

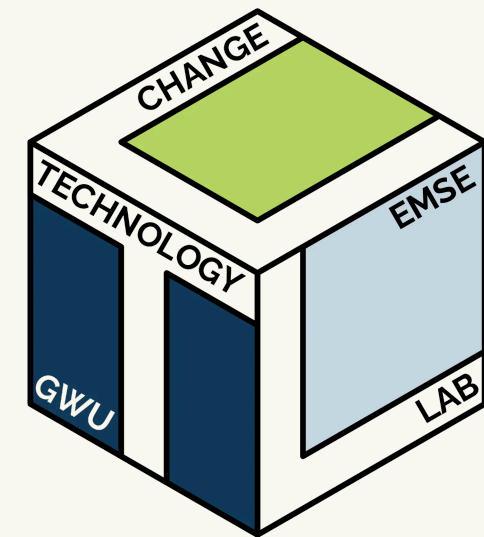
Quantifying the Peak-Shaving Potential and Cost Efficiency of BEV Supplier-Managed Charging

Integrating consumer enrollment
with grid simulation in CAISO and NYISO

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EDUCATION

-  **PhD Candidate in Systems Engineering**, advised by Dr. John Helveston, George Washington University, USA
-  **M.P.E in Mechanical Engineering**, University of Sydney, Australia
-  **B.S. in Industrial Engineering**, Pennsylvania State University, USA

WORK EXPERIENCE

-  **Assistant Process Engineer**, Kurtz Erska, Germany
-  **Project Engineer**, Daimler Beijing, China
-  **Project Engineer**, Hasco Rail, USA





Research Interests



Data Science in transportation systems and human behavior



Open-Source Software in R tools for survey research

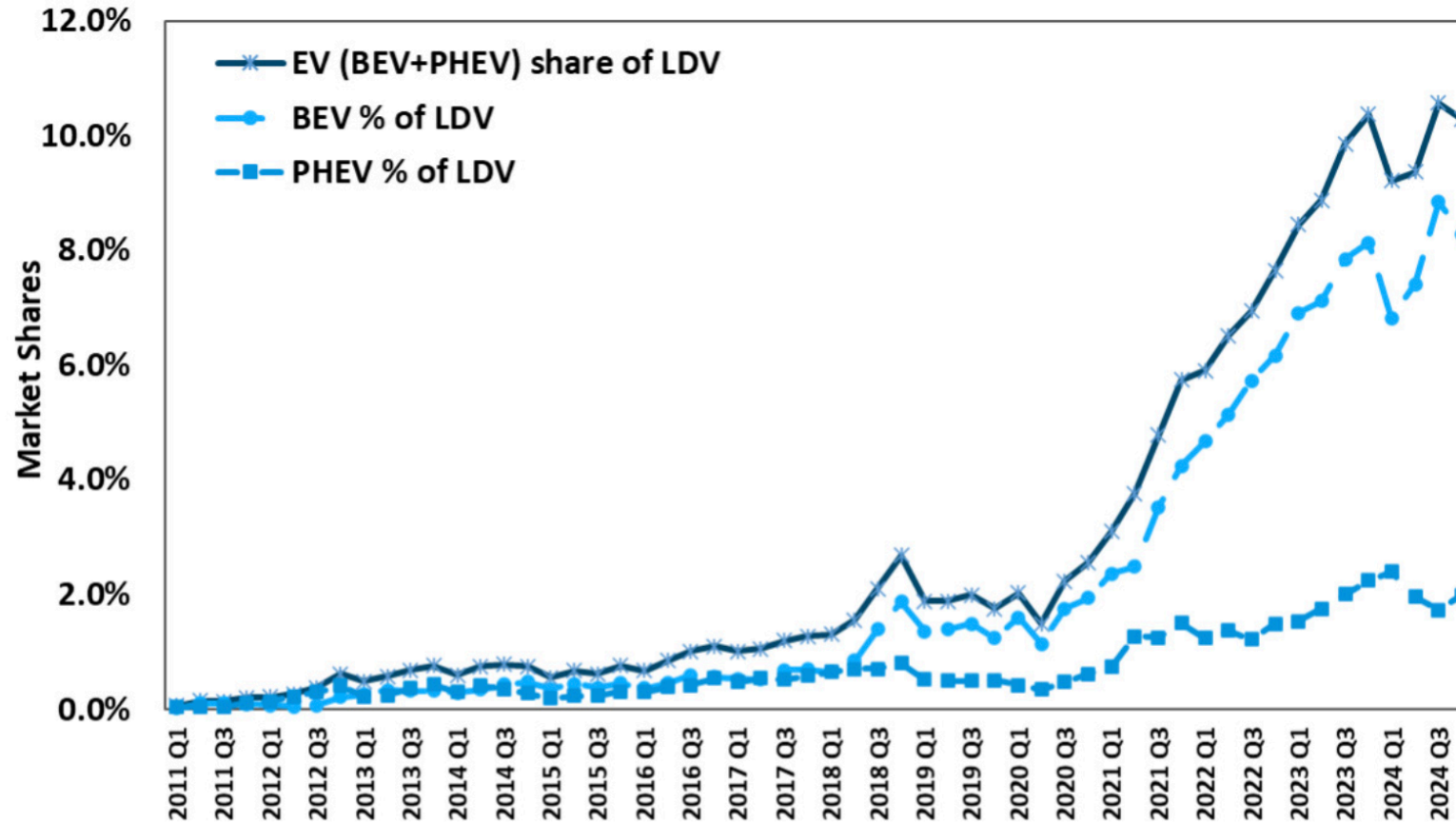


Agentic AI Engineering around Claude Code

pingfan.org ↗



EV sales in US reaching ~10% of sales

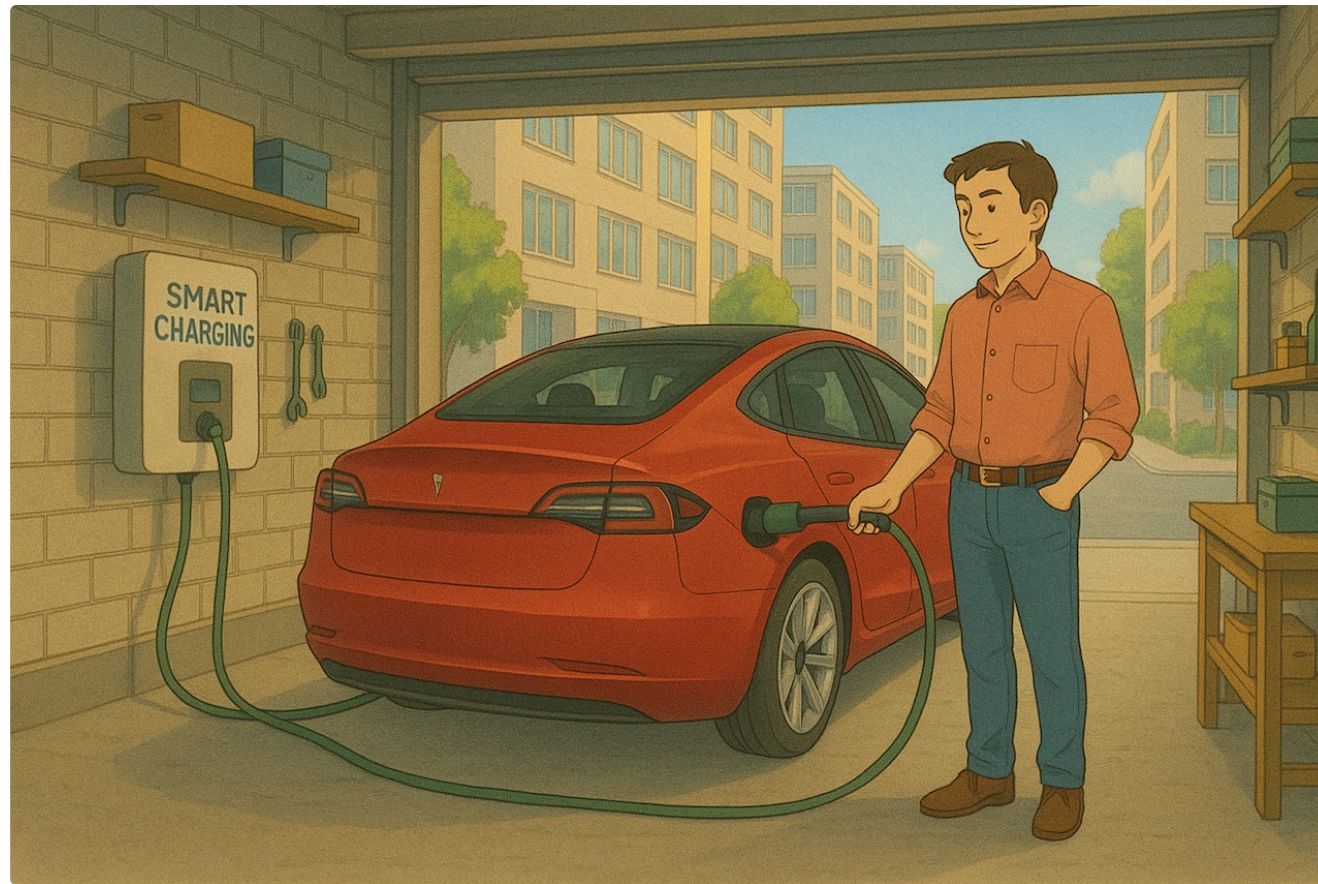


Source: Argonne National Lab, www.anl.gov/ev-facts/model-sales



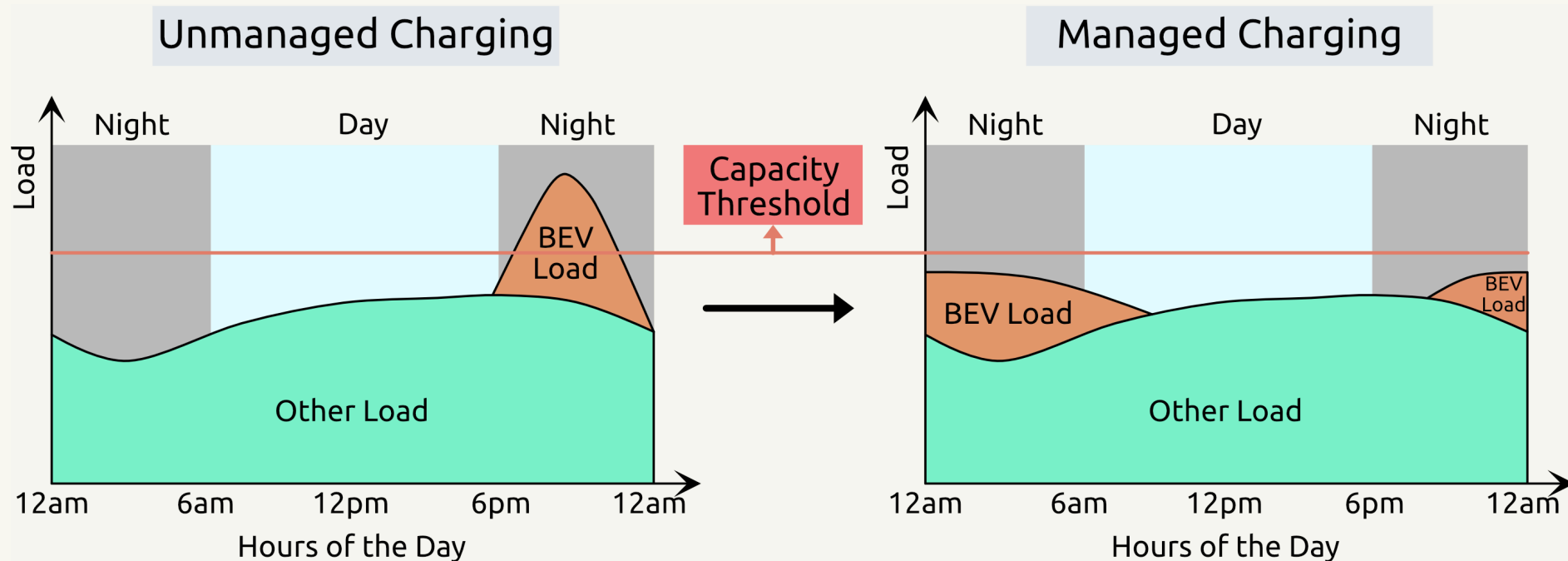
Introduction

- **Unmanaged** BEV charging is becoming a problem to the grid.
- **Managed** charging is cheaper and smooths out the grid load.



SMC - Supplier Managed Charging

- SMC smooths out the BEV charging spike (called “Peak-shaving”).
- Electricity demand is controlled below the capacity threshold.
- It saves money and reduces pollution.



Managed charging avoids overload caused by BEV charging.



Smart charging effectiveness depends on enrollment and peak-shaving.

PRIOR STAGE



Enrollment

Will BEV owners opt in,
and at what incentive?

CURRENT STAGE



Peak-shaving

How much peak can SMC shave,
and at what cost?



Prior stage: willingness to enroll in SMC

Conjoint survey of BEV owners (Hu et al., 2025)



1,356

BEV owner responses



803 + 553

Meta Ads + Dynata, 2024



5 attributes

cash, overrides, battery thresholds

(1 of 6) If your utility offers you these 2 SMC programs, which one do you prefer?
(Your BEV has maximum range of **300** miles.)

[Access the SMC Attributes](#)

Option 1	Option 2	Option 3
Enrollment Cash: \$100 Monthly Cash: \$20 Override Allowance: 1 per Month	Enrollment Cash: \$200 Monthly Cash: \$10 Override Allowance: 1 per Month	
Battery Thresholds (in Miles): 	Battery Thresholds (in Miles): 	Not Interested



Existing studies assume enrollment is high and free

1. Most grid studies **assume** optimal or near-100% participation (Coignard et al., 2018; Tarroja et al., 2015), but real pilots enroll far fewer.
2. Enrollment is **not free**: utilities must pay incentives (Bailey et al., 2023; Wong et al., 2023), yet costs are rarely counted.
3. Few studies compare peak-shaving **across grid regions** with different load shapes.

We connect **consumer enrollment** with **grid simulation**.



Research Questions

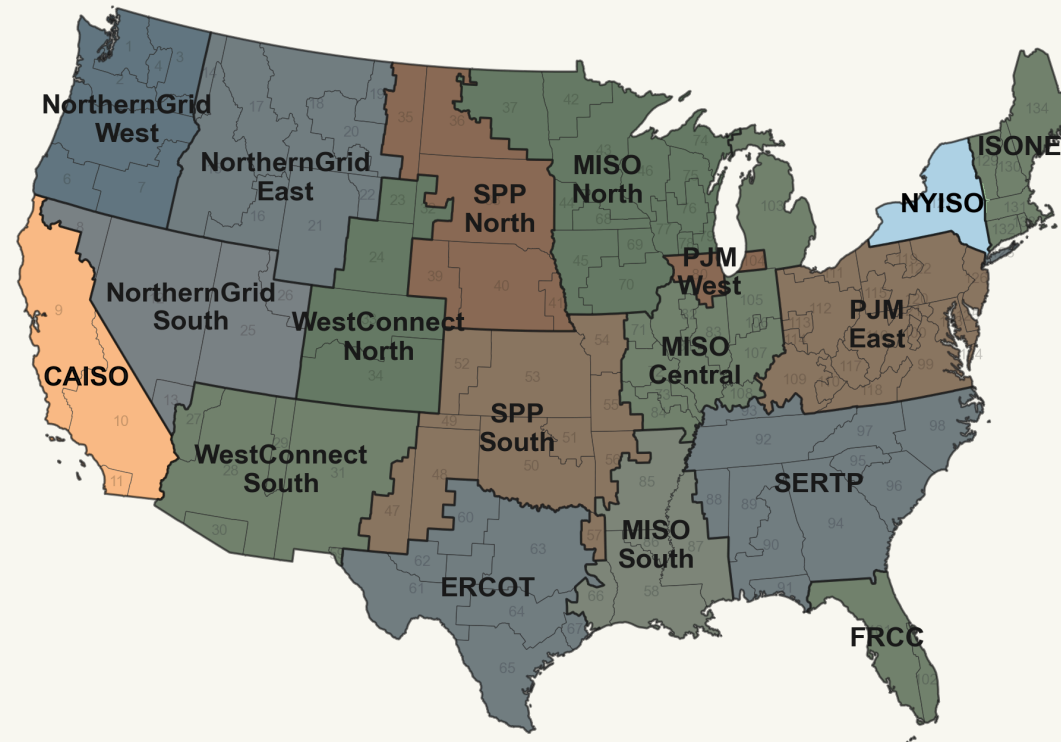
1. **Peak-shaving:** How much can SMC reduce peak demand in contrasting grid regions?
2. **Cost efficiency:** How much does peak shaving cost per unit, and is more enrollment always better?

Approach

1. **Scenario-based simulation** for CAISO and NYISO.
2. **Enrollment curve** from the prior stage: incentives vs participation.



Two contrasting regions: CAISO and NYISO



	Single families	Energy source	Net load shape	Seasonal effect
CAISO	7.69 million	Solar	"Duck curve"	Minimal
NYISO	3.16 million	Hydro	Flat profile	Strong in winter

Both lead in BEV adoption, with contrasting grid structures.



Simulation Overview

Scenario Inputs

Regions

CAISO
NYISO

Time Periods

Annual average
Extreme days
Seasonal

EV:House

1:1
1:2
1:4

SMC Enrollment

0%
10%
...
100%

Load Shifting Window

10AM-8PM -> 8PM-7AM
10AM-9PM -> 9PM-7AM
10AM-10PM -> 10PM-7AM
10AM-11PM -> 11PM-7AM
10AM-12AM -> 12AM-7AM



Peak-Shaving Model

Data Source

Grid Net Load

2025 CAISO & NYISO
time-series data

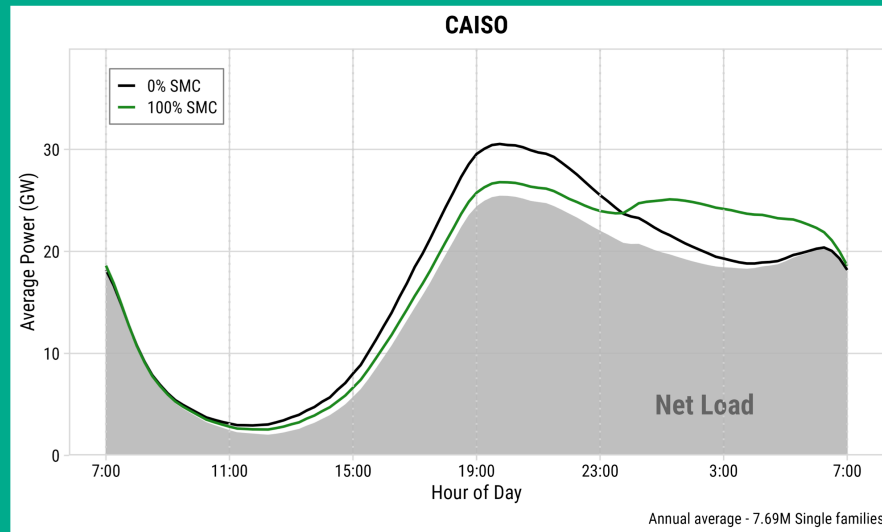
Household Count

2025 U.S. Census
CAISO: 7.69M
NYISO: 3.16M

Travel Patterns

2022 NHTS Results

One Example Run



Run the peak-shaving model multiple times with varying scenario inputs.



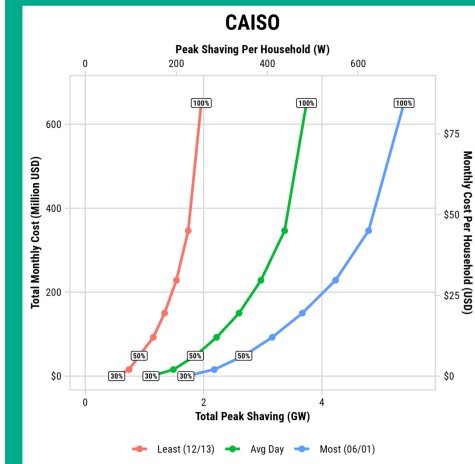
Cost Efficiency Simulation

Data Source

Enroll vs Cost Model

2024 Discrete Choice
Experiment
(1,356 BEV owners)

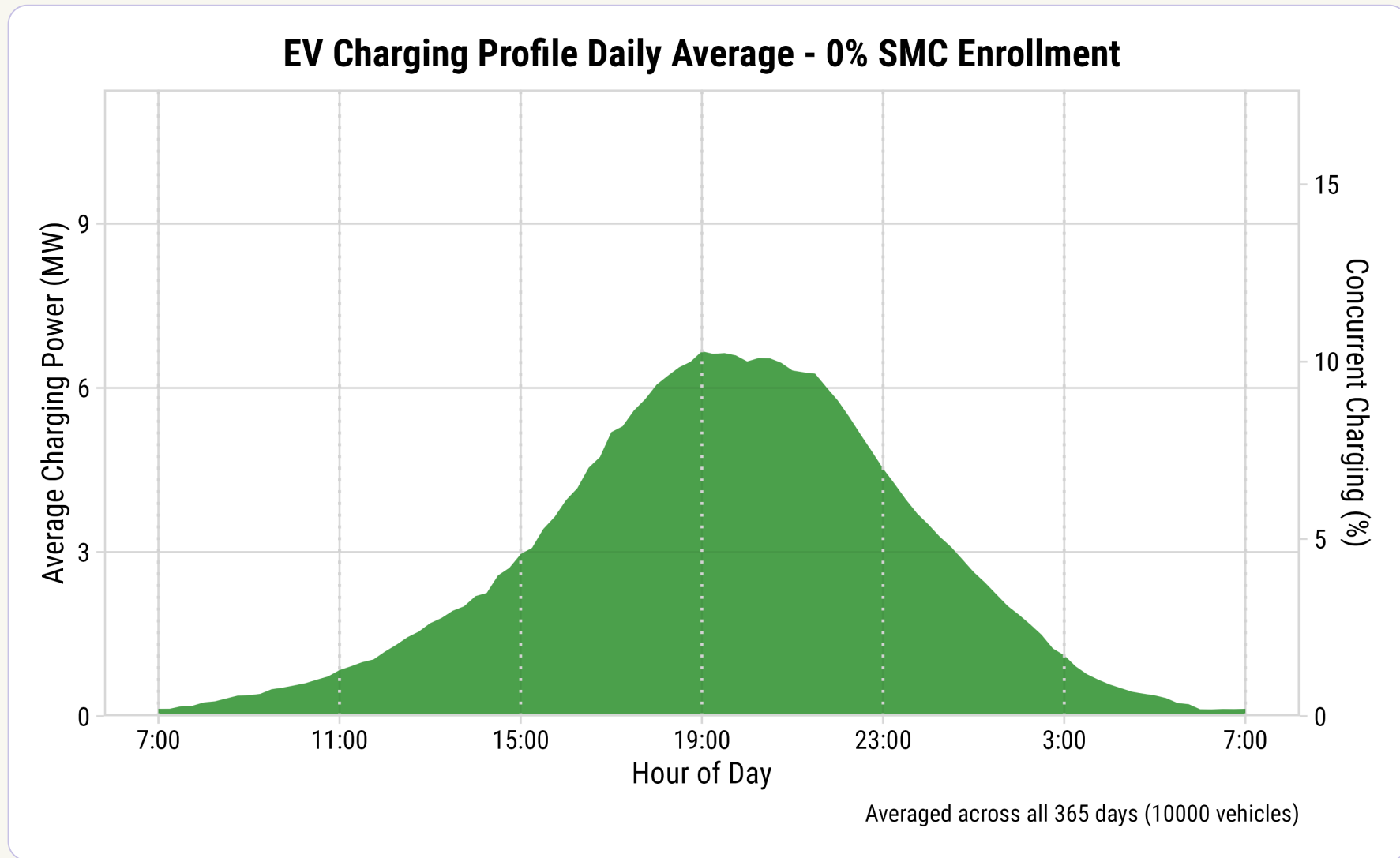
Extreme Days Example



Contains annual average, extreme days, seasonal averages, and different EV-to-house ratios



Step 1: BEV Charging Load Profile

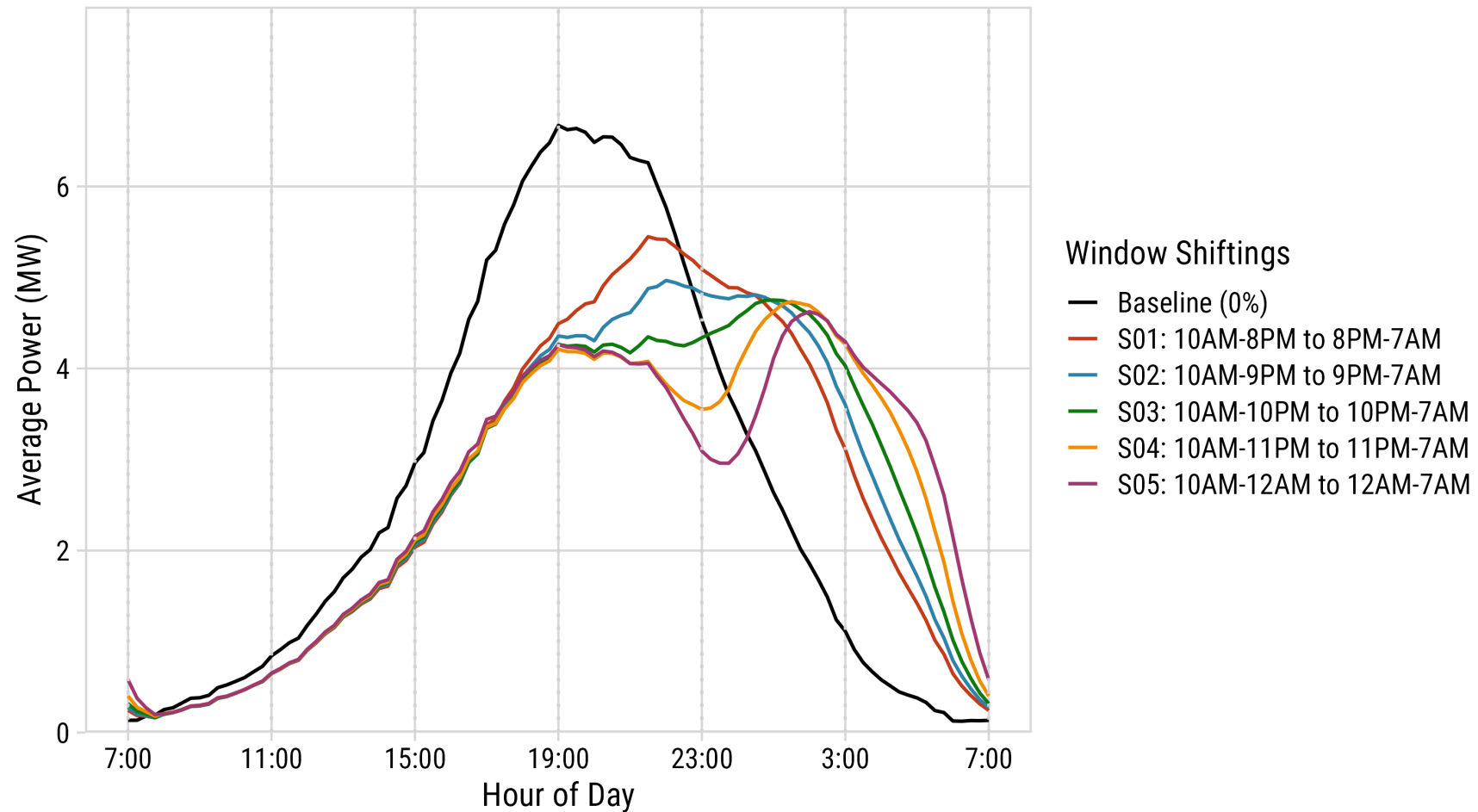


Simulation of 10,000 vehicles based on ~26,000 trip records from 2022 NHTS.



Step 2: BEV Load Peak Shaving

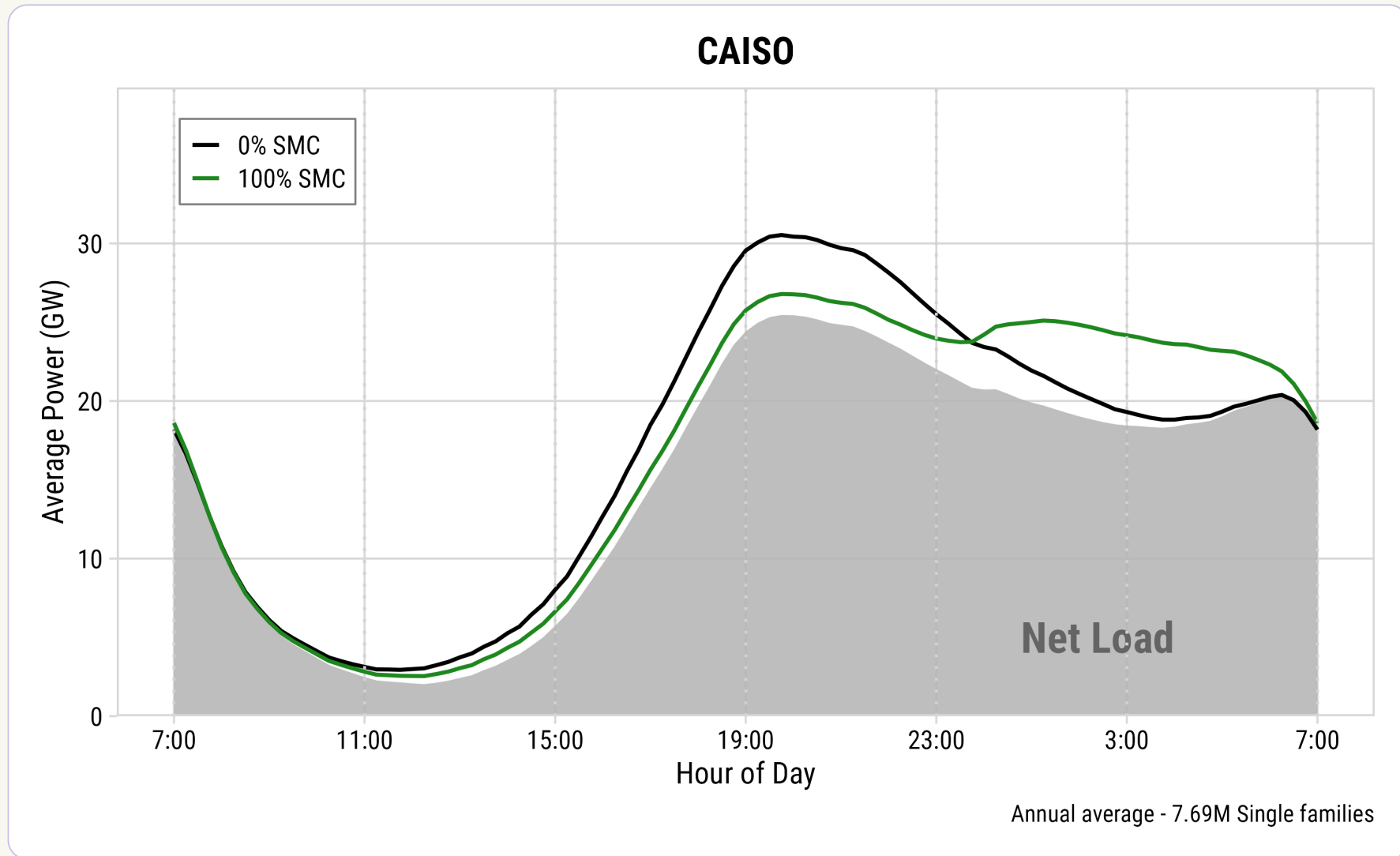
Comparison: 50% SMC Enrollment



Five configurations with different peak/valley windows.



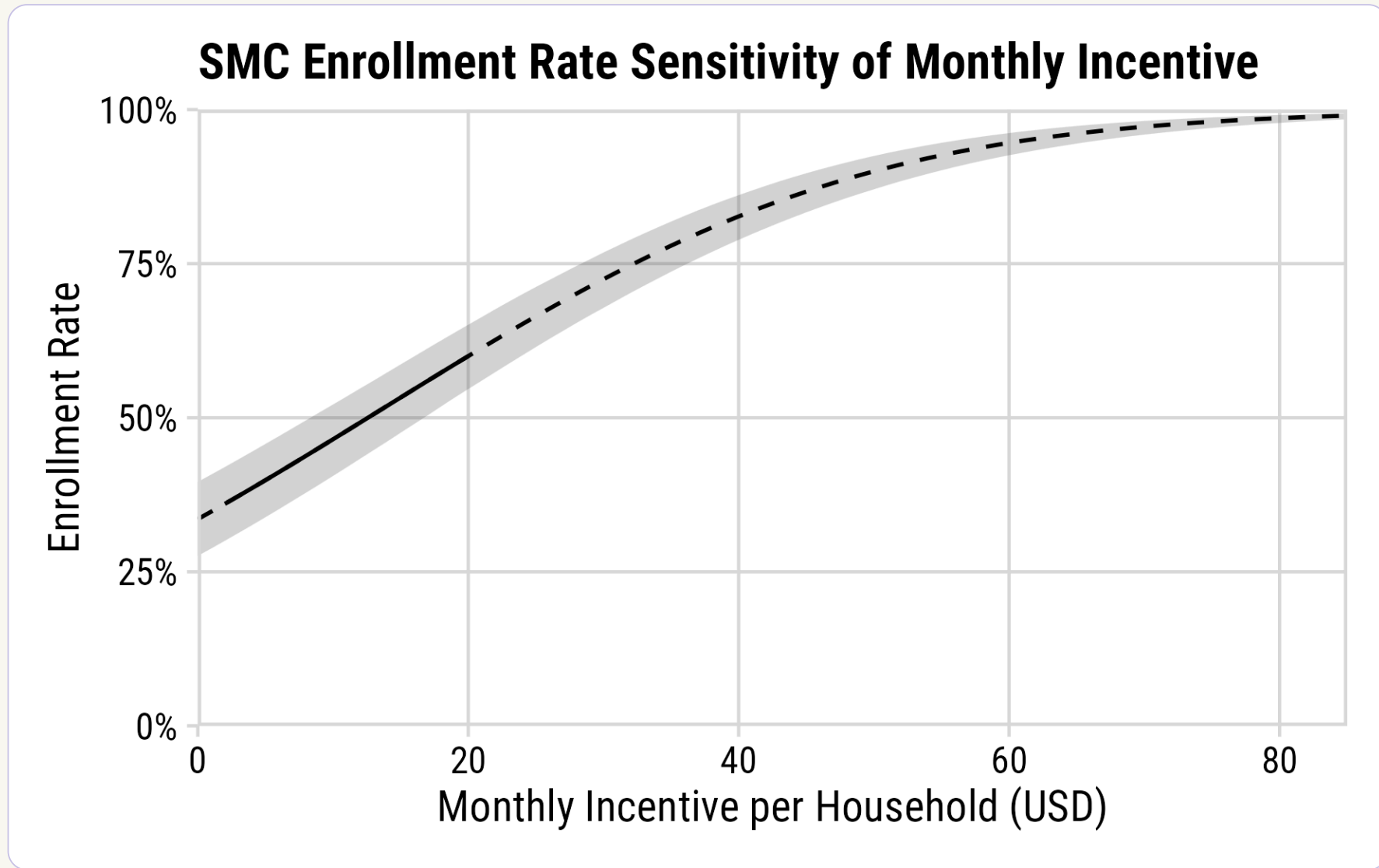
Step 3: Net Load + BEV & Peak Shaving



BEV load scaled to fleet size and stacked on net load.



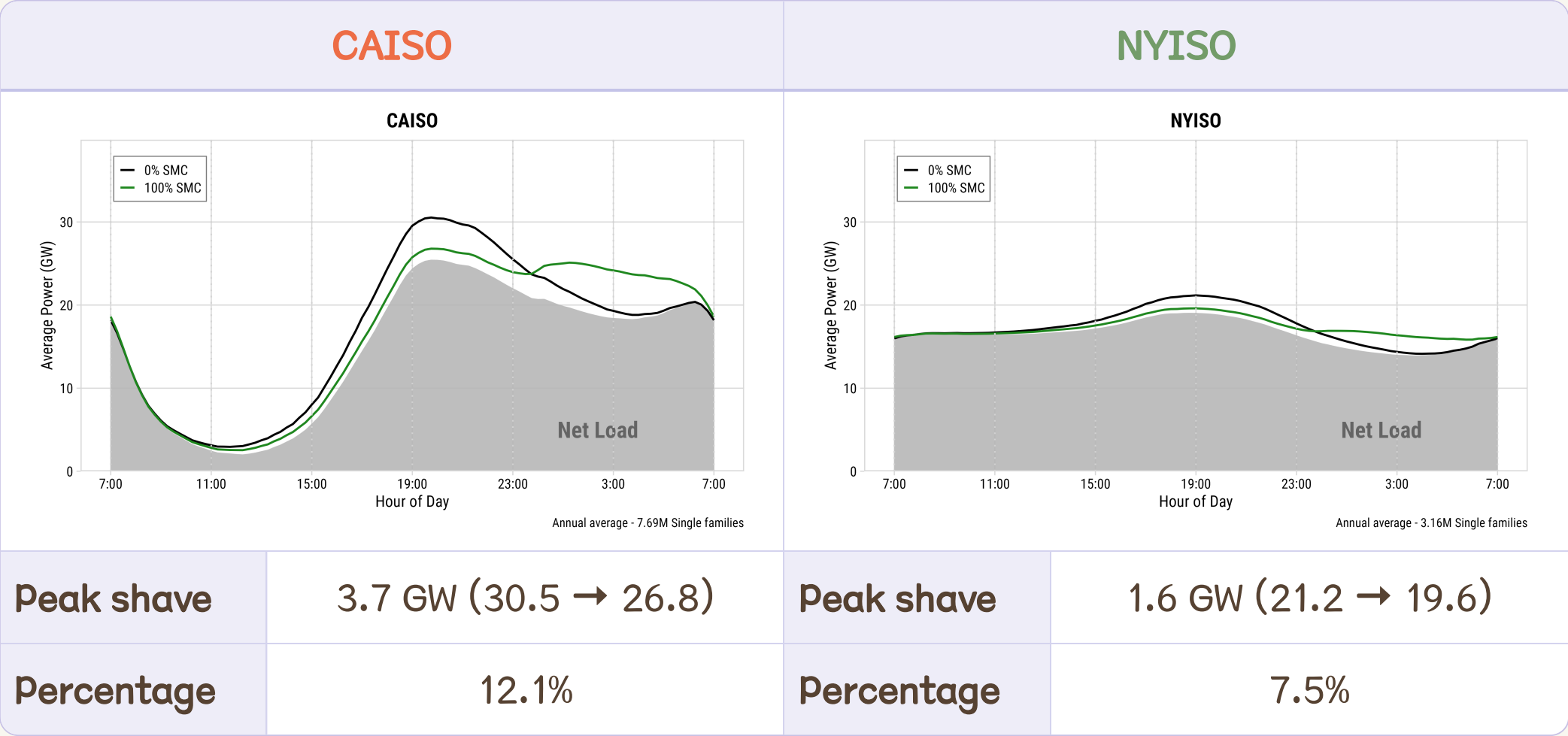
Enrollment Curve from Prior Stage



Mixed logit prediction based on 1,356 real BEV owners.

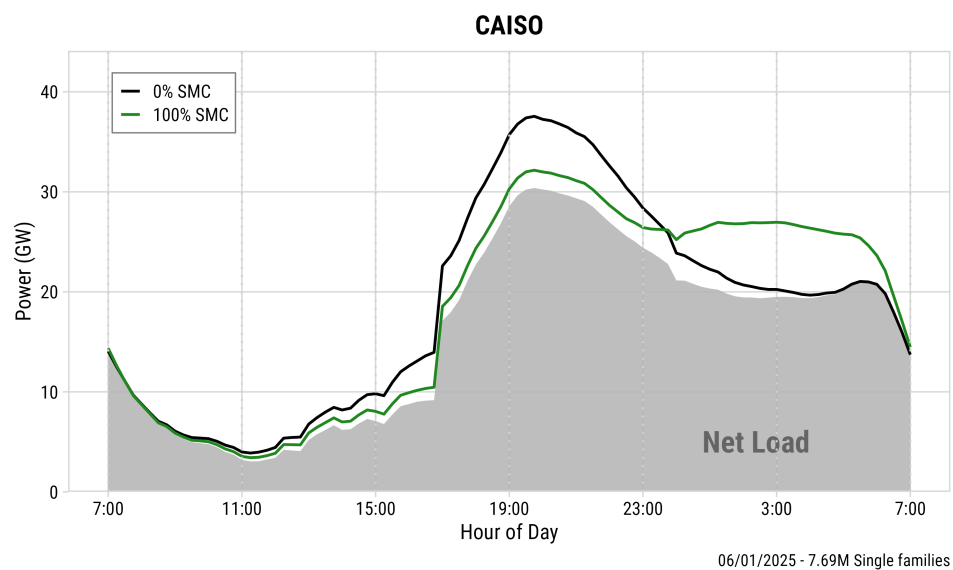


Peak Shaving: Annual Average

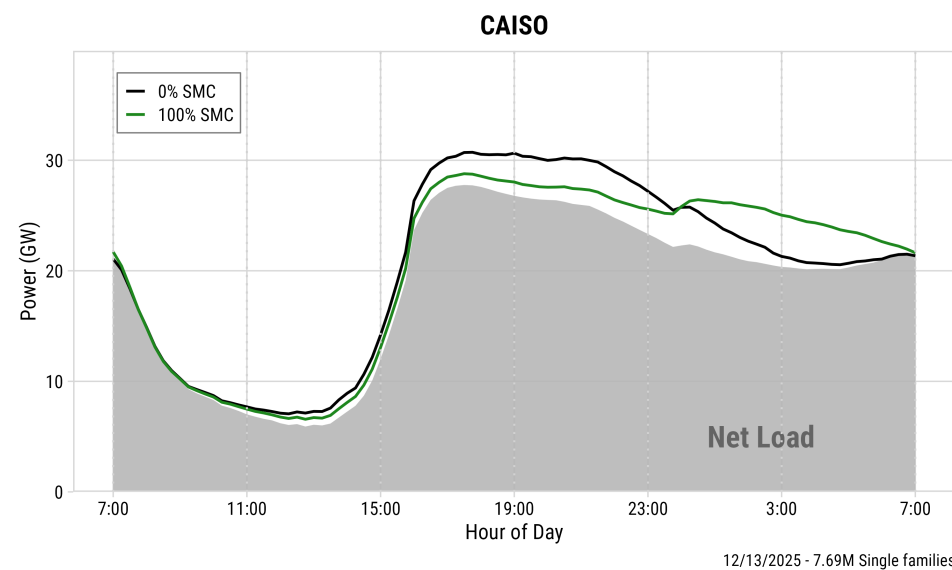


Peak Shaving: CAISO Extreme Days

Best Day (Jun 1)



Worst Day (Dec 13)



Peak shave

5.4 GW (37.6 → 32.2)

Percentage

14.4%

Peak shave

1.9 GW (30.7 → 28.8)

Percentage

6.2%

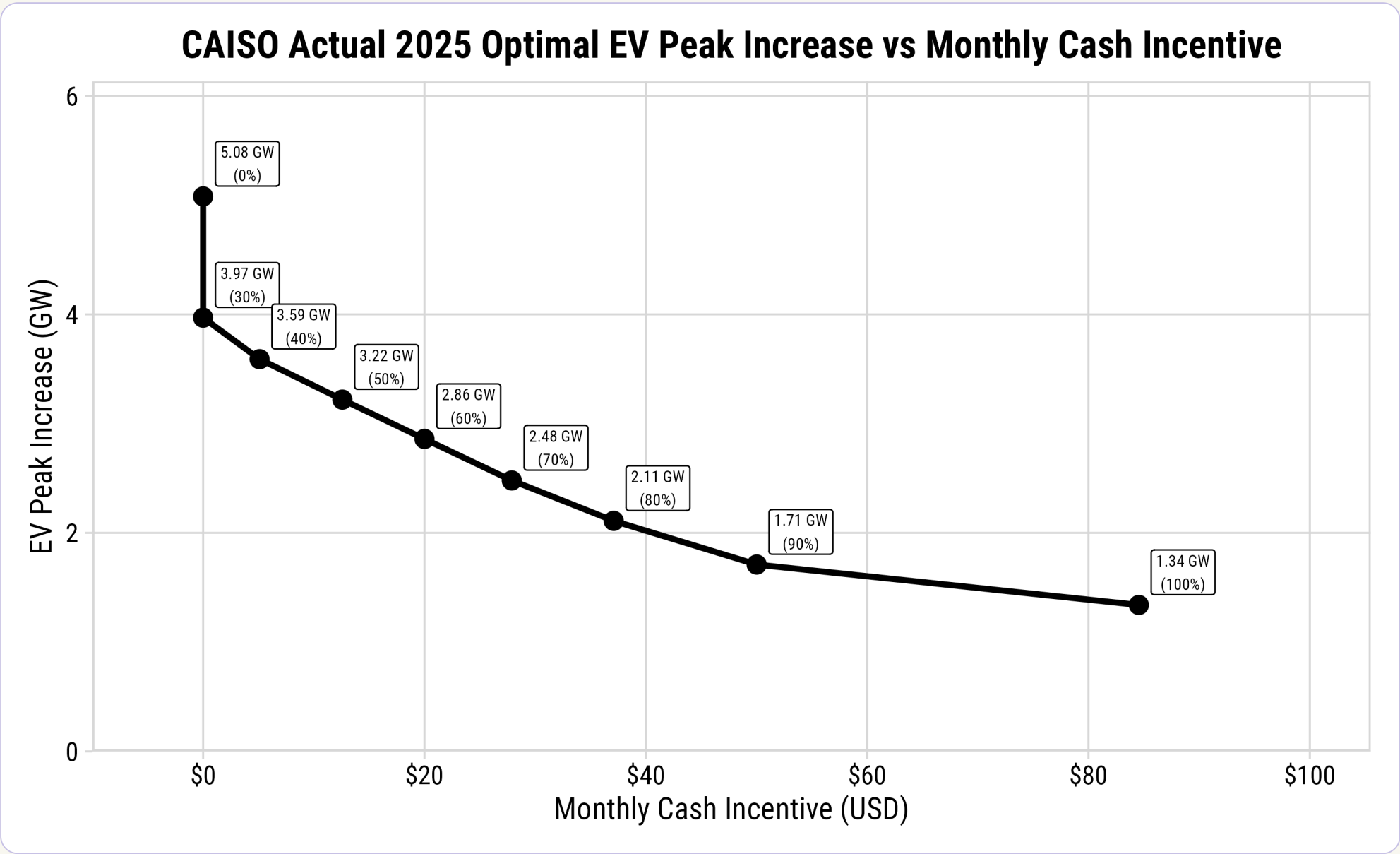


Peak Shaving: NYISO Extreme Days

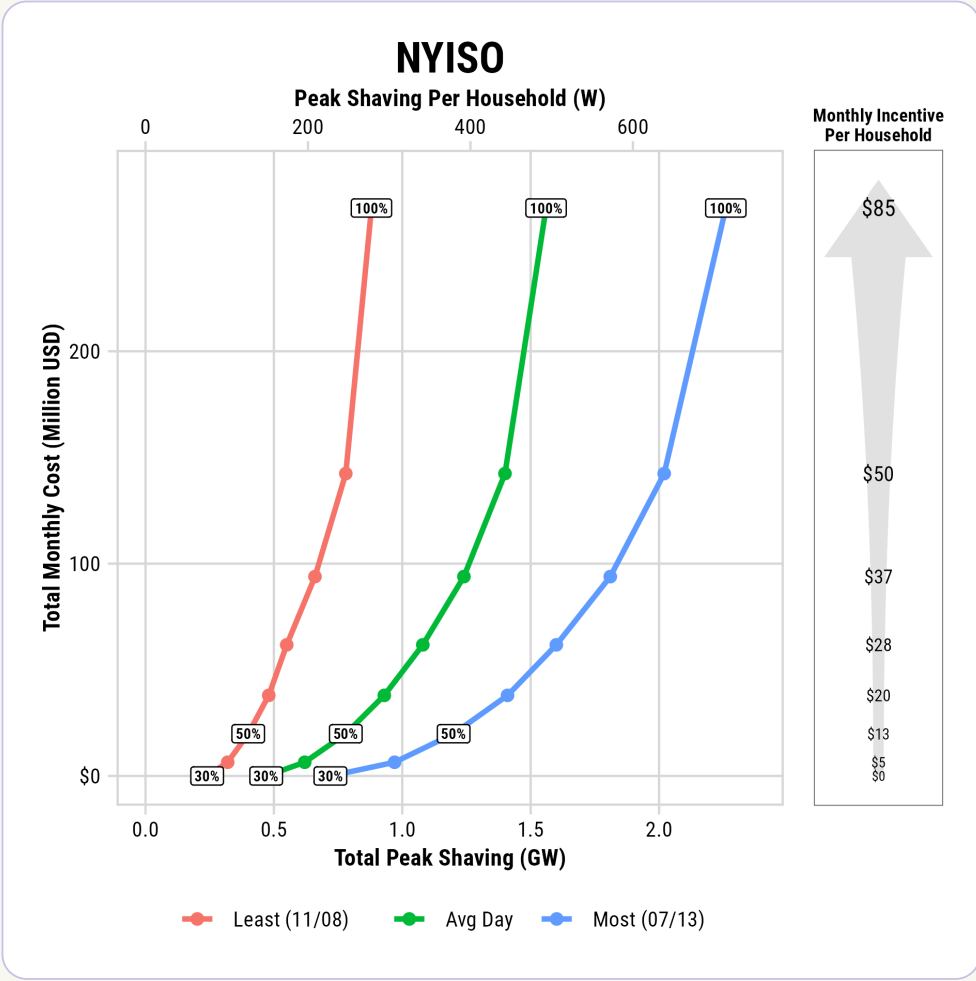
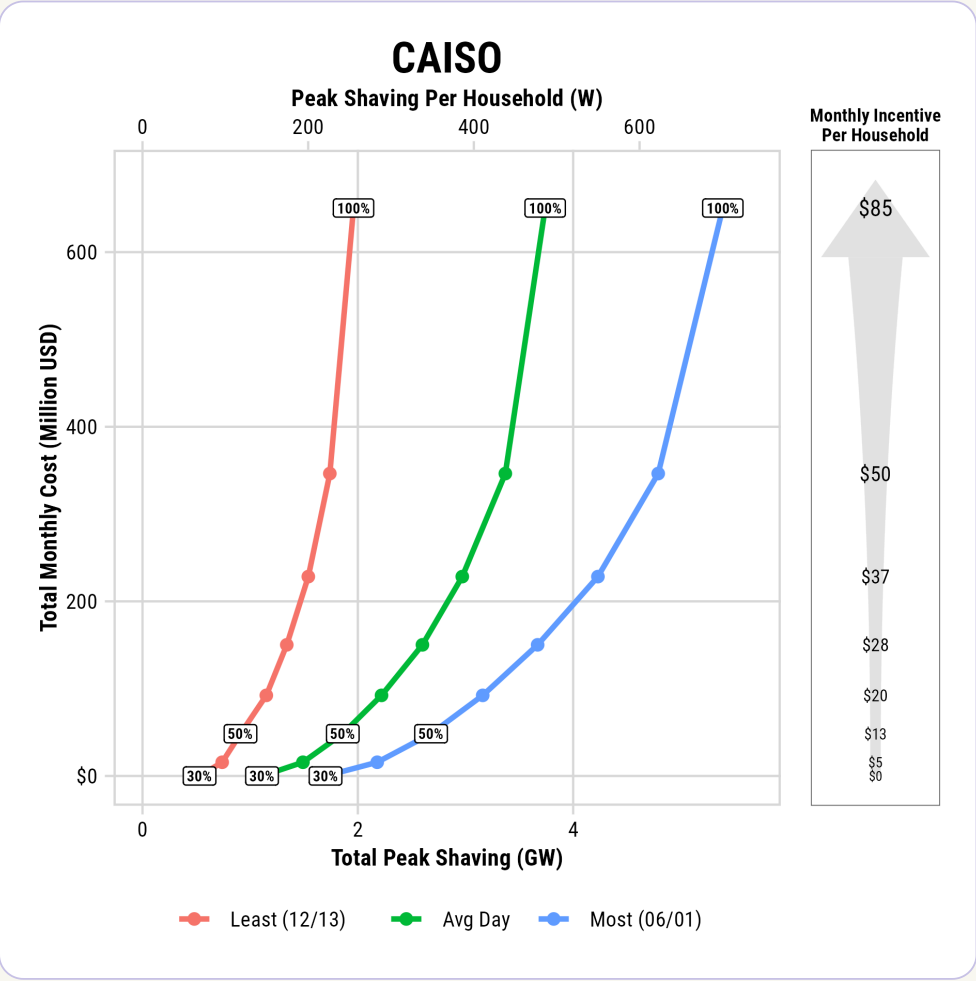
Best Day (Jul 13)		Worst Day (Nov 8)	
NYISO 07/13/2025 - 3.16M Single families		NYISO 11/08/2025 - 3.16M Single families	
Peak shave	2.2 GW (27.8 → 25.6)	Peak shave	0.8 GW (17.8 → 17.0)
Percentage	7.9%	Percentage	4.5%



Peak from BEV charging decreases with higher enrollment



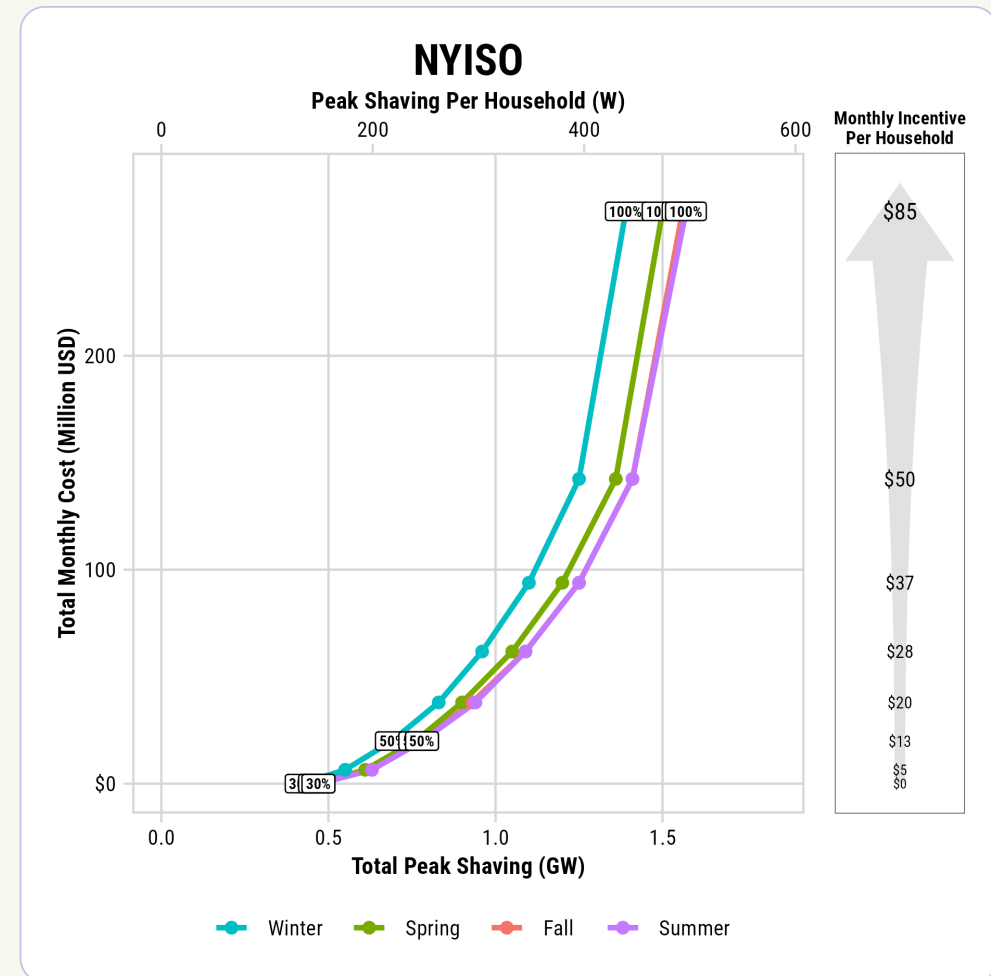
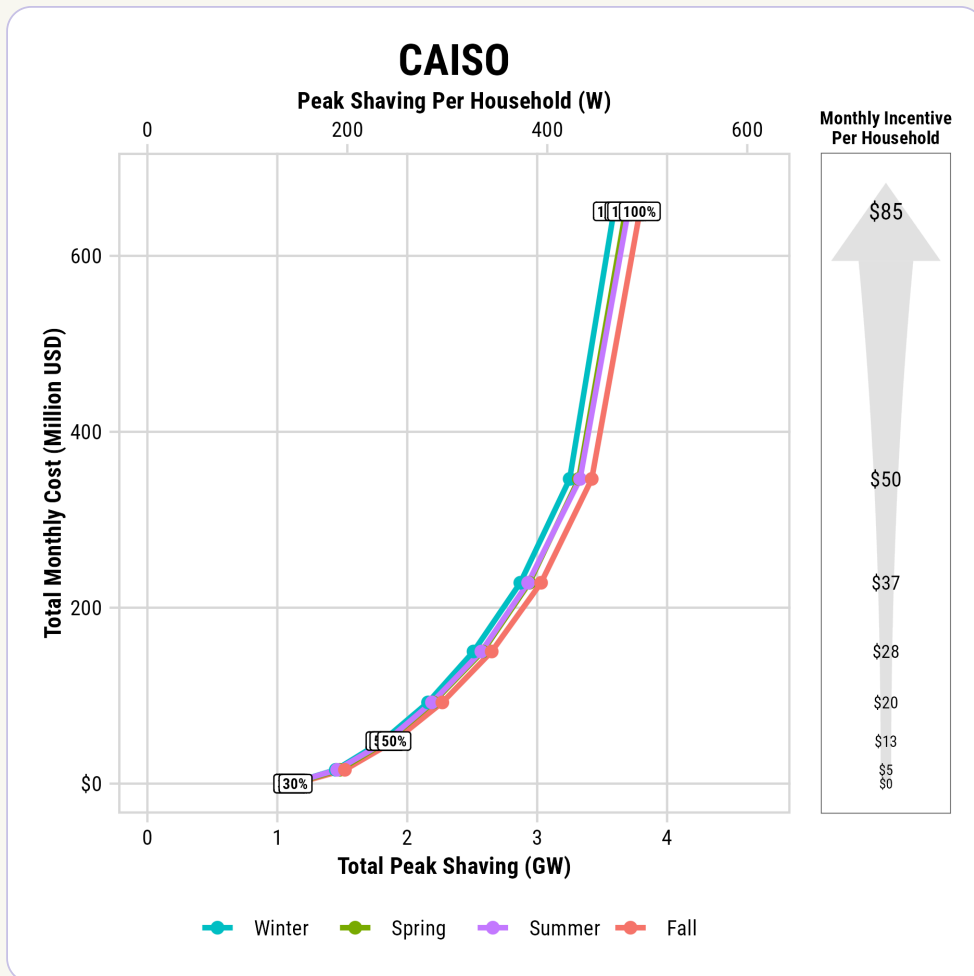
Cost Efficiency Frontier



Cost efficiency is highest at moderate enrollment (30–50%).

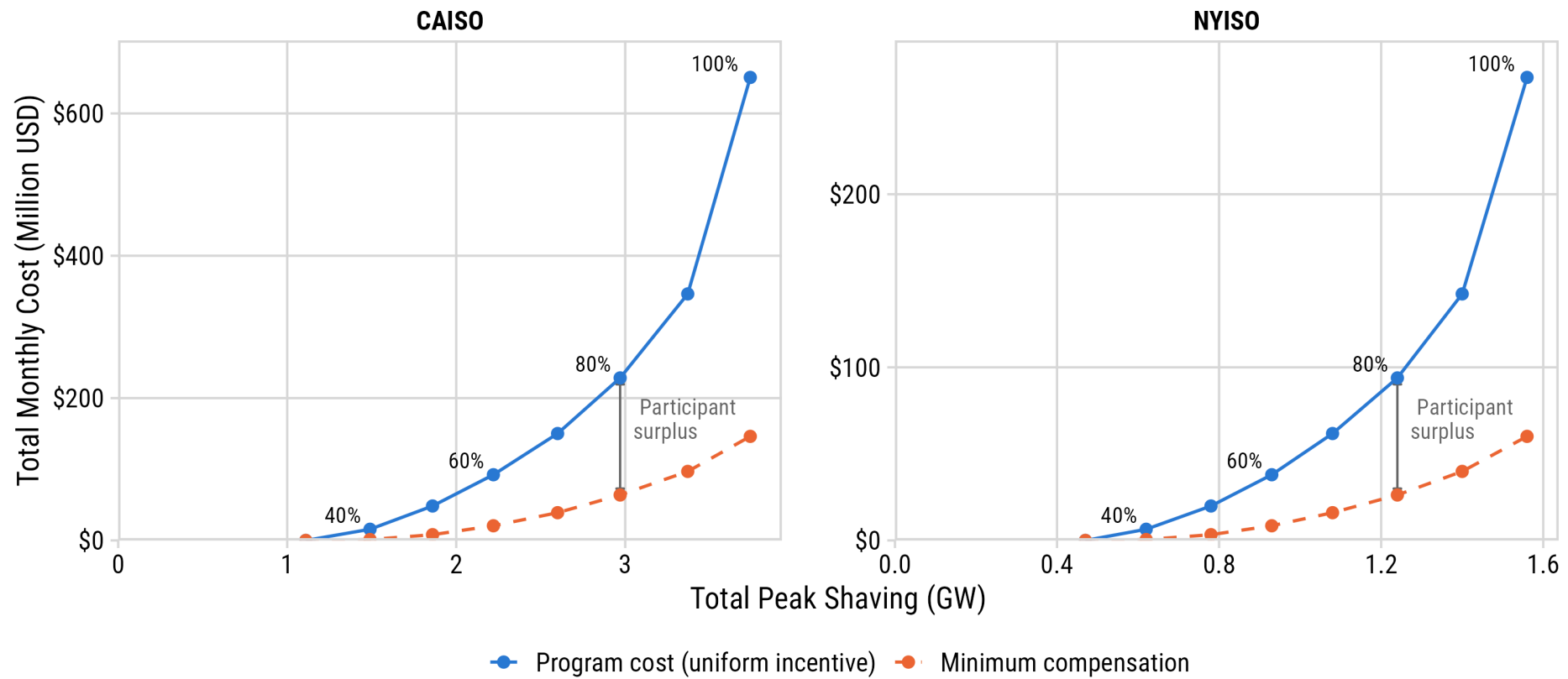


Seasonal cost efficiency is consistent in CAISO, but varies in NYISO.



Most program cost is participant surplus

Program Cost and Minimum Compensation



72–92% of uniform payments exceed what enrolled households would accept.



Conclusions

1. **Peak-shaving** potential is:
up to 14.4% (5.4 GW) for CAISO, and 7.9% (2.2 GW) for NYISO.
2. The **cost-effectiveness** of peak shaving requires:
moderate enrollment (30–50%), and seasonal effect consideration.
3. Most program cost is **participant surplus** (72–92%):
better-targeted incentives could deliver the same shaving for less.

Limitations

- a. Stated preference might be optimistic.
- b. Only considered single-family homes.
- c. Grid conditions based on 2025 data.



Acknowledgments



CO-AUTHORS

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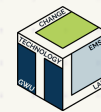


DATA & CODE

github.com/pingfan-hu/2025-grid-peak-shaving-public



ALFRED P. SLOAN
FOUNDATION



Helveston Lab



Thanks for listening!



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About



Blog



Research



Works



Appendix

Supporting Details



Data Sources

Source	Provides	Role in Simulation
2022 NHTS	Real trip records nationwide	Charge time & energy needs
2025 GridStatus.io	Net load time series	Regional grid baselines
2025 U.S. Census	Single-family counts	Scale to total fleet energy
Prior stage	Enrollment curve	Cost efficiency analysis



Vehicle & Charging Assumptions



BEV RANGE

200 miles



CHARGING

Level 2 (6.48 kW)



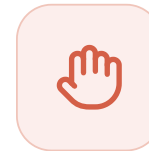
BATTERY SOC

20% – 80%



TRAVEL NEEDS

Guaranteed



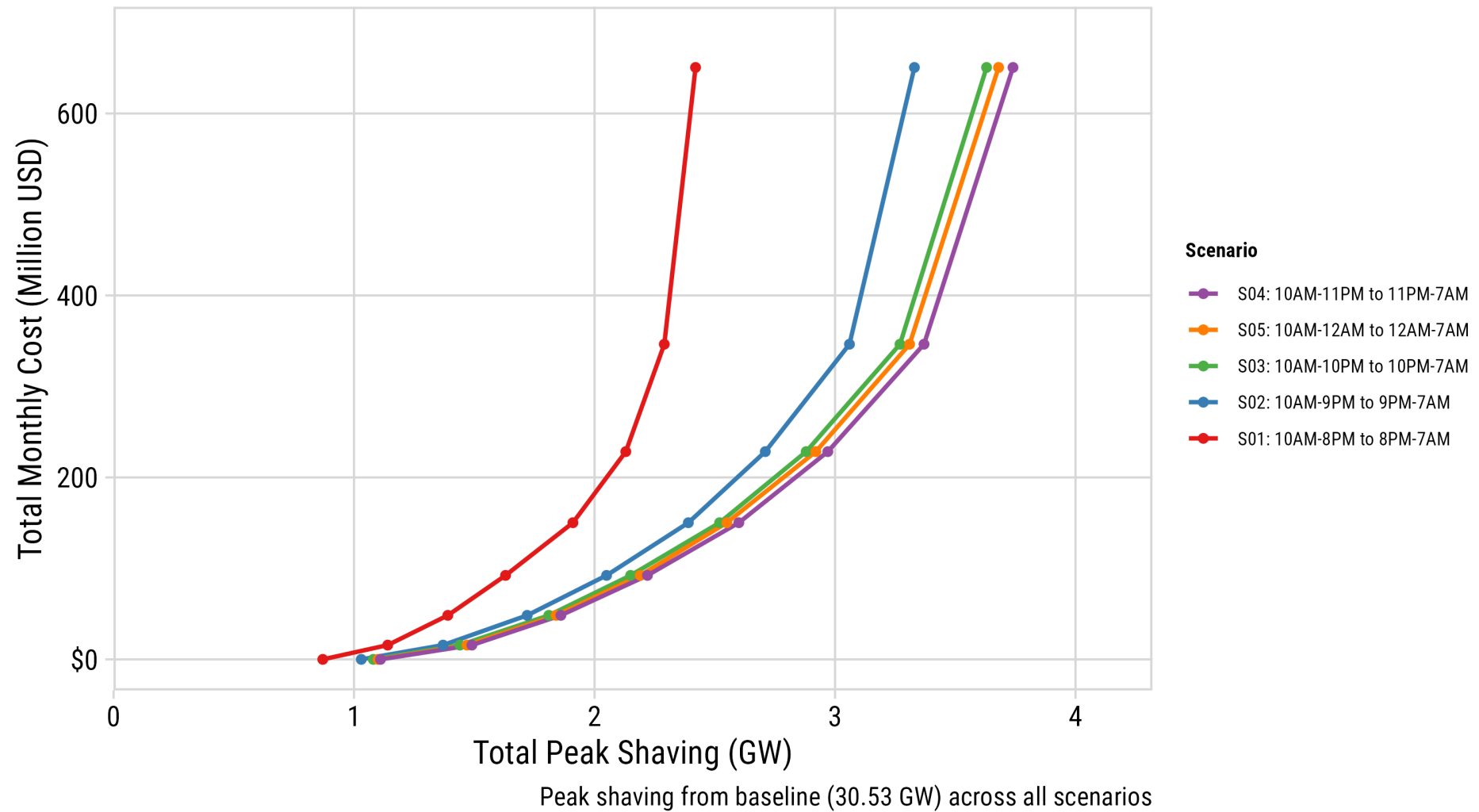
OVERRIDES

2 – 3 per month



TOU window: 11 PM valley start performs best

CAISO Actual 2025 Monthly Cost vs Peak Shaving

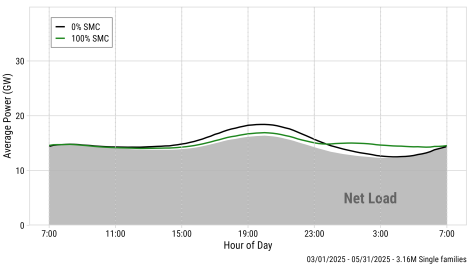
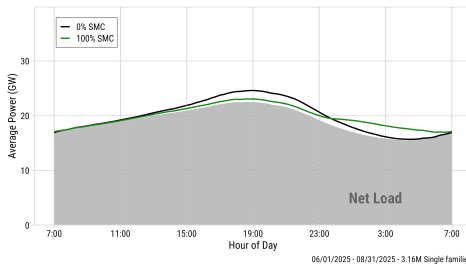
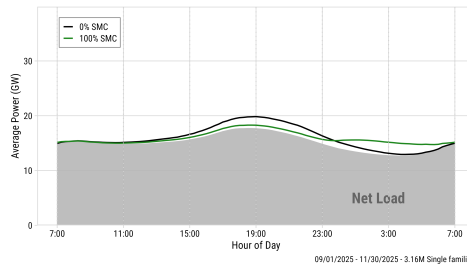
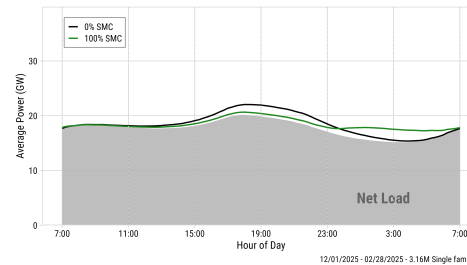


Seasonal Patterns: CAISO

Spring	Summer	Fall	Winter
CAISO 0% SMC 100% SMC Average Power (GW) Hour of Day Net Load 03/01/2025 - 05/31/2025 - 7.69M Single families	CAISO 0% SMC 100% SMC Average Power (GW) Hour of Day Net Load 06/01/2025 - 08/31/2025 - 7.69M Single families	CAISO 0% SMC 100% SMC Average Power (GW) Hour of Day Net Load 09/01/2025 - 11/30/2025 - 7.69M Single families	CAISO 0% SMC 100% SMC Average Power (GW) Hour of Day Net Load 12/01/2025 - 02/28/2025 - 7.69M Single families
3.7 GW (27.5 → 23.8)	3.7 GW (34.3 → 30.6)	3.8 GW (32.3 → 28.5)	3.6 GW (29.1 → 25.5)
13.5%	10.8%	11.8%	12.4%
Peak shave for all seasons: 3.6–3.8 GW (10.8–13.5%)			

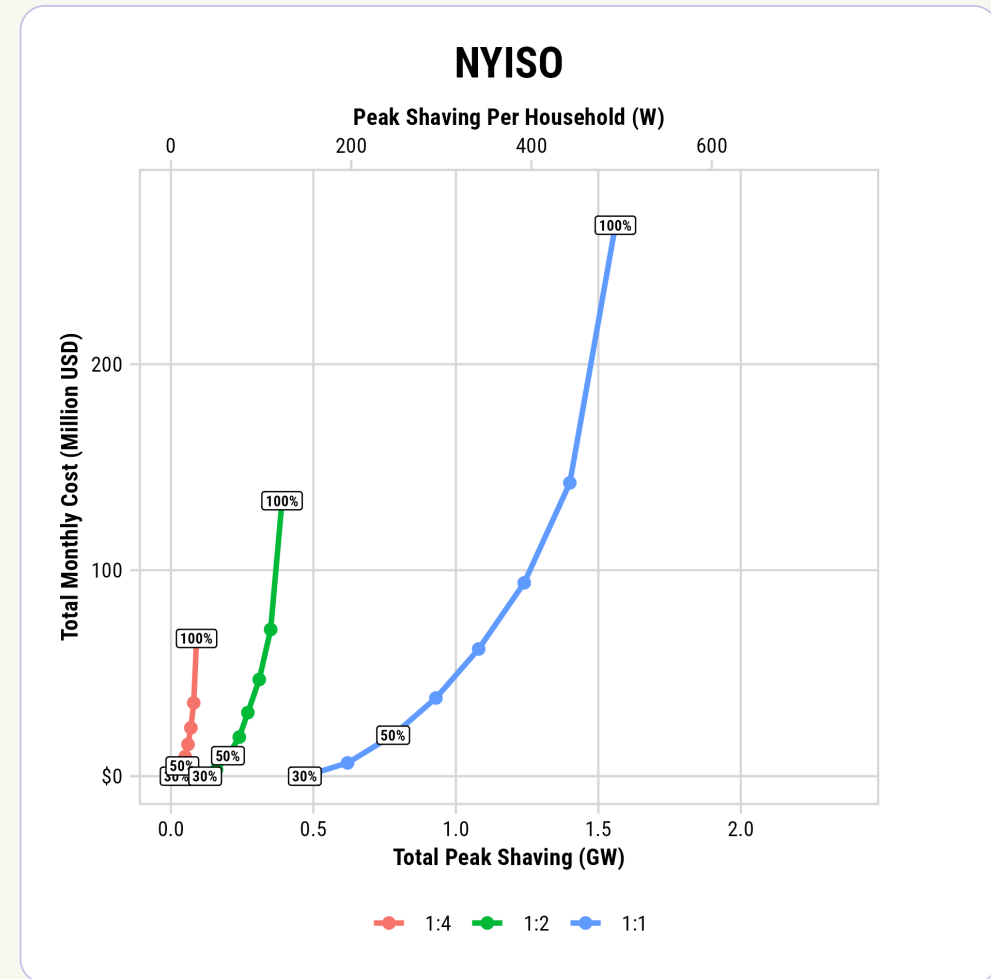
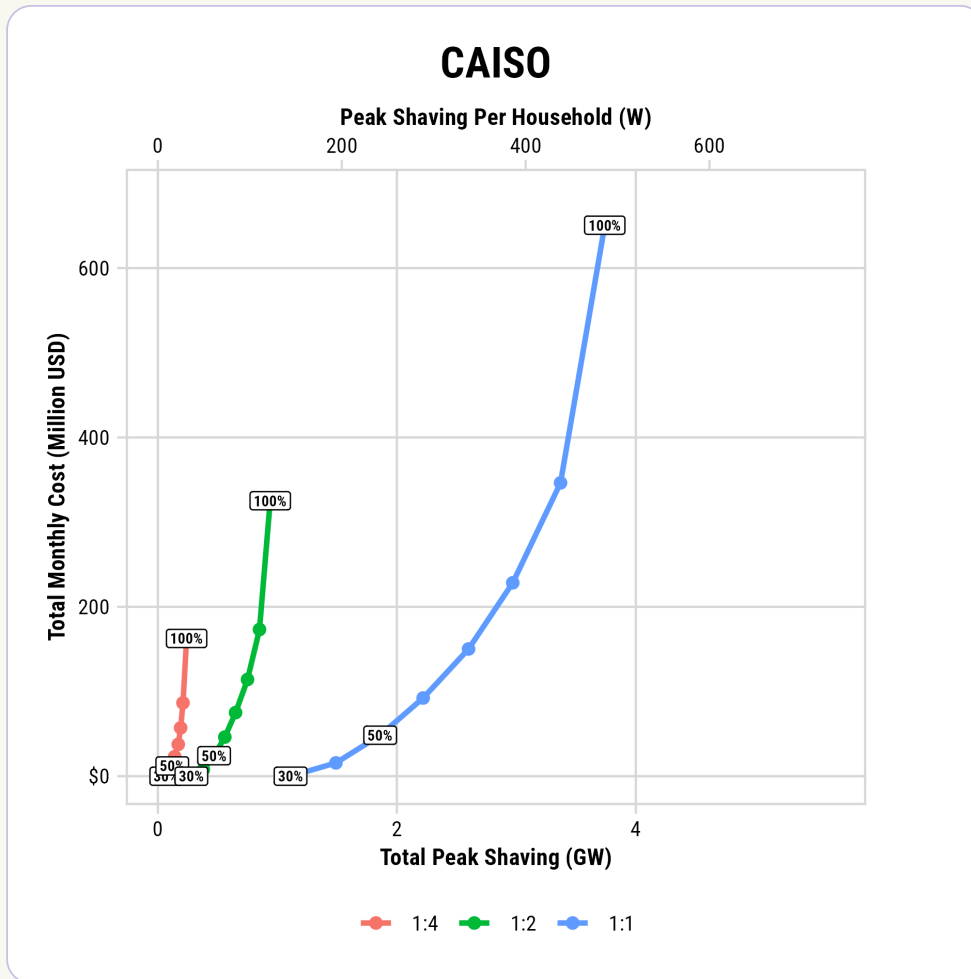


Seasonal Patterns: NYISO

Spring	Summer	Fall	Winter
 03/01/2025 - 05/31/2025 - 3.16M Single families	 06/01/2025 - 08/31/2025 - 3.16M Single families	 09/01/2025 - 11/30/2025 - 3.16M Single families	 12/01/2025 - 02/28/2025 - 3.16M Single families
1.5 GW (18.4 → 16.9)	1.6 GW (24.6 → 23.0)	1.5 GW (19.8 → 18.3)	1.4 GW (22.1 → 20.7)
8.2%	6.5%	7.6%	6.3%
Peak shave for all seasons: 1.4–1.6 GW (6.3–8.2%)			



Cost efficiency across BEV adoption rates



How Do Pilot Programs Compare?

Program	Incentive	Enrollment
PCE Managed Charging (CAISO)	\$0 → \$40 per month	1.4% → 10.6%
MCE Sync (CAISO)	\$50 bonus + \$10 per month	10% of serviceable market
SmartCharge New York (NYISO)	Up to \$400 per year	~7% of registered EVs (731 vehicles)

- Smart charging programs motivated EV owners to **charge off-peak**.
- More incentive results in more enrollment.
- Stated preference surveys are not calibrated against current pilot programs.



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