2028 Title 24 Lifecycle Cost & Source Energy Metrics

CALBEM 2025

November 18, 2025

Energy+Environmental Economics

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Roadmap

1. **Metrics background & definitions**
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 | Source Energy Factors

Metrics background & principles

Energy+Environmental Economics

Overview of Metrics for California Energy Code

Warren-Alquist Act (1974) 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"

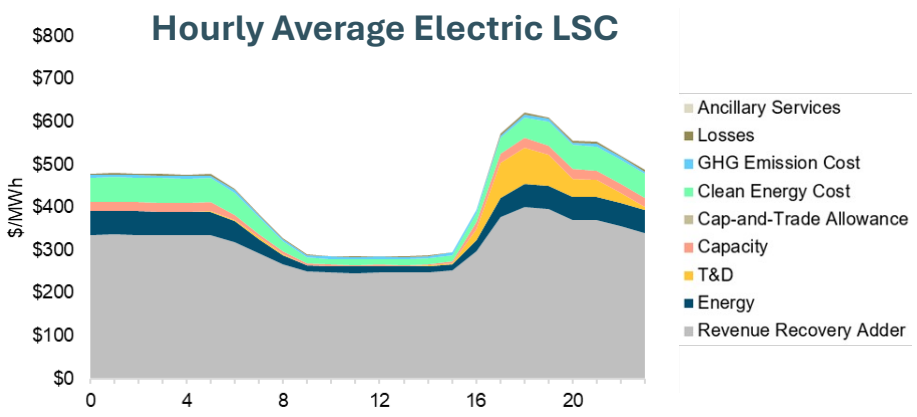
Two Metrics in Energy Code

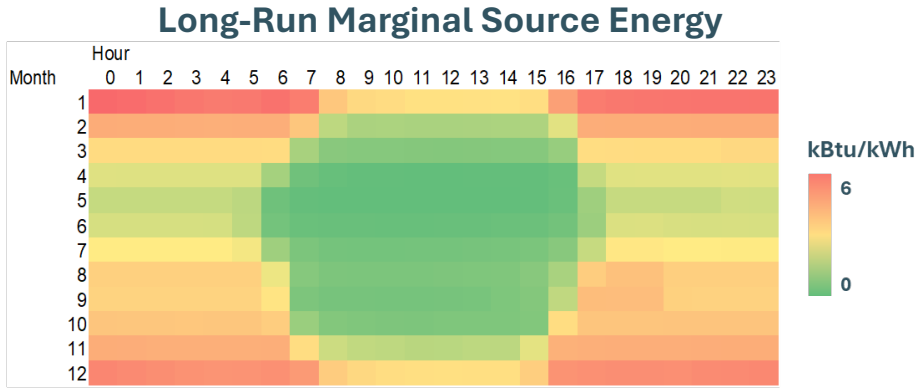
'Long-term System Cost (LSC) Factor' is used to measure cost-effectiveness

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



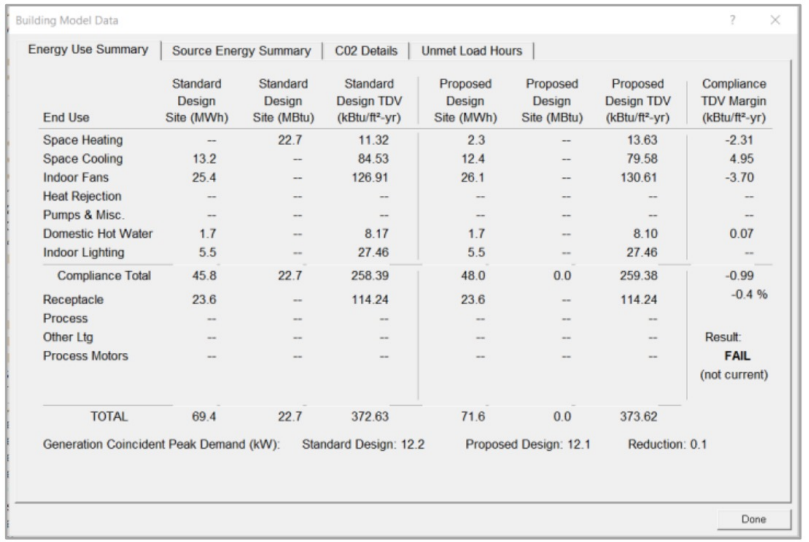


Two Uses of Energy Code Metrics

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

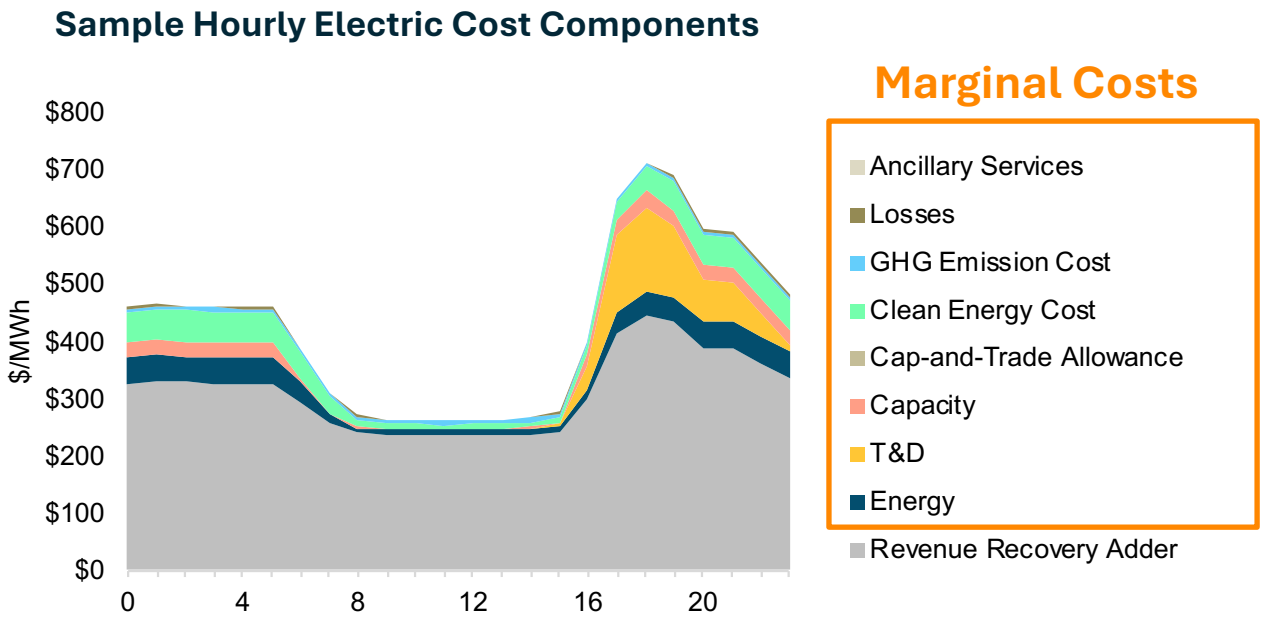
End Use	Standard Design Site (MWh)	Standard Design Site (MBtu)	Standard Design TDV (kBtu/ft²-yr)	Proposed Design Site (MWh)	Proposed Design Site (MBtu)	Proposed Design TDV (kBtu/ft²-yr)	Compliance TDV Margin (kBtu/ft²-yr)
Space Heating	--	22.7	11.32	2.3	--	13.63	-2.31
Space Cooling	13.2	--	84.53	12.4	--	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

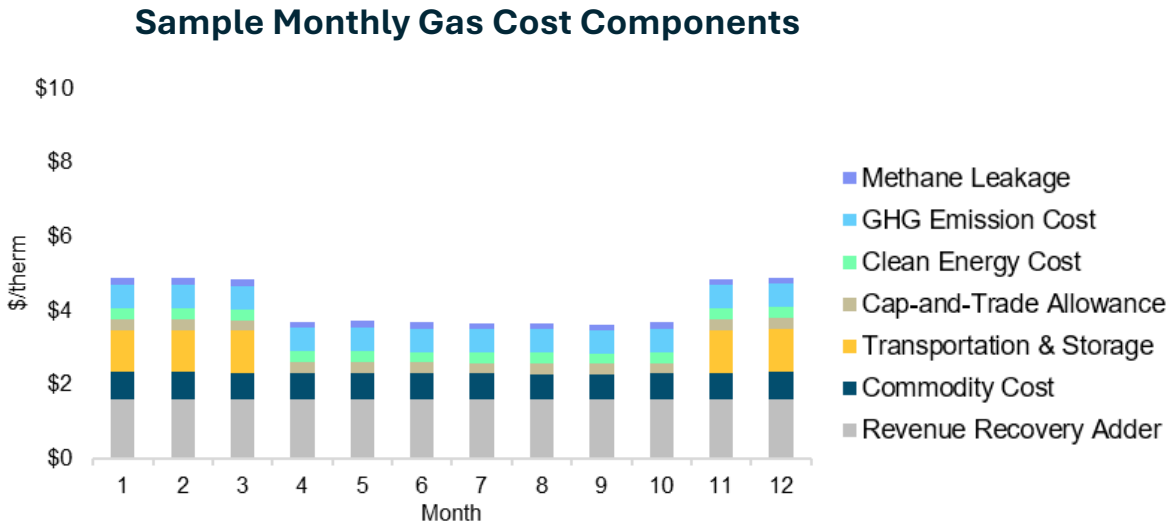
Magnitude and shape of Electric LSC is driven by many cost components

- **Marginal Costs:** Costs that change when electricity use increases or decreases
- **Revenue Recovery Adder:** This component ensures that the total projected revenue requirement components match the average retail electricity rate.



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.
- **Revenue Recovery Adder:** Ensures that the total projected revenue requirement components match the average retail gas rate.



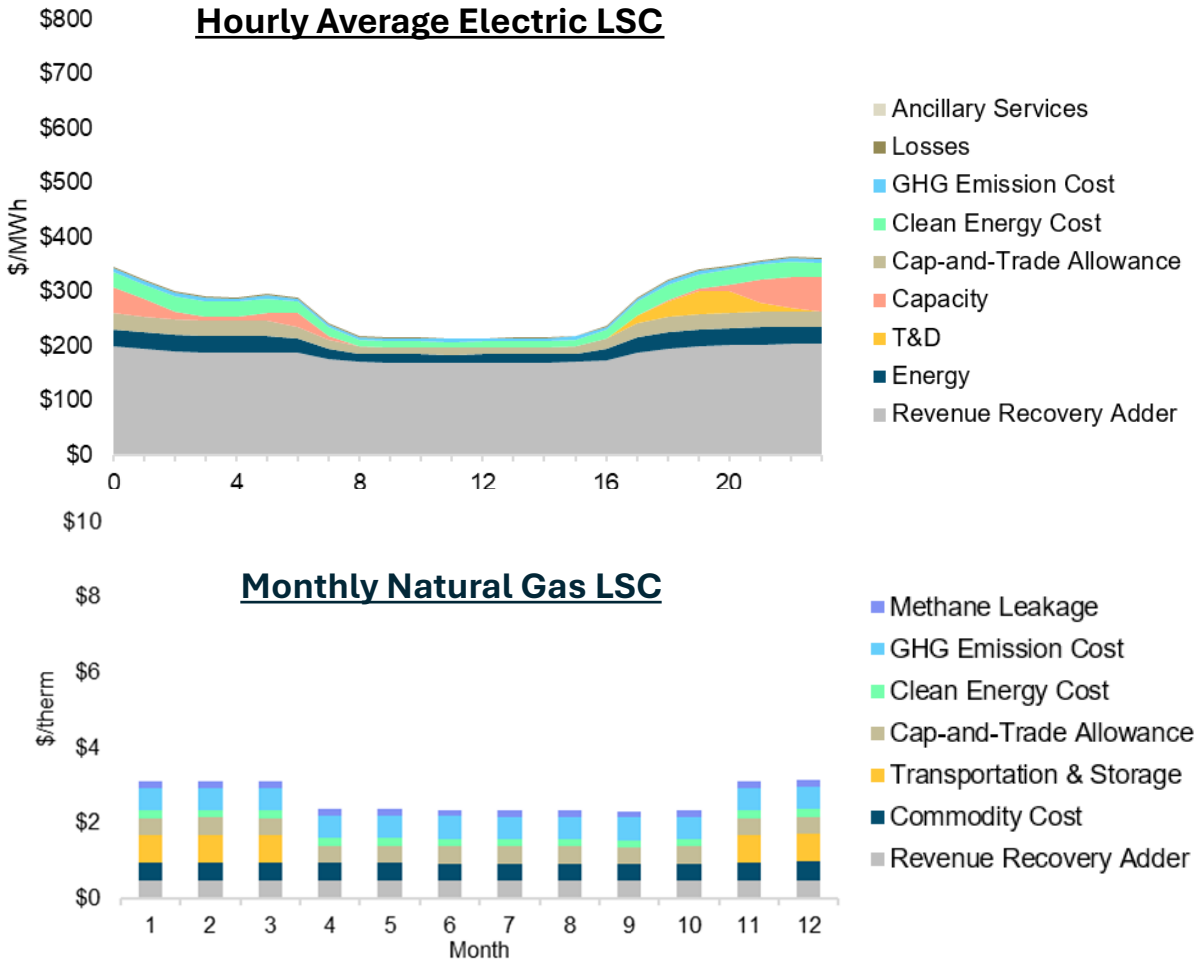
Assembly Bill 130 Signed June 2025

Important News

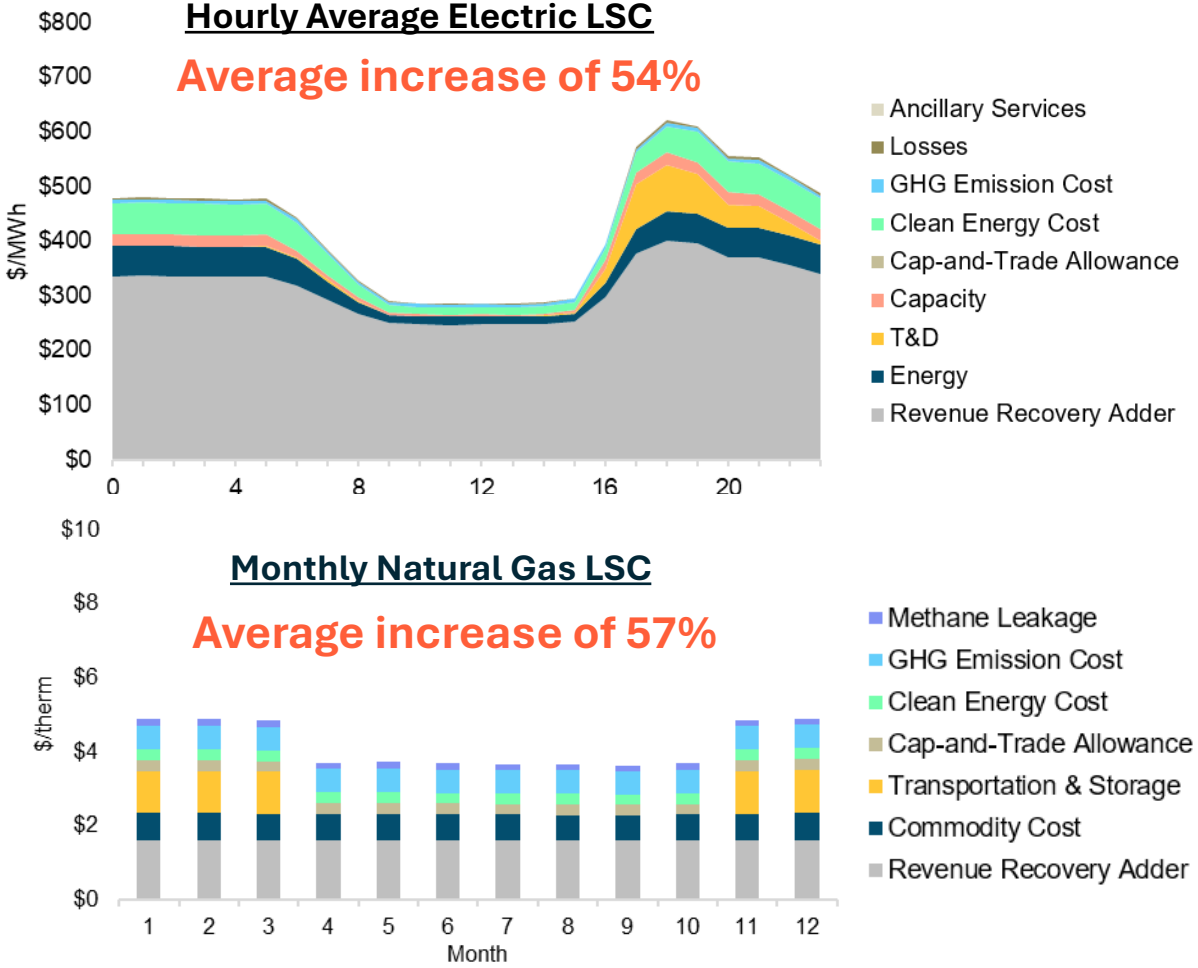
- Forthcoming 2028 update to the LSC and source energy methodology will ONLY apply to nonresidential building types
- Residential buildings will continue to be evaluated using the LSC, source energy metrics and weather profiles from the 2025 code cycle

High Level LSC Results – Comparison to 2025 LSC Factors

2025 LSC Factors
Example from CZ9, Average by hour



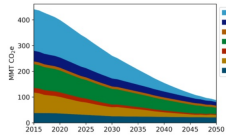
2028 LSC Factors
Example from CZ9, Average by hour



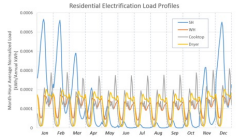
Modeling overview & major updates in 2028 cycle

Development of 2028 electric metrics

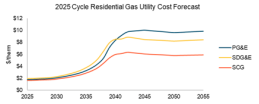
Inputs



Demand Scenario Selection

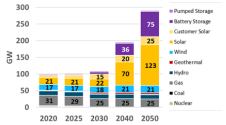


Hourly Load & Renewable Shaping

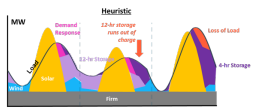


Retail Rate Forecast

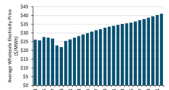
Electric System Modeling



Capacity Expansion Modeling



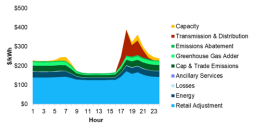
Reliability Modeling



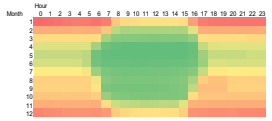
Production Cost Simulation

T&D Modeling

Outputs



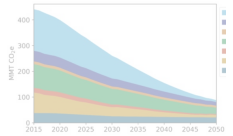
Long-term System Costs



Hourly Source Energy

Development of 2028 electric metrics

Inputs



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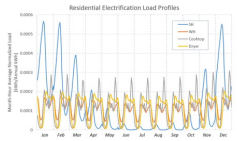
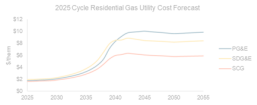


Hourly Load & Renewable Shaping

New weather files
New EV shapes



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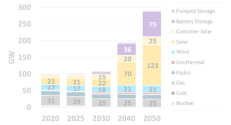

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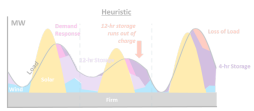
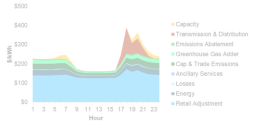


Reliability Modeling

Production Cost Simulation

T&D Modeling

Outputs



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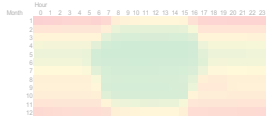
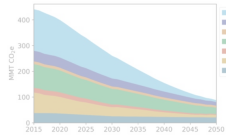


Hourly Source Energy

Development of 2028 electric metrics

Inputs



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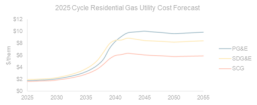

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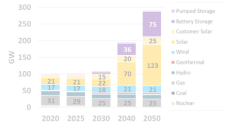

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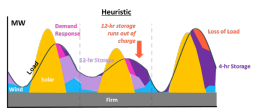


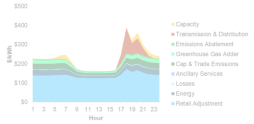
Reliability Modeling

New definition of critical hours

Production Cost Simulation

T&D Modeling

Outputs



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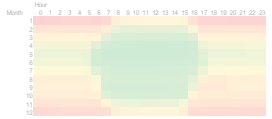


Hourly Source Energy

Evolving metrics in the changing grid

Energy+Environmental Economics

Long-term forecast behind the 2028 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

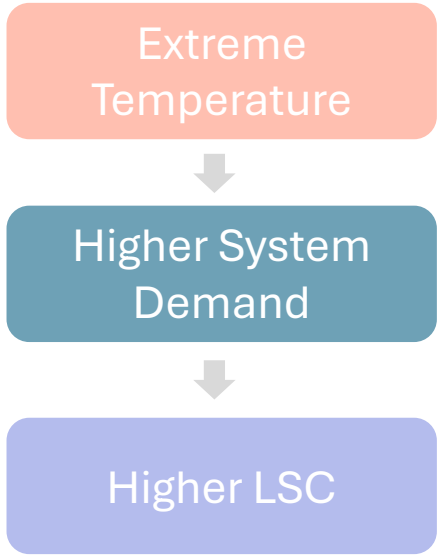
Energy Infrastructure

- 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)

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

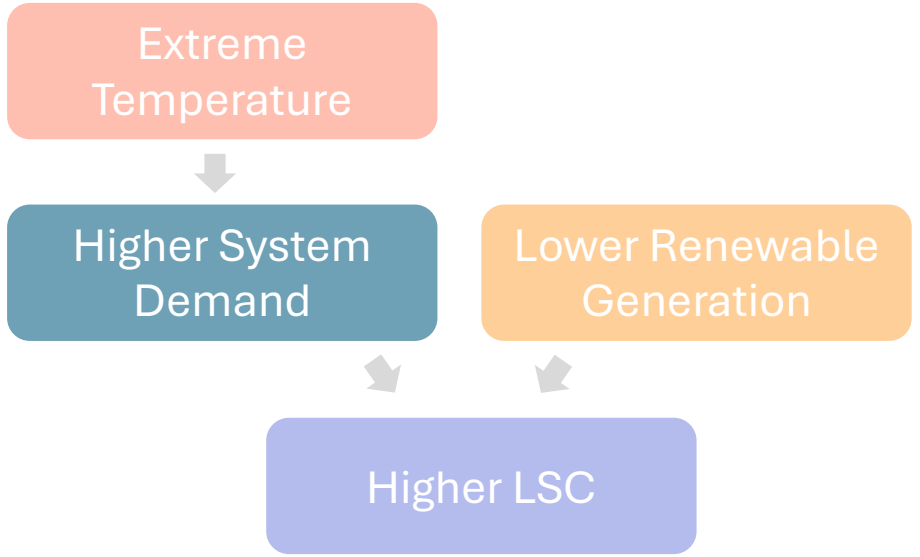
Traditional

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



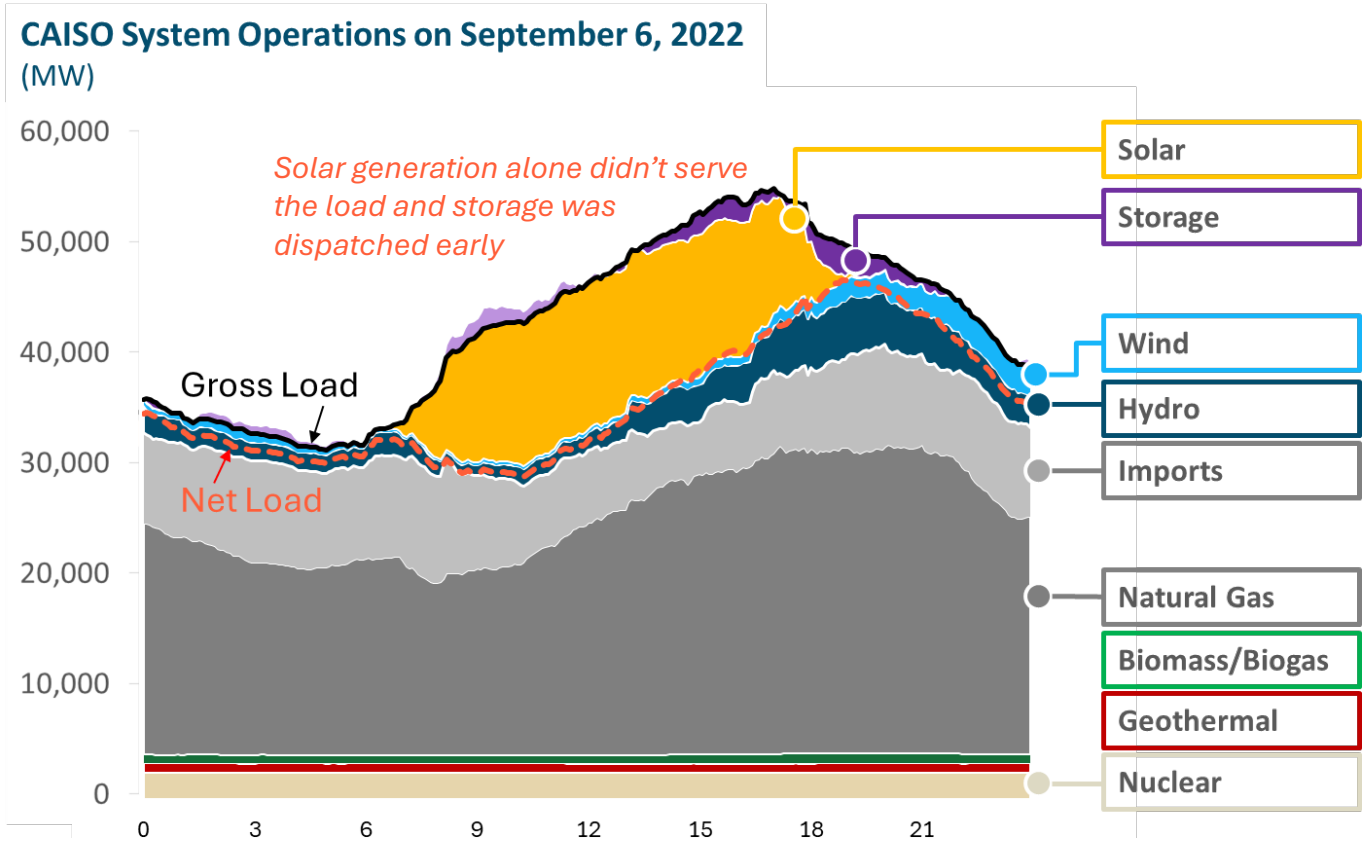
High Renewable Penetration

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



Real life example

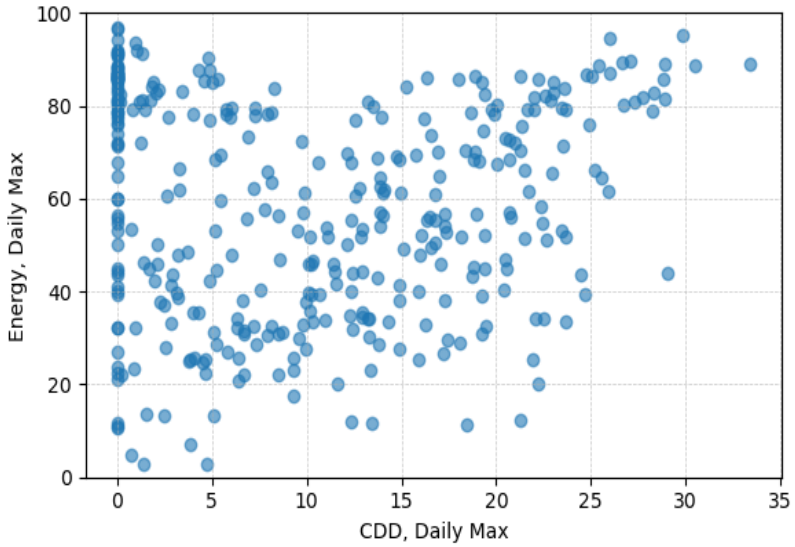
- Net load = Total System Demand – Renewable Generation
- On September 6, 2022, CAISO issued a Flex Alert to request energy conservation
- While the total system demand (gross load) peaked at 5PM, the grid is the most constrained at 7PM, when net load was the highest



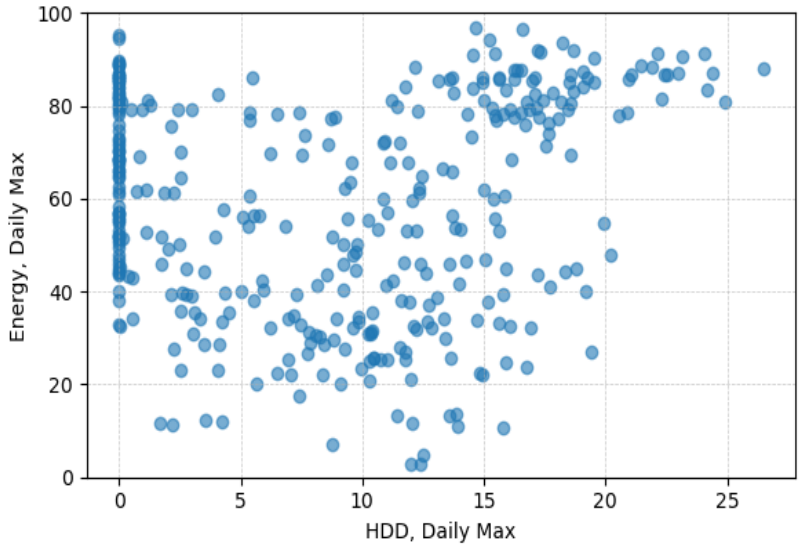
Certain LSC components are more correlated to net load than temperature

- 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

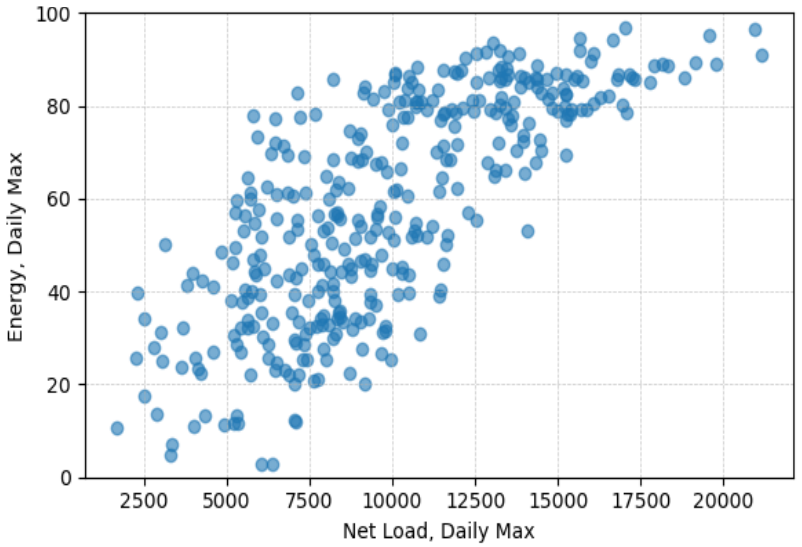
CZ9 Energy vs Daily Max CDD



CZ9 Energy vs Daily Max HDD



CZ9 Energy vs Daily Max Net Load

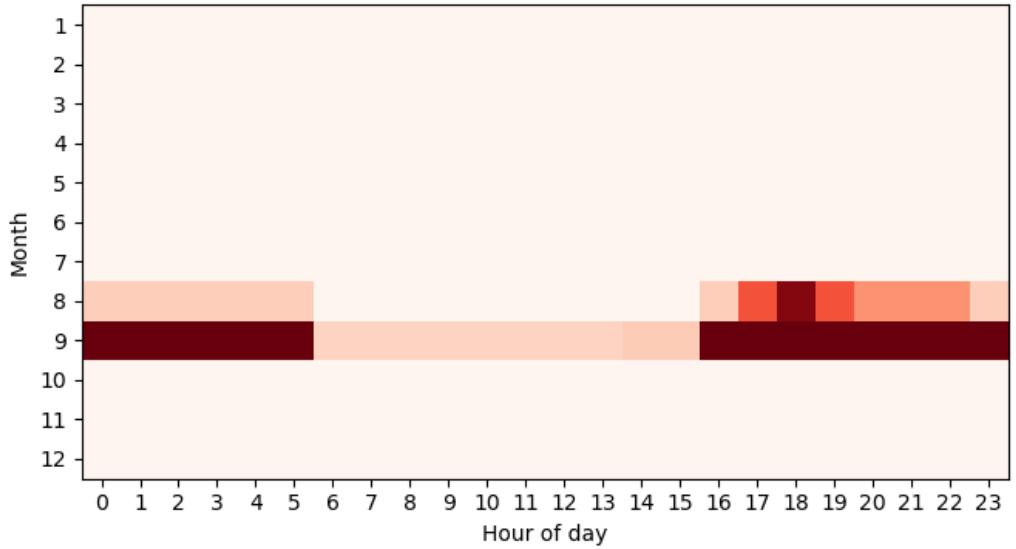


Decarbonization will eventually shift timing of critical hours into winter months

+ **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**

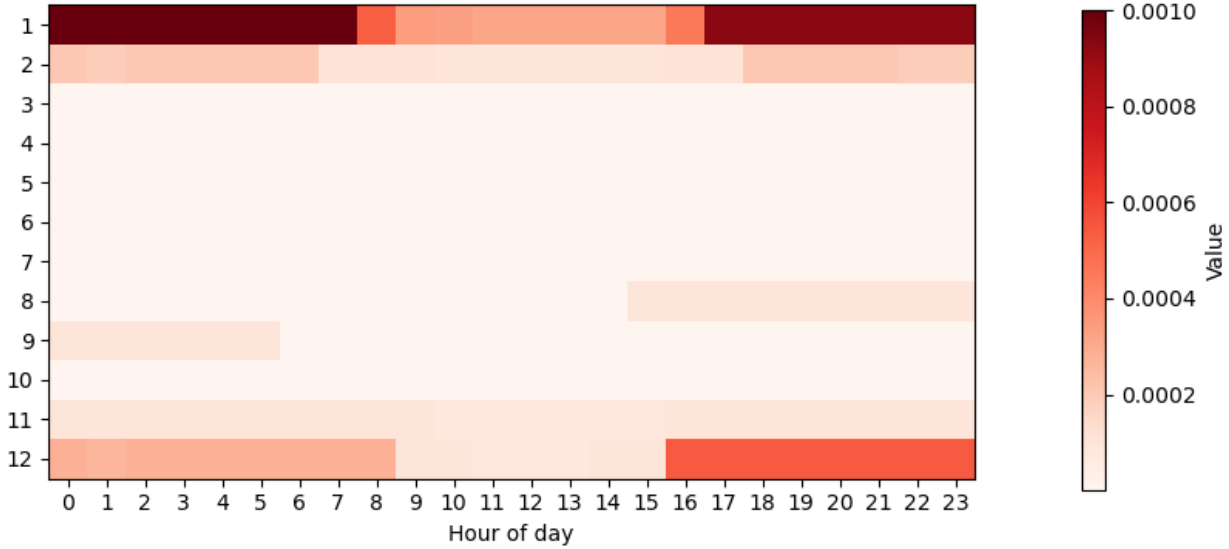
2029

Month-hour averages of critical hours



2045

Month-hour averages of critical hours

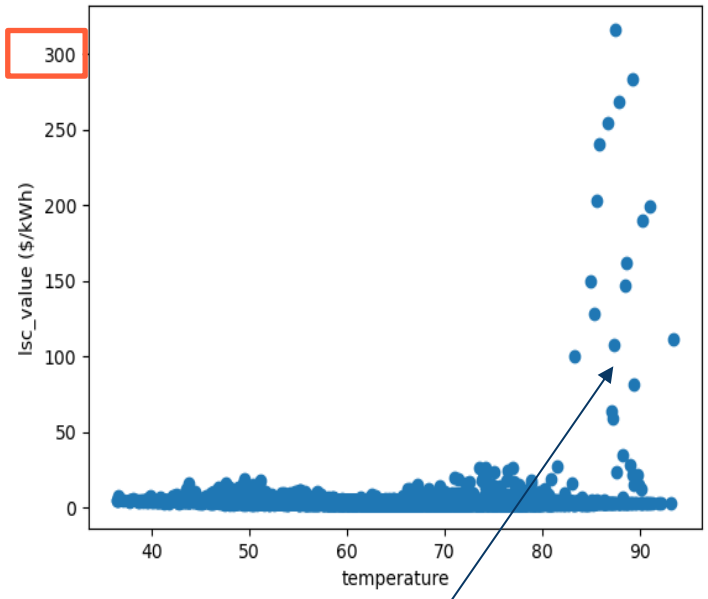


The color scale represents the portion of generation capacity cost allocated to each month-hour block

Latest LSCs reflect a “U” shape in relation to temperature

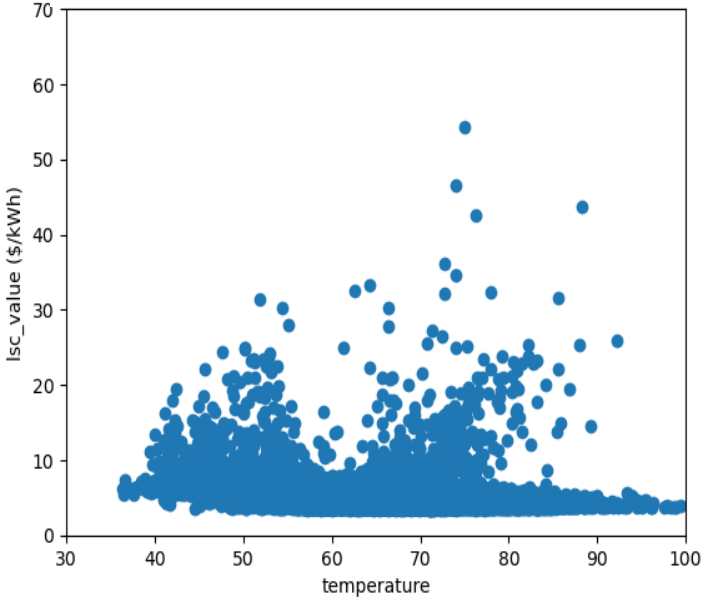
2022

CZ9 LSC Values vs Temperature



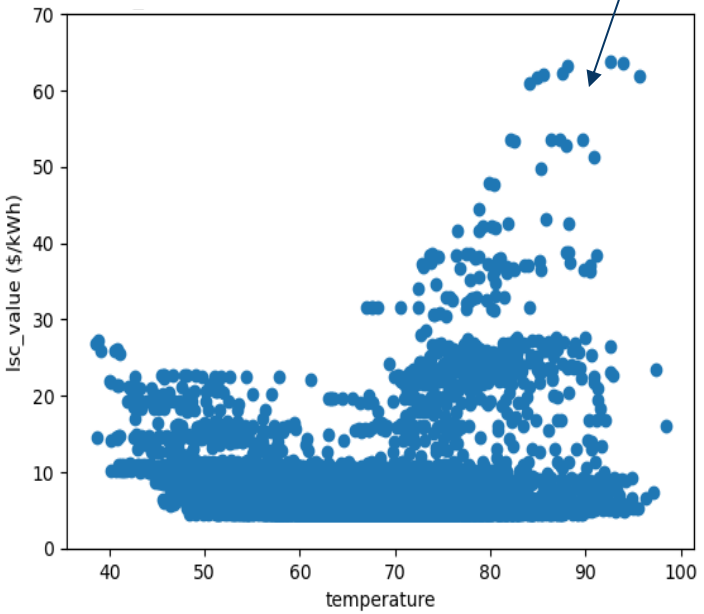
2025

CZ9 LSC Values vs Temperature



2028

CZ9 LSC Values vs Temperature



Latest LSCs are flatter, reflecting high storage penetration

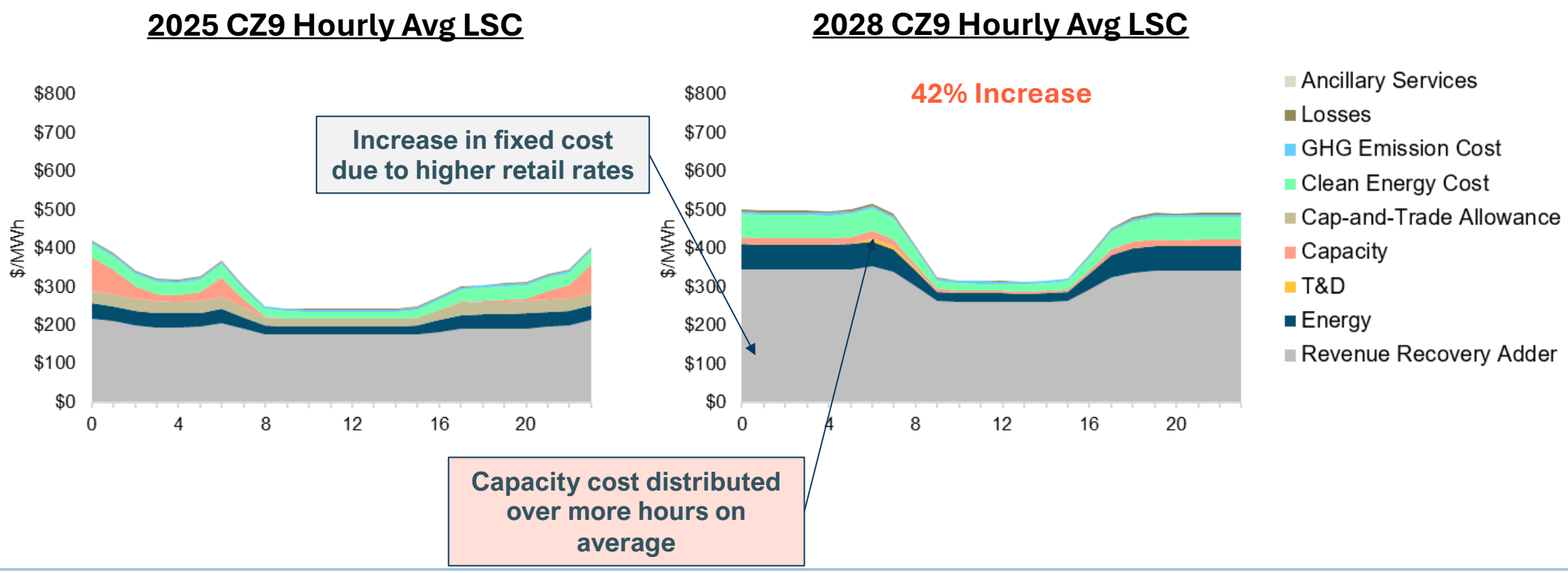
2022 LSC were extremely peaky in summer

2028 code cycle metrics results

Energy+Environmental Economics

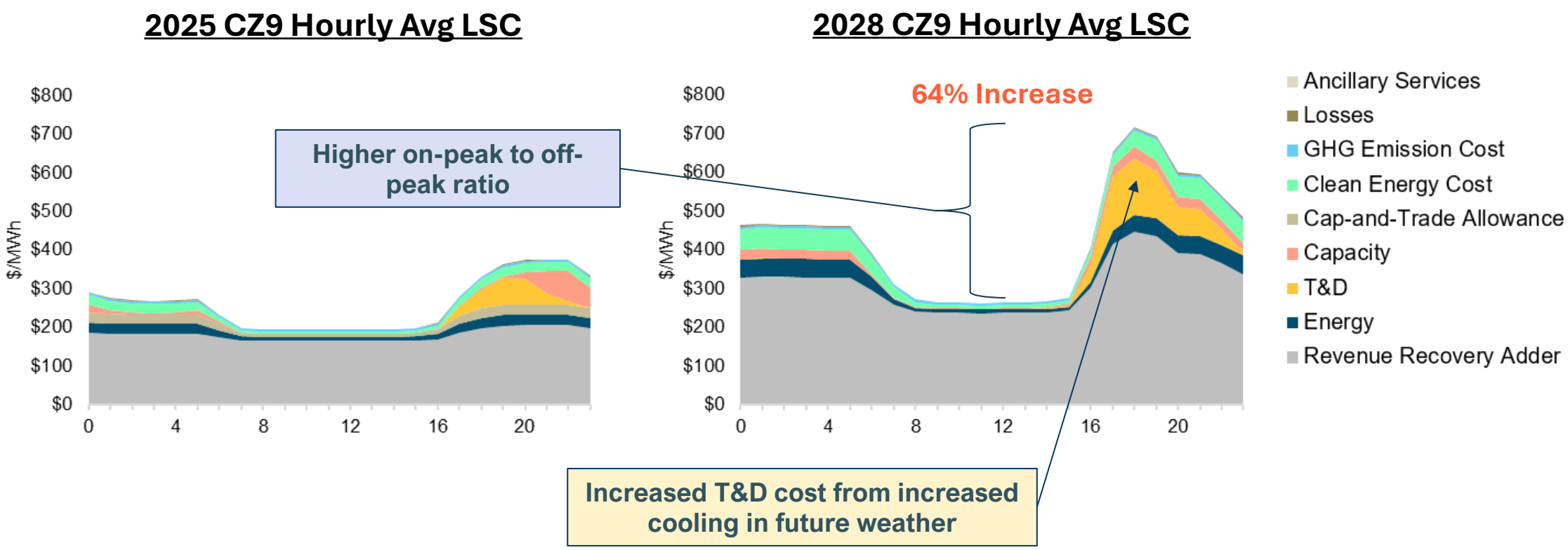
Winter Electricity LSC

Winter electric factors are **35-53% higher** than 2025 cycle, mainly due to increases in fixed costs & clean energy costs

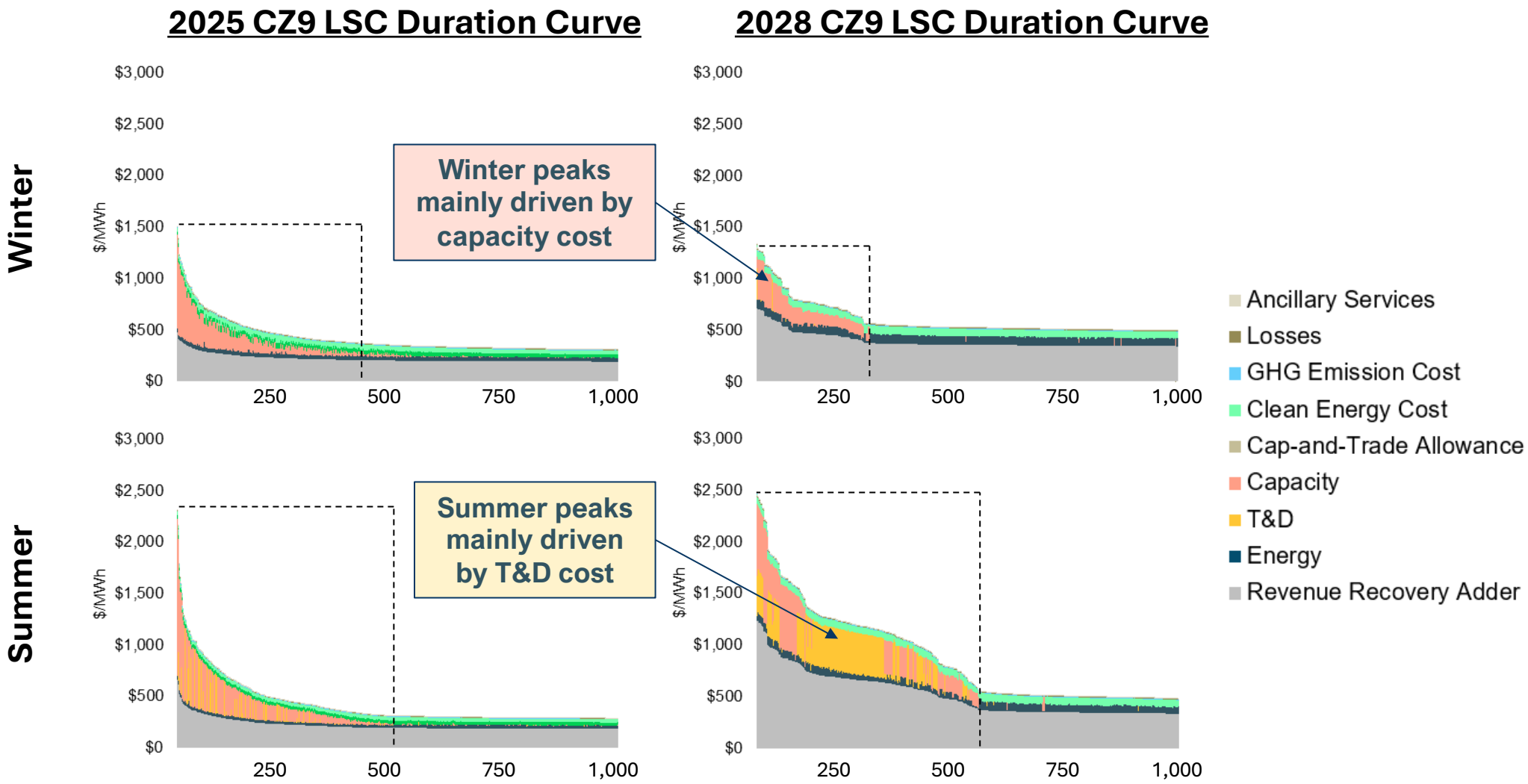


Summer Electricity LSC

Summer electric factors are **57-71% higher** than 2025 cycle, mainly due to increases in fixed costs, clean energy costs, and impacts of future weather

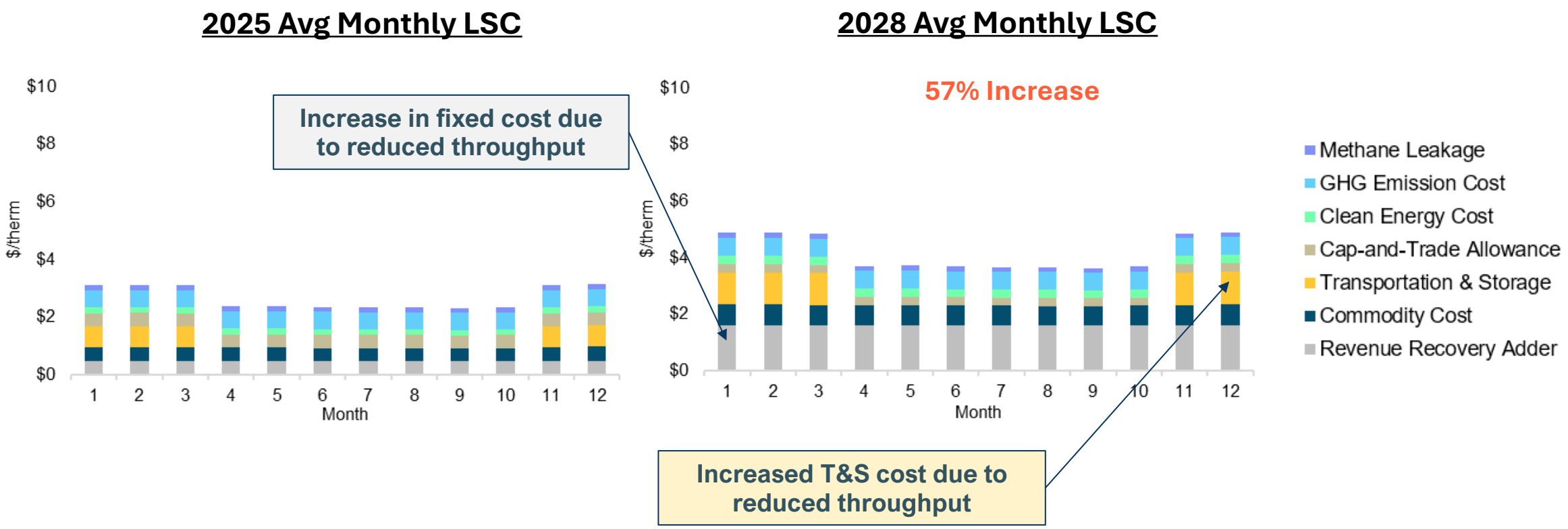


Peaks in electric LSC may create opportunities for load flexibility



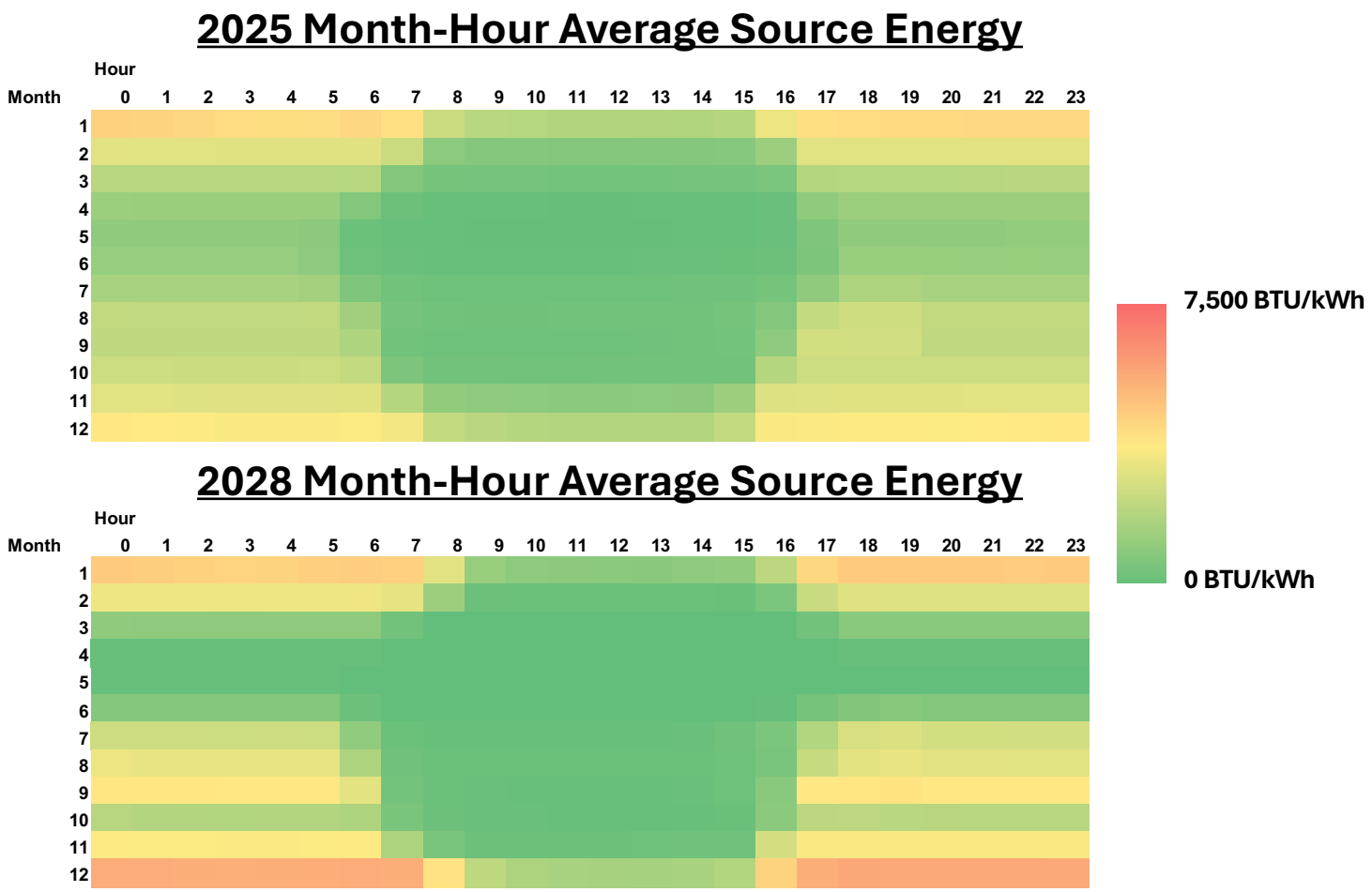
Natural Gas LSC

Natural gas LSC factors are ~55% than 2025 cycle, mainly due to increases in revenue recovery adder and transportation and storage costs



Electric Source Energy

- Daytime hours: LOWER than 2025 cycle, due to more years with high renewable penetration
- Winter and Summer nighttime hours: HIGHER than 2025 cycle due to more accurate evaluation of marginal units



Summary

1

As California builds more renewable energy and storage, the Energy Code electric Long-Term System Cost Factors (LSCs) will evolve as well:

1. LSCs are more correlated to net load than to temperature
2. LSCs are increasing during winter months
3. LSCs are becoming flatter

2

2028 Electric LSCs have increased since 2025 cycle due to higher revenue recovery adder and clean energy costs

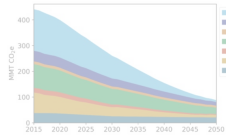
3

2028 Gas LSCs have increased since 2025 cycle due to higher revenue recovery adder and T&S costs

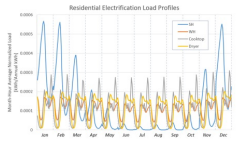
Appendix

Development of 2028 electric metrics

Inputs

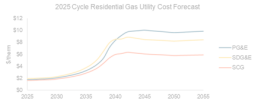


Demand Scenario Selection



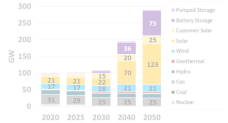
Hourly Load & Renewable Shaping

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

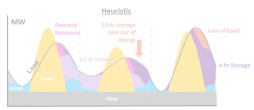


Retail Rate Forecast

Electric System Modeling



Capacity Expansion Modeling

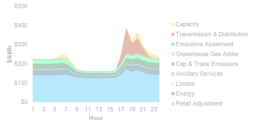


Reliability Modeling

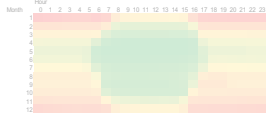
Production Cost Simulation

T&D Modeling

Outputs



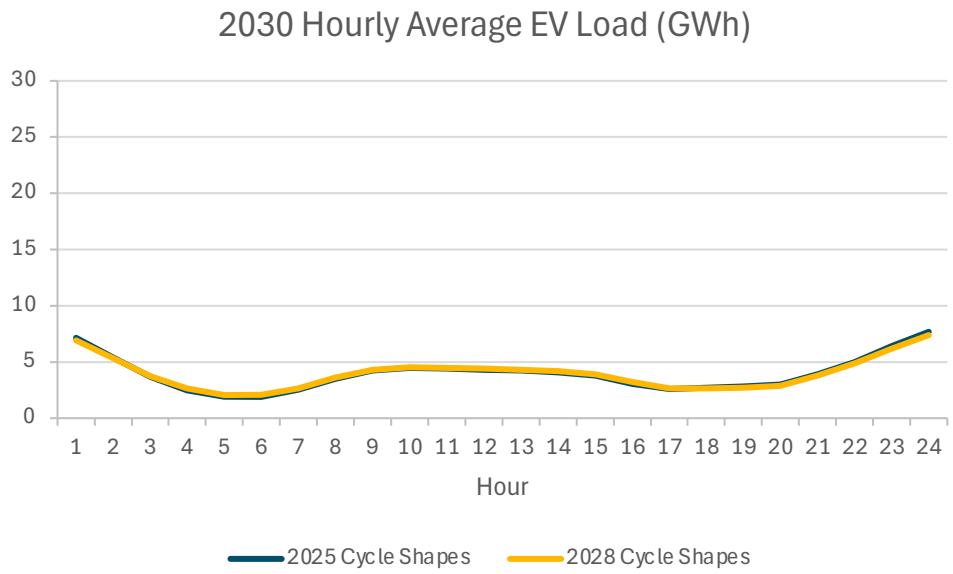
Long-term System Costs

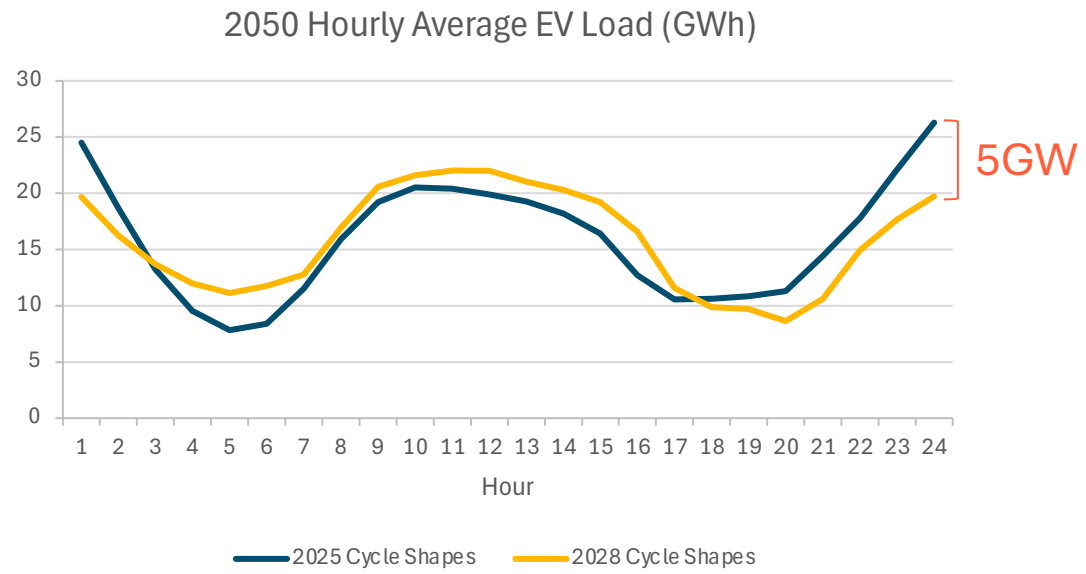


Hourly Source Energy

Updated EV load shapes

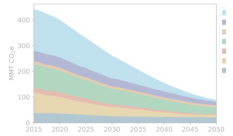
- The EV shape for the 2025 cycle reflected existing time-of-use (TOU) retail rates but might not represent the changing patterns with future TOU rates
- A new EV shape has been developed for the 2028 cycle to incorporate more charging in the mid-day when solar generation is abundant
- The final EV shape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





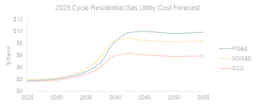
Development of 2028 electric metrics

Inputs



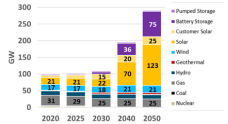
Demand Scenario Selection

Hourly Load & Renewable Shaping



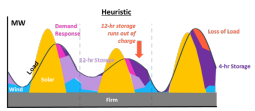
Retail Rate Forecast

Electric System Modeling



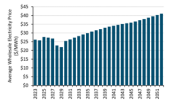
Capacity Expansion Modeling

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

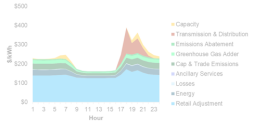


Production Cost Simulation

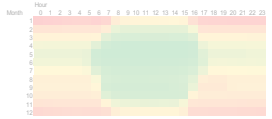
Calculate hourly energy price across WECC to reflect impacts of interzonal trade, transmission constraints, and available resources

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

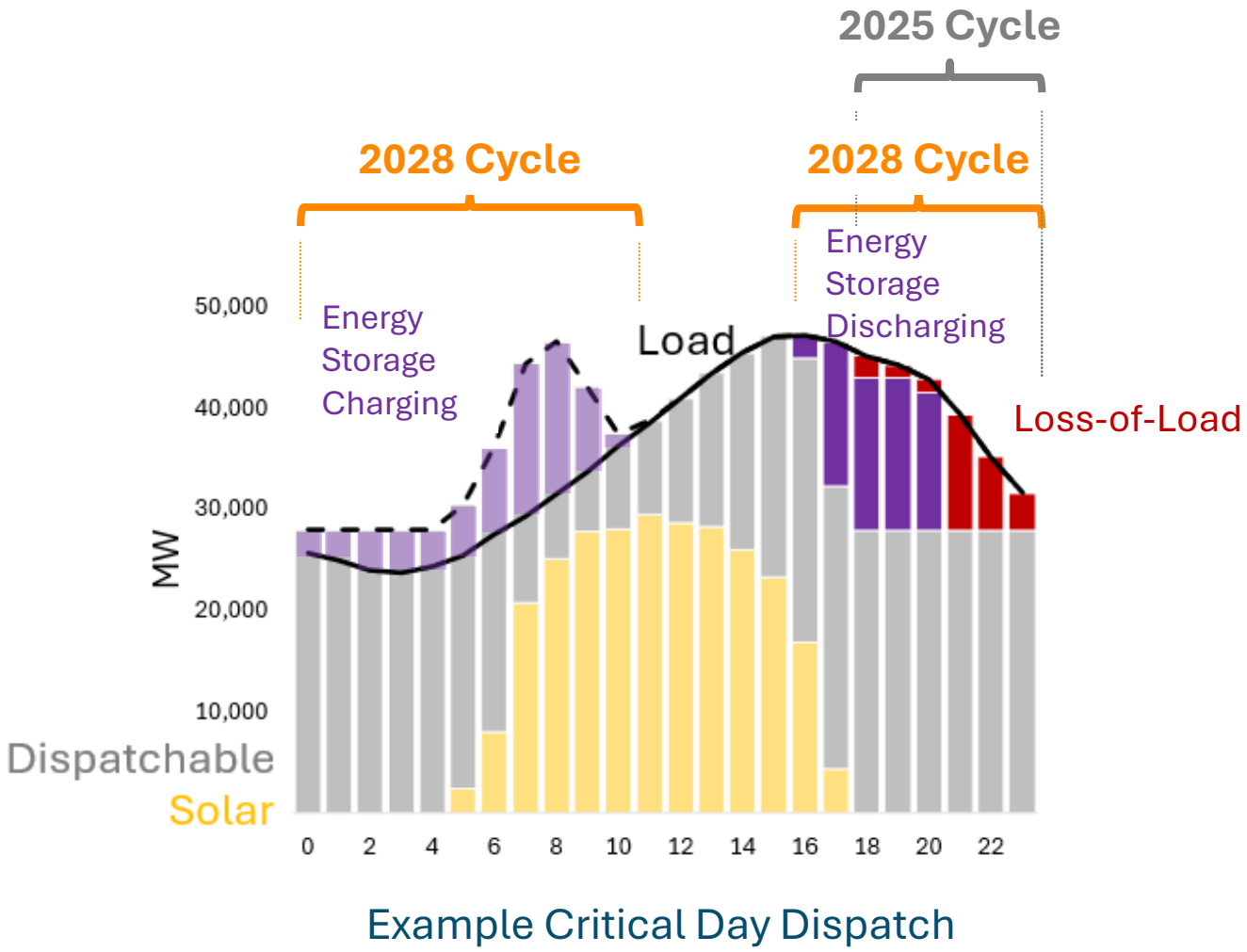
New! More granular & robust solar generation profiles

→ Reliability Modeling (RECAP)

→ **Hourly system operation on days with loss-of-load (LOL)**

→ **Re-mapped allocation factors to match the typical meteorological year weather data**

Updated allocation of generation capacity cost



Example Critical Day Dispatch

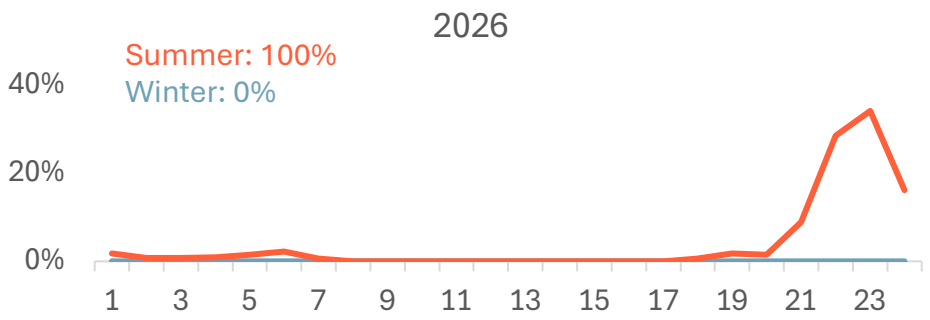
2025 (Traditional) Approach: Define critical hours as **loss-of-load** hours

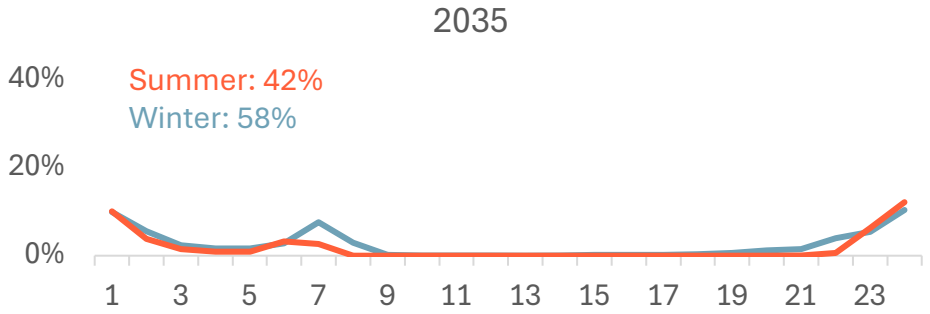
2028 Approach: Define critical hours as **energy storage charging & discharging** hours and **loss-of-load** hours

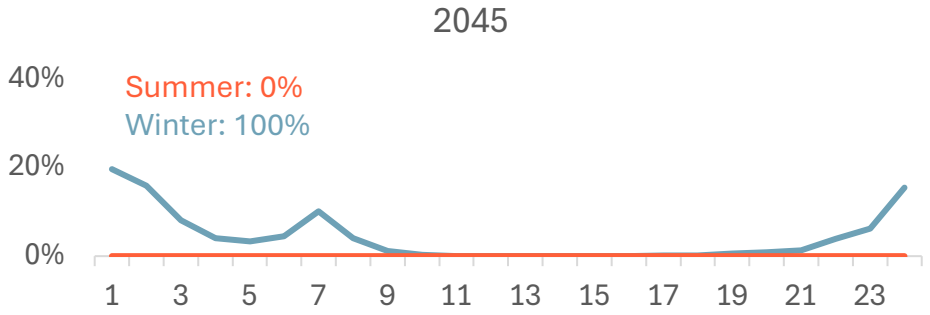
The new approach is necessary to capture critical hours in a system with large amount of storage

Updated allocation of generation capacity cost

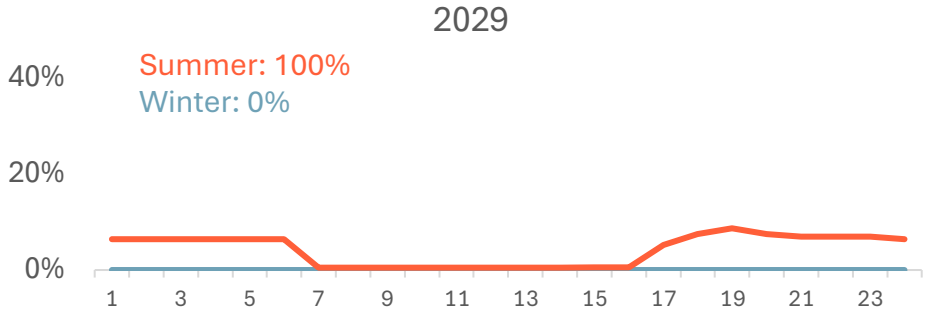
2025 Code Cycle

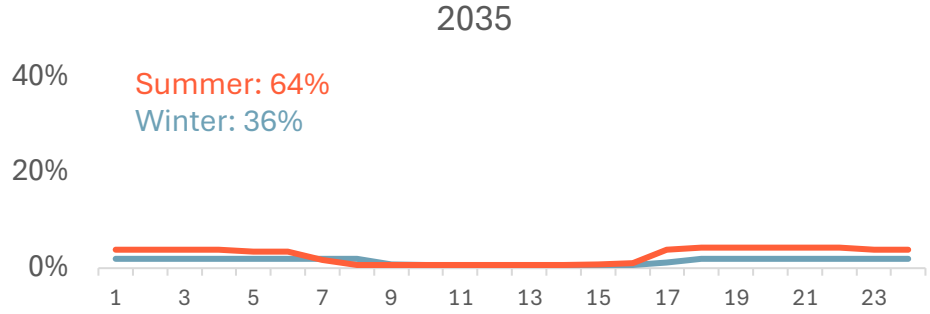


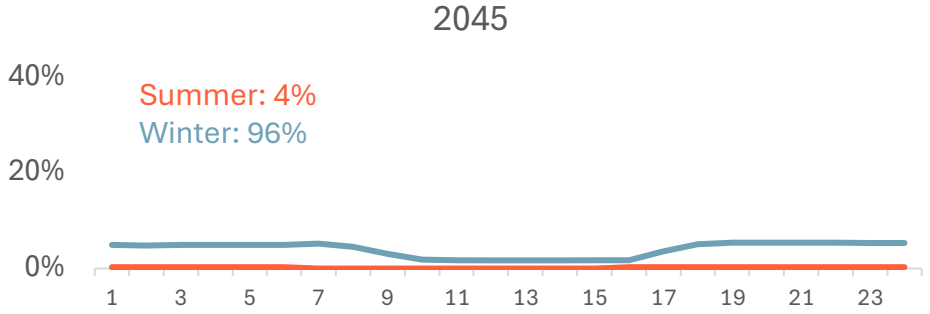




2028 Code Cycle



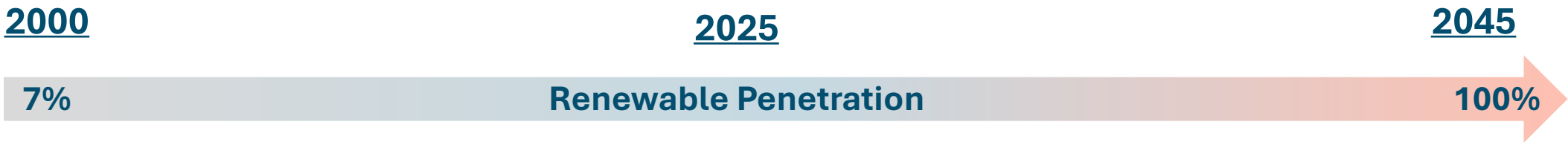




Evolving timing in grid challenges with increasing renewable penetrations

+ **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

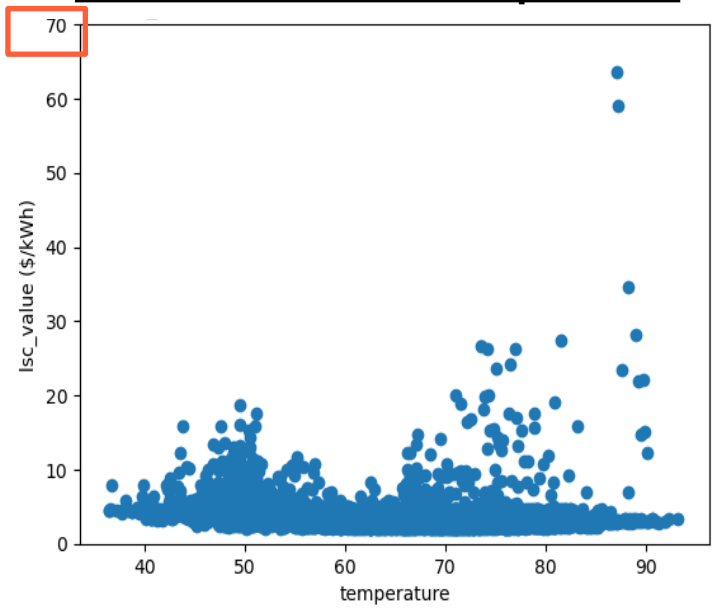
At high penetrations of renewables, periods of sustained low renewable production – most often in the winter - present the greatest challenge to operations

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

2028 cycle reflects warmer winter and hotter summer

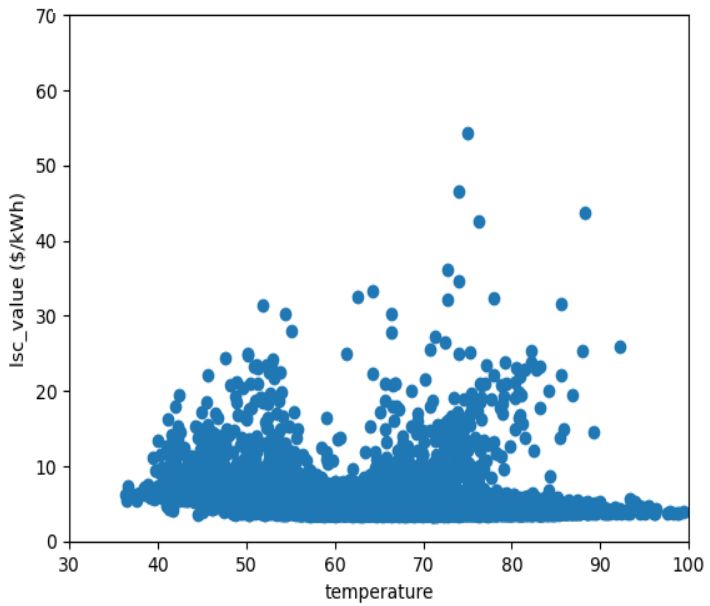
2022

CZ9 LSC Values vs Temperature



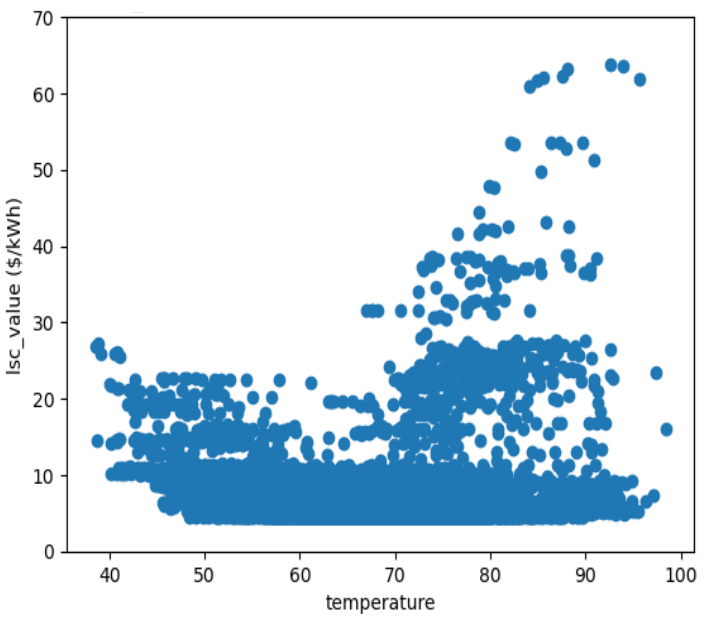
2025

CZ9 LSC Values vs Temperature



2028

CZ9 LSC Values vs Temperature



LSCs are higher in summer and winter