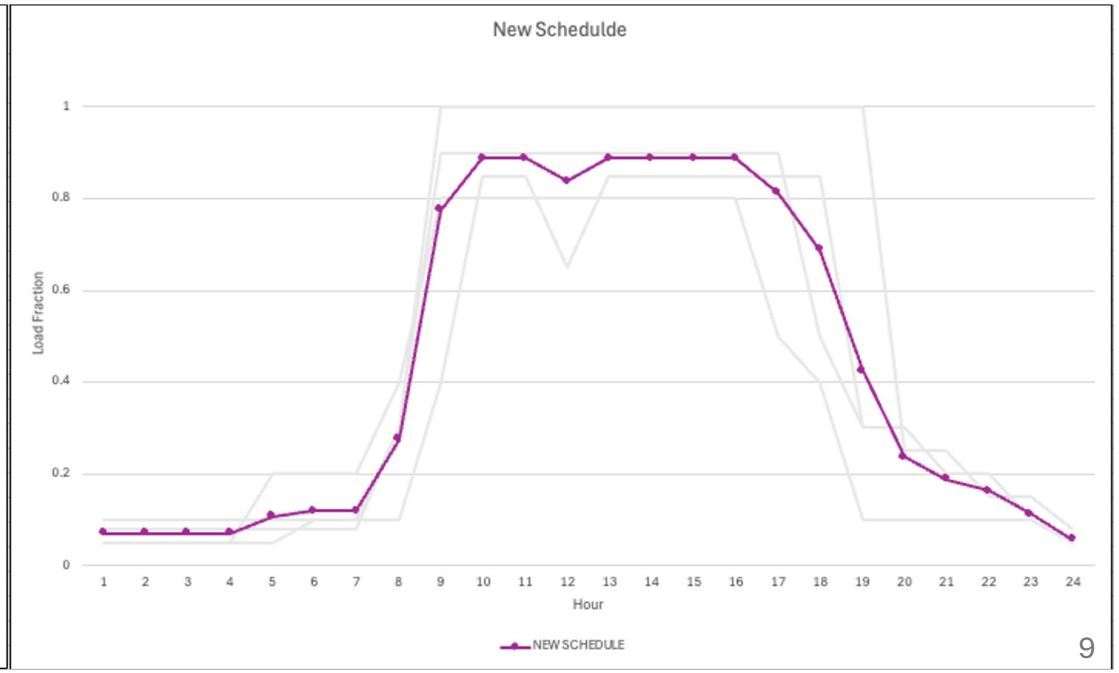
1. Updated as part of a separate project
2. Subject to determination that transient dwellings are outside the scope of AB 130.

Note that Building Energy Model Prototype Updates were discussed earlier in today's agenda. Proposed updates to schedules and EPD to be incorporated into the prototypes.

Methodology for Schedule Updates

- "Comparative Approach":
  - Generate plots of current ACM schedules compared to other available data sources
  - Review schedule segments and identify most representative curves

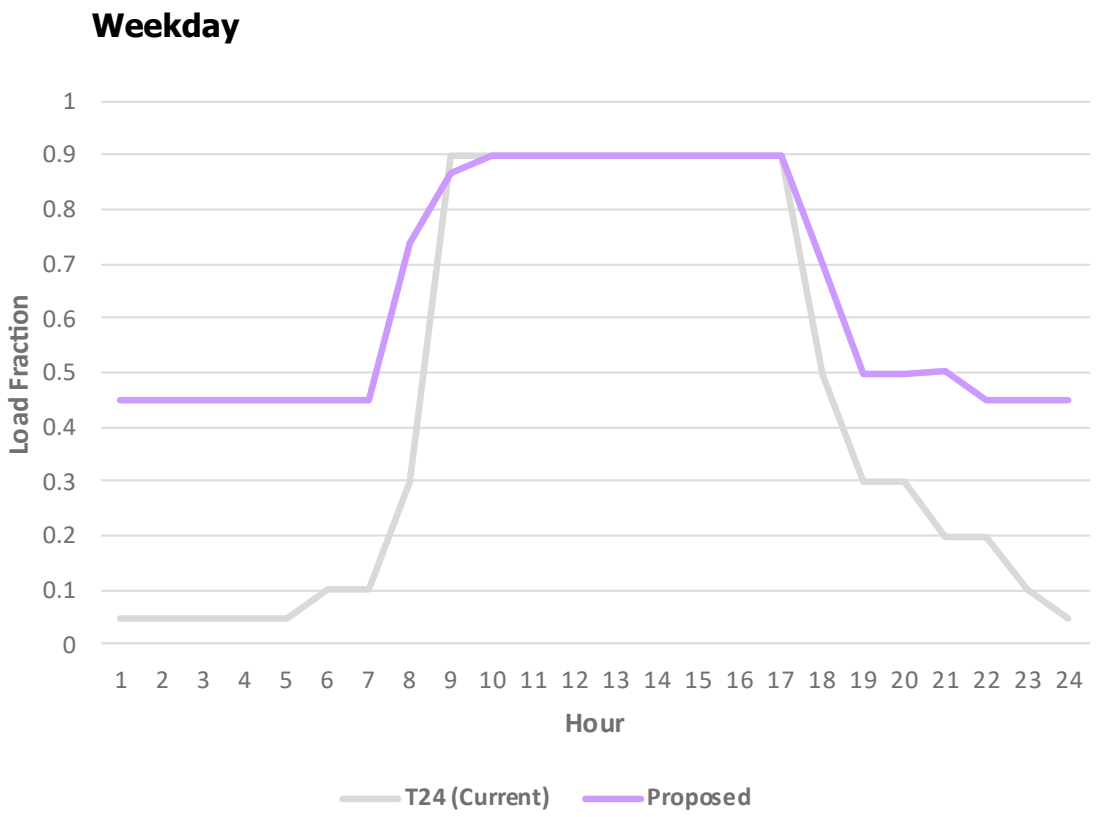




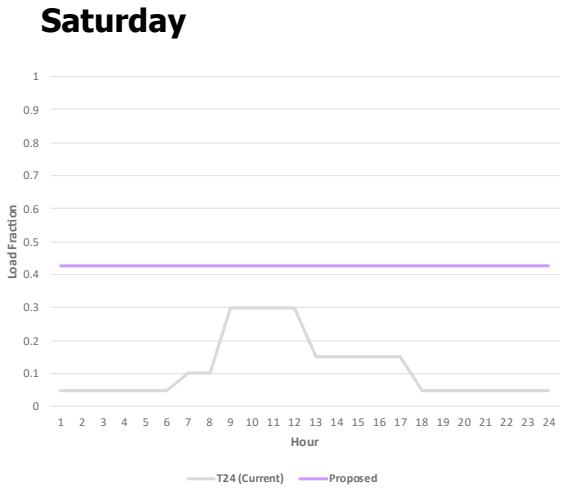
Data Sources

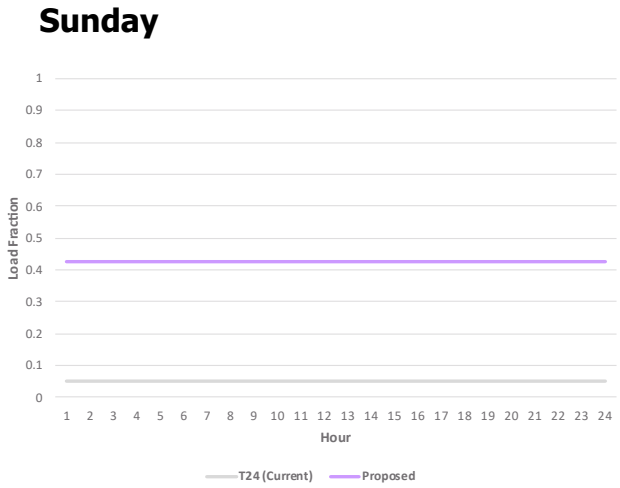
- Analysis included review of several data sources:
  - Current ACM schedules
  - Pacific Northwest National Laboratory Paper on Internal Loads and Load Schedules
  - Commercial Building Sector Stock Model (ComStock)
  - ASHRAE 90.1 Prototype Models and Reference Building Models
  - 2022 California Commercial End-Use Survey (CEUS)
  - Additional building-type-specific data sources

Proposed Update to Office Receptacle Schedule



- Base load fraction increased during unoccupied periods
- Weekend schedules to remain flat at this base load level



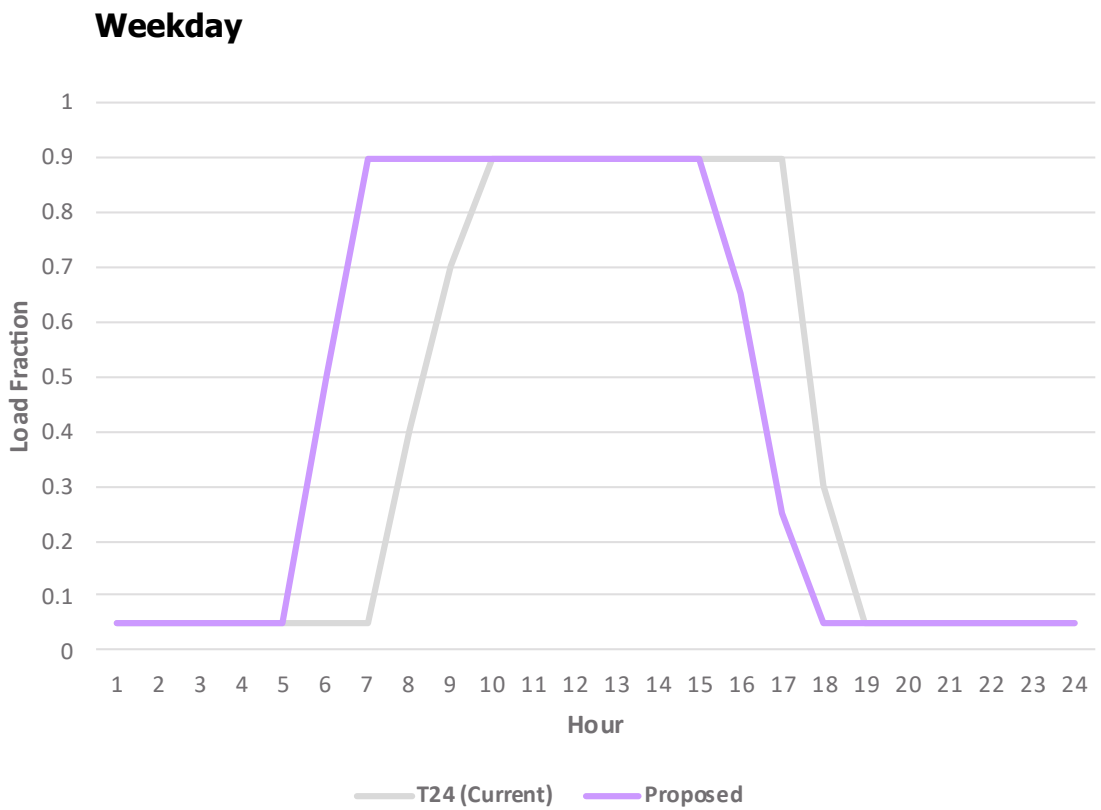


Proposed Update to Office Receptacle Schedule
(continued)

Weekday

- Multiple data sources suggest that base load fraction is higher during unoccupied periods

Proposed Update to Warehouse Receptacle Schedule



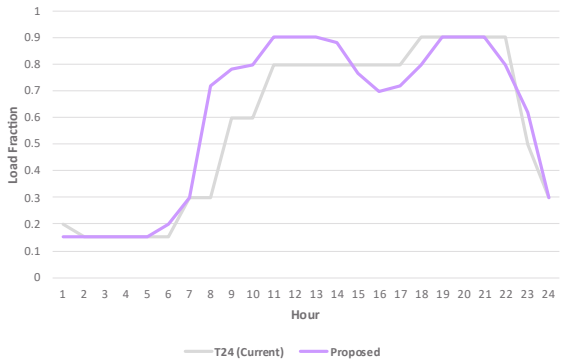
- Building operation shifts to earlier in the day on weekdays
- Weekend schedules to remain unchanged
- According to CEUSS 2022, ~73% of warehouses operate between 4-12 hours per day.
- Note: Other warehouse schedules (e.g. occupancy, lighting, HVAC) will be aligned with the proposed shift in operating hours.

Proposed Update to Restaurant Receptacle Schedule

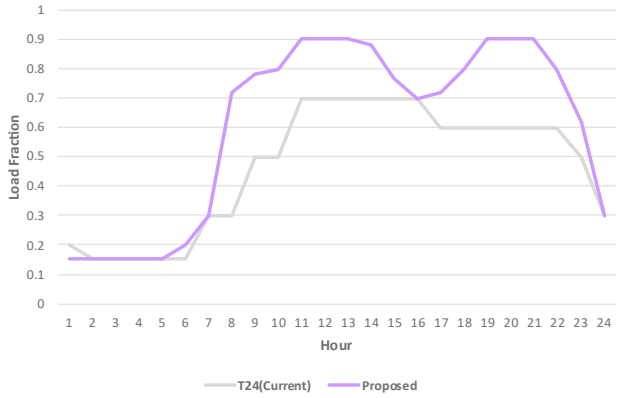
Weekday

- Faster ramp-up period in the morning
- Reduction in equipment use between lunch and dinner
- Consistent schedule for weekday and weekends

Saturday



Sunday



Proposed Update to Retail Receptacle Schedule

Weekday

- Base load fraction increased during unoccupied periods for all days
- Sunday retains reduced hours, but Sunday peak increased to match other days

Saturday

Sunday

Proposed (new) Hotel Living Schedule Group

Weekday

- Developed to differentiate guest room occupancy patterns from residential occupancy
- Consistent schedule proposed for weekdays and weekends
- Note: Other Residential Living schedules (e.g. occupancy, lighting, HVAC) will be aligned with the proposed new Hotel Living schedule function group.
- Proposed edits are subject to AB 130 determination.

Saturday

Sunday

Refrigeration Load Updates

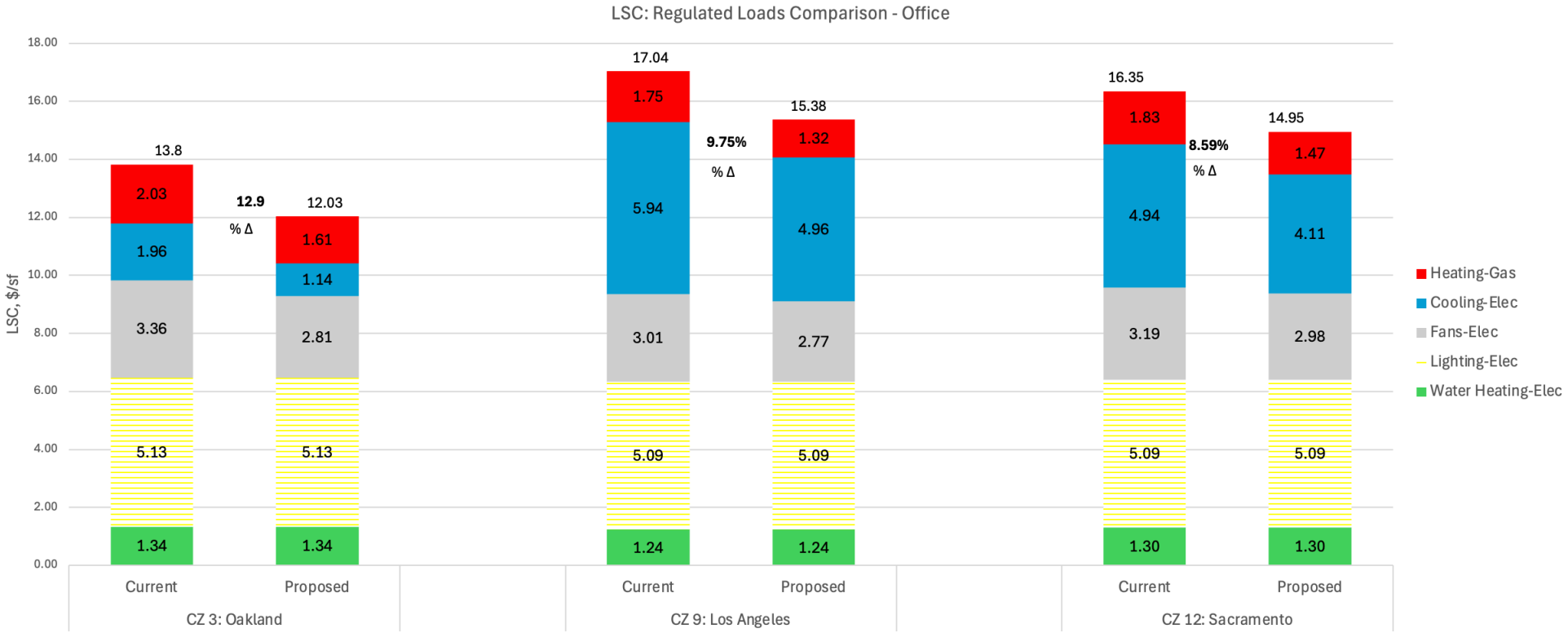
- Grocery Sales Area – Recommended Updates
  - No change to 5.0 W/ft2 refrigeration load
  - In compliance software, allow user to specify a fraction of zone area that contains refrigerators/freezers
  - Allow user to specify fraction of equipment with remote (outdoor) condensers that will not add heat to the space

- Hotel Living
  - Add a 0.12 W/ft2 refrigeration load to account for presence of refrigerator or mini-fridge
  - Load will operate at a constant 0.9 load fraction

Compliance Impacts of Proposed Updates

- Simulation performed on prototype energy models to determine the impacts of the proposed changes
- Most prototypes experienced relatively small changes to total LSC (+/- 1 to 3%)
- The office prototype experienced larger changes – LSC decreased by ~10%

LSC Impacts – Medium Office Prototype



- Heating, cooling, and fan energy and LSC reduced – HVAC measures may contribute less towards compliance
- Lighting and water heating make up larger percentage of LSC – measures will be more impactful

Future Work

- Warehouse – coordinate other schedules to accommodate “shift”
- Hotel Living – coordinate other schedules as needed
- Consider evaluating hospital and laboratory plug loads and schedules with input from subject matter experts

Q&A