Day-Ahead Market Enhancements discussion

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General Session
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Discussion topics

- Real-time energy offer cap to incorporate energy costs into capacity procurement
- Energy storage resources and capacity procurement
- Local market power mitigation of imbalance reserves and reliability capacity

Day-Ahead Market Enhancements

REAL-TIME ENERGY OFFER CAP TO INCORPORATE ENERGY COSTS INTO CAPACITY PROCUREMENT

Real-time energy offer cap to incorporate energy costs into capacity procurement

- Market does not differentiate between two resources with same capacity offer but different energy offers when awarding upward capacity products
- Objective is to prevent opportunities for high energy cost resources from routinely being awarded IRU/RCU when the resources will rarely be dispatched for energy in the RTM
- Greater concern for IRU/RCU than contingency reserves because there is a higher likelihood of being dispatched for energy in RTM

Real-time energy offer cap limits imbalance reserve awards to resources with energy bids less than expected real-time price under high imbalance scenario

- Proposal includes a real-time energy bid price cap ("strike price") that applies to all resources awarded IRU/RCU
  - Bid cap set to expected real-time price under high upward imbalance scenario
- Resources with energy costs above cap must incorporate financial risk into IRU/RCU bid → higher bids for RCU and IRU → less likely to be awarded → meets policy objective
- Quantity of real-time energy bids subject to the real-time energy bid price cap limited to the MW quantity of IRU/RCU awards

Real-time energy offer cap calculation methodology and analysis

- **Objective**: calculate a real-time energy offer cap ($/MWh) at hourly or daily granularity that is available prior to close of day-ahead market bidding window

- Analysis explored a quantile regression using historical data to project next day's real-time energy offer cap
  - Regressors: ISO net load, natural gas commodity prices
  - Historical data: simple average of FMM DLAPs

Overview of real-time energy offer cap methodologies

Inputs
- Regressor
- Lookback period
- Data treatment

Regression
- Quantile
- Formula
- Additional steps

Projection
- RT energy offer cap ($/MWh)
- Daily or hourly granularity

Example methodologies

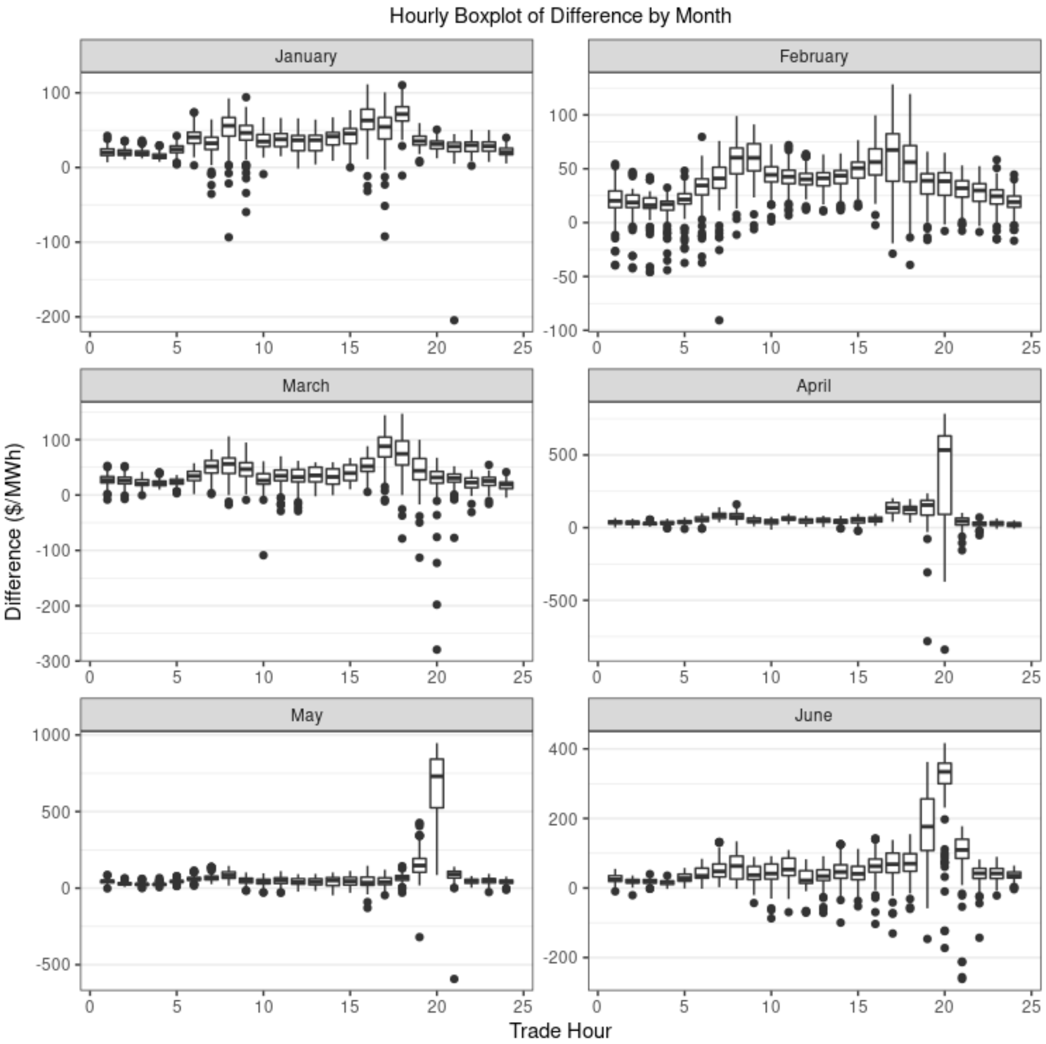
	Regressor(s)	Lookback period	Regression type	Quantile	Data granularity	Additional Treatment
1	Avg. gas price [a]	60/60	Linear	97.5	Fifteen minute	--
2	Avg. gas price	60/60	Linear	90	Fifteen minute	1.2 scalar [b]
3	Avg. gas price	45/0	Quadratic	97.5	Hourly	Weekend distinction
4	Avg. gas price and net load	30/30	Linear	90	Fifteen minute	--

a. Simple average of Socal Citygate and PG&E Citygate
b. Configurable scalar value

Metrics to compare effectiveness of real-time energy offer cap calculation methodologies

- **Coverage:** Percentage of time that the projected bid cap was sufficient to cover, i.e., was greater than or equal to, the actual FMM price.
- **Difference**: Difference between the projected bid cap and the actual FMM price. Positive difference indicates that the projected bid cap covers the actual FMM price.
- **Closeness**: Absolute difference between the projected bid cap and the actual FMM price.
- **Scale:** Ratio of the actual FMM price to the projected bid cap. A scale value less than one indicates that the projected bid cap covers the actual FMM price.

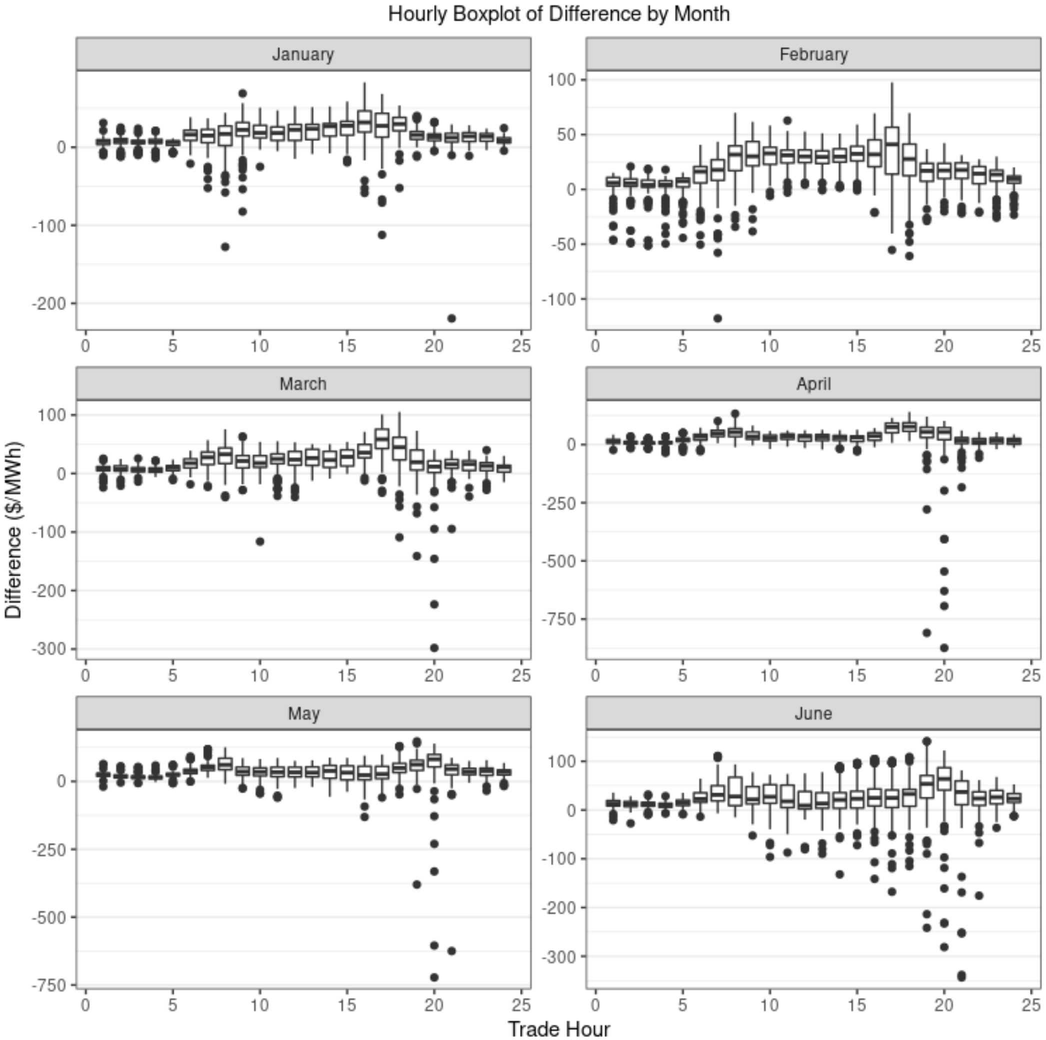
Methodology 1: Avg. Gas Price, 97.5 Quantile, 60/60 Lookback



Month	Coverage	Avg Closeness	Avg Difference	Avg Scale
Jan 2022	99.19%	35.75	35.21	0.60
Feb 2022	96.32%	37.32	36.20	0.54
Mar 2022	97.68%	37.88	36.73	0.53
Apr 2022	97.81%	73.95	70.80	0.49
May 2022	97.51%	81.35	79.87	0.51
Jun 2022	95.59%	64.04	60.92	0.59

- Some case examples for variation:
  - 2022-04-07 prices near $1000
  - 2021-07-09 prices above $1000, up to $1500

Methodology 2: Avg. Gas Price, 90 Quantile, 60/60 Lookback, 1.2 Scalar



Month	Coverage	Avg Closeness	Avg Difference	Avg Scale
Jan 2022	98.42%	29.92	29.13	0.64
Feb 2022	96.13%	32.39	31.22	0.57
Mar 2022	97.21%	33.80	32.48	0.55
Apr 2022	97.57%	50.01	46.07	0.53
May 2022	97.78%	57.73	55.12	0.51
Jun 2022	95.21%	47.74	43.45	0.62

- Scalar of 1.2 was selected as it provided modest increase to coverage while keeping closeness at lower values

Methodology 1 vs. Methodology 2 – all metrics

1. Avg gas price, 97.5 quantile, 60/60 lookback

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2. Avg gas price, 90 quantile, 60/60 lookback, 1.2 scalar

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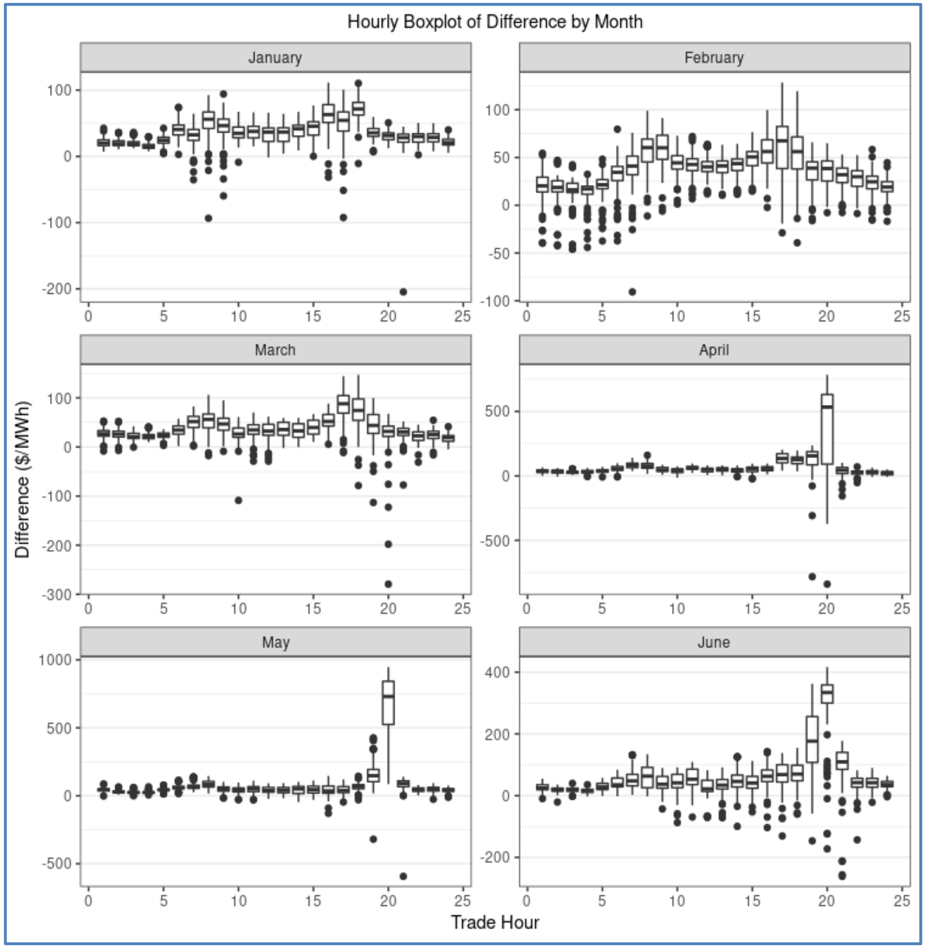
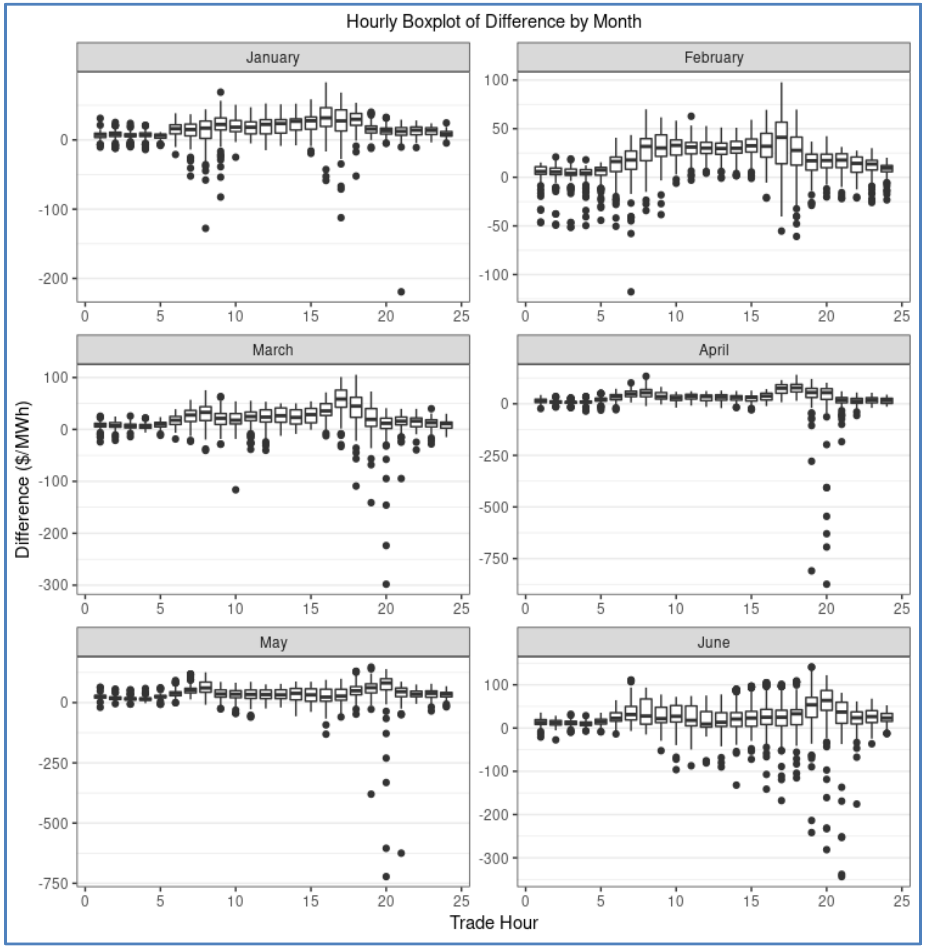
- Similar metrics for coverage and scale
- Lower closeness and difference values for methodology 2 → indicates lower potential to overestimate cap
- Application of 1.2 scalar improved coverage metrics across study months, while sacrificing modest increases in closeness, difference, and decrease in scale (compared to the same test without application of a scalar)

Methodology 1 vs. Methodology 2 - Difference





Day-Ahead Market Enhancements

ENERGY STORAGE RESOURCES AND CAPACITY PROCUREMENT

Energy storage resources and capacity procurement

- IFM limits the capacity that can be awarded to an energy storage resources to not violate state of charge constraints

$$SOC_{i,t} = SOC_{i,t-1} - \left(EN_{i,t}^{(+)} + \eta_i\, EN_{i,t}^{(-)}\right)$$

$$\left.\begin{aligned} \underline{SOC}_{i,t} + RU_{i,t} + SR_{i,t} + NR_{i,t} + IRU_{i,t} \le SOC_{i,t} \\ SOC_{i,t} \le \overline{SOC}_{i,t} - \eta_i\left(RD_{i,t} + IRD_{i,t}\right) \end{aligned}\right\}, \forall i \in S_{LESR} \wedge t = 1,2,\ldots,T$$

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$$SOC_{i,t} = SOC_{i,t-1} - \left(EN_{i,t}^{(+)} + \eta_i EN_{i,t}^{(-)} \right)$$

A resource's state of charge in the current interval is the state of charge in the previous interval +/- the current interval charging or discharging schedule

$$\left. \begin{array}{l} \underline{SOC}_{i,t} + RU_{i,t} + SR_{i,t} + NR_{i,t} + IRU_{i,t} \leq SOC_{i,t} \\ SOC_{i,t} \leq \overline{SOC}_{i,t} - \eta_i \left(RD_{i,t} + IRD_{i,t} \right) \end{array} \right\}, \forall i \in S_{LESR} \wedge t = 1,2, \ldots, T$$

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The sum of upward capacity awards cannot exceed the quantity between the resource's current state of charge and it's minimum state of charge

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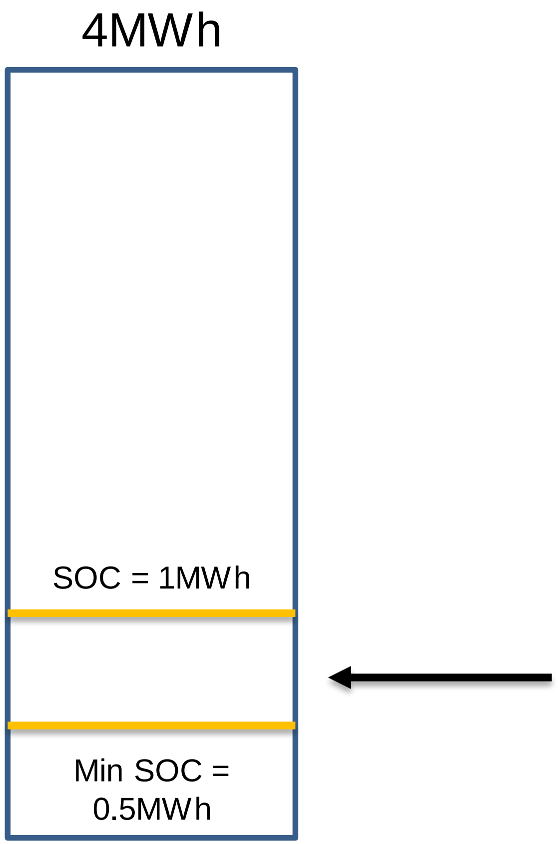
The sum of downward capacity awards cannot exceed the quantity between the resource's current state of charge and it's maximum state of charge

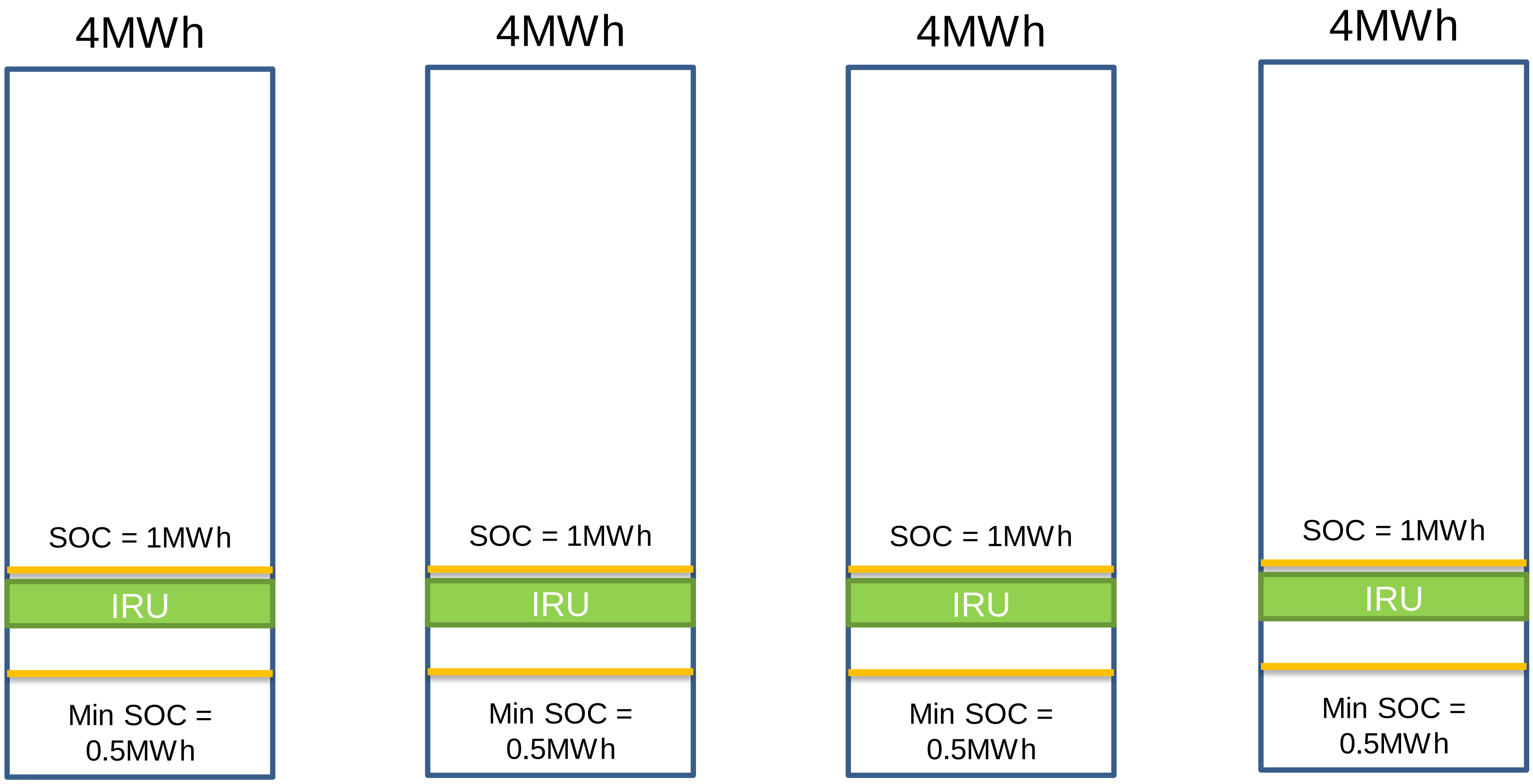
Energy storage resources and capacity procurement



SOC capacity constraint ensures upward capacity cannot exceed this range within any hourly interval. But what about between intervals?

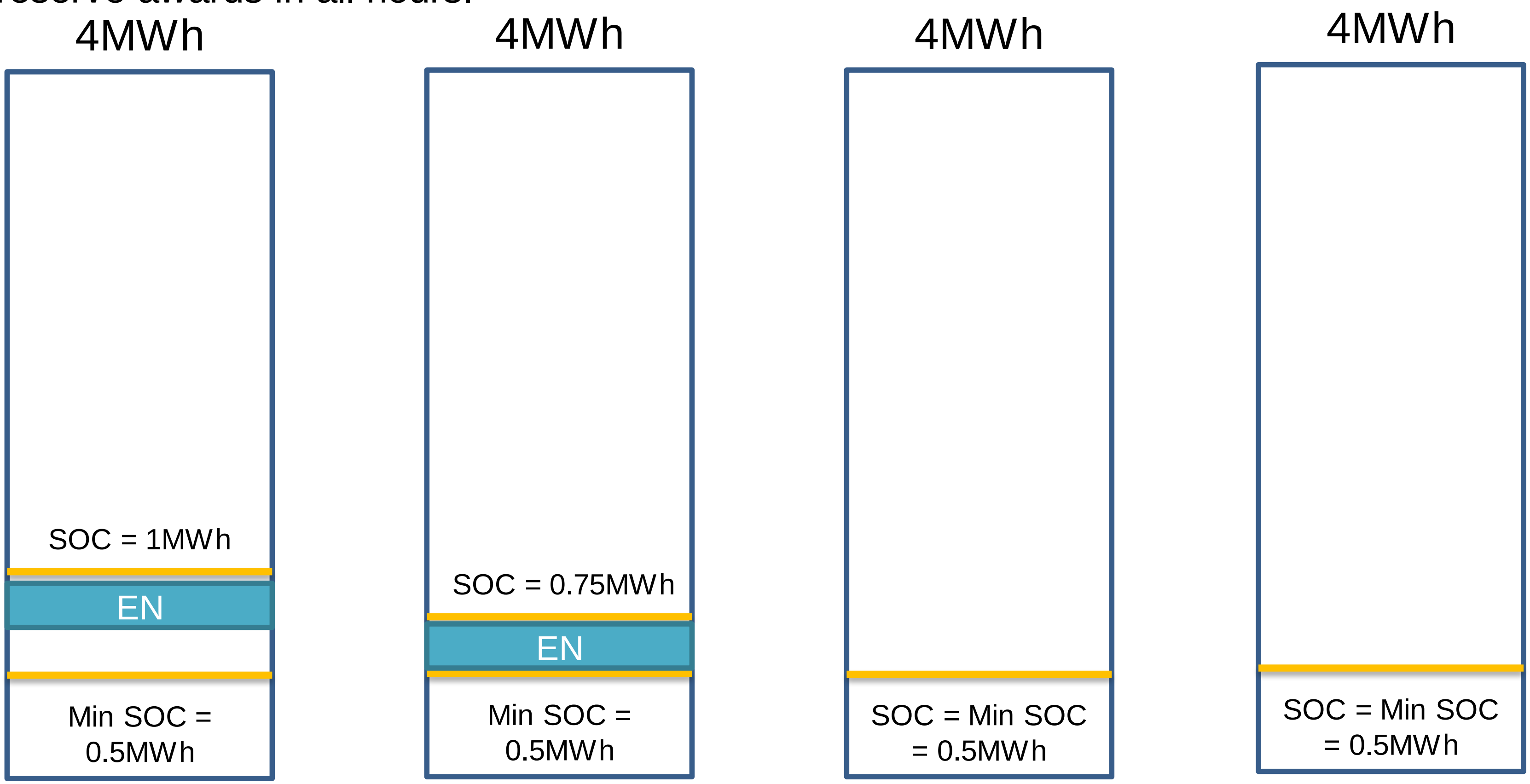
Energy storage resources and capacity procurement

In the day-ahead market, this resource can get an imbalance reserve up award over several consecutive hours. That the SOC is not changing over hours assumes the resource is not receiving charging/discharging schedules.



Energy storage resources and capacity procurement

In the real-time market, this resource has a must-offer obligation to provide energy bids. Assuming upward uncertainty materializes, this resource is dispatched for energy. The resource does not have sufficient state of charge to maintain imbalance reserve awards in all hours.



Energy storage resources and capacity procurement

- State of charge formulation does not assume capacity awards ultimately increase/decrease state of charge
- This can result in “leaky” capacity and dilutes the quantity of reserves held across the day
- Also creates a disconnect between the way storage resources are incentivized to participate in the market and how they can be most useful to the system
  - E.g., when load uncertainty materializes we want to rely on resources holding imbalance reserves to provide RT energy, but storage resources have to manage their exposure to no pay settlements

Energy storage resources and capacity procurement

- $SOC_{i,t} = SOC_{i,t-1} - \left(EN_{i,t}^{(+)} + a_{RU}\, RU_{i,t} + a_{SR}\, SR_{i,t} + a_{NR}\, NR_{i,t} + IRU_{i,t} + \eta_i \left(EN_{i,t}^{(-)} - a_{RD}\, RD_{i,t} - IRD_{i,t}\right)\right)$
- State of charge formulation would be updated to assume that imbalance reserve awards are deployed in the real-time market (similar formulation would be extended to RCU/RCD)
- The configurable coefficients “a” are between 0 and 1 and reflect the expectation that some energy will be produced/consumed for positive/negative capacity services.

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LOCAL MARKET POWER MITIGATION OF IMBALANCE RESERVES AND RELIABILITY CAPACITY

Local market power mitigation of imbalance reserves and reliability capacity

- **Previous proposal**: mitigate imbalance reserve and reliability capacity offers using DCPA criteria but only use competitive LMP as mitigation price (no default bids)
  - "Default availability bids" ≠ default energy bids

- Local market power mitigation of imbalance reserves and reliability capacity is appropriate because they are nodally procured and therefore local market power could exist

- Modifying proposal to re-introduce a default bid and not just mitigate availability bids only to a competitive LMP

Default availability bids

- Need more information to design **default availability bids** to the same rigor as **default energy bids**

- CAISO believes a conservative (from supplier's perspective) and system-wide default bid (same for all resources) can provide a mitigation "floor" in the short-run as CAISO and market participants gain operational experience with imbalance reserves and reliability capacity
  - Would still propose to limit mitigation to competitive LMP if it is higher

- After sufficient information on costs of offering these products under competitive conditions is available, CAISO would re-engage stakeholders on developing a more rigorous methodology

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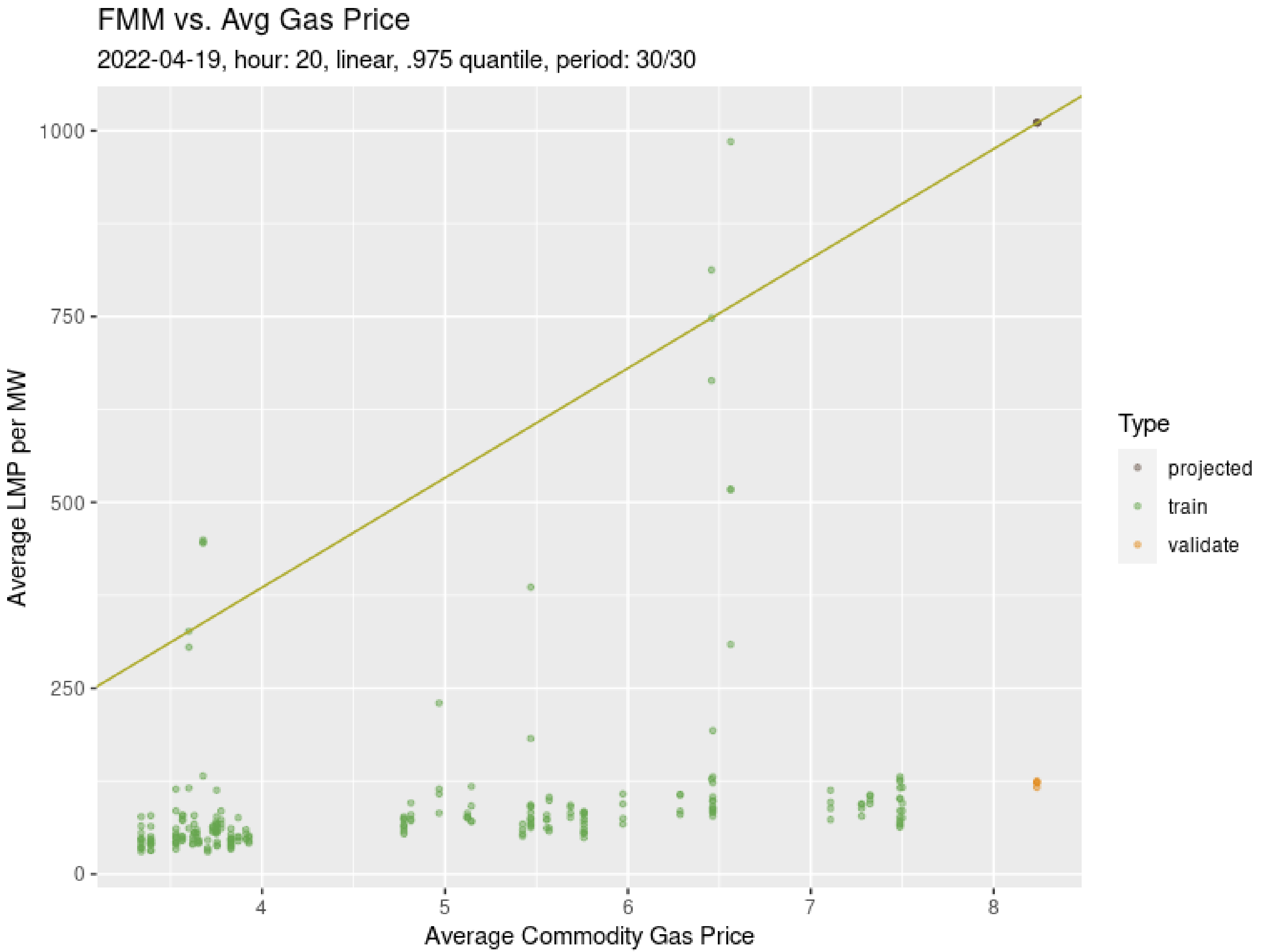
APPENDIX

Motivation for testing different quantiles



Other methodologies and inputs explored

- Quantile regression w/ quadratic formula
  - Observed multiple instances of extreme outliers with the projected cap much greater than actual FMM price
- Using net load as regressor
  - Generally performed worse than comparable tests that only used gas prices; modest improvement when considered along with gas prices in a multivariate regression
- Week days/weekends as a feature in the regression
  - Lower coverage without significant improvement in other metrics
- Daily bid cap instead of hourly bid cap (i.e. one $/MWh value per day instead of 24 distinct $/MWh values)
  - Eliminates some variability present with hourly methodologies and introduces simplicity but may over/underestimate cap depending on how it is set