Capturing Net Load Uncertainty:
RUC Uncertainty and Imbalance Reserve Requirements

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Special thank you to Hong Zhou & Tobiah Steckel for work in this area

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ESIG Meteorology and Markets Workshop – Denver, CO

Agenda

- CAISO Overview

- CAISO Net-Load Uncertainty Requirement Product Review

- Review metrics to analyze performance of probabilistic uncertainty forecasting

- Review of existing process

  – RUC Uncertainty Requirement Recommendation

  – Define Realized Uncertainty

- Review Transition to Imbalance Reserve Requirements

  – Extreme weather conditions considerations

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As a federally regulated nonprofit organization, the ISO manages the high-voltage electric grid.
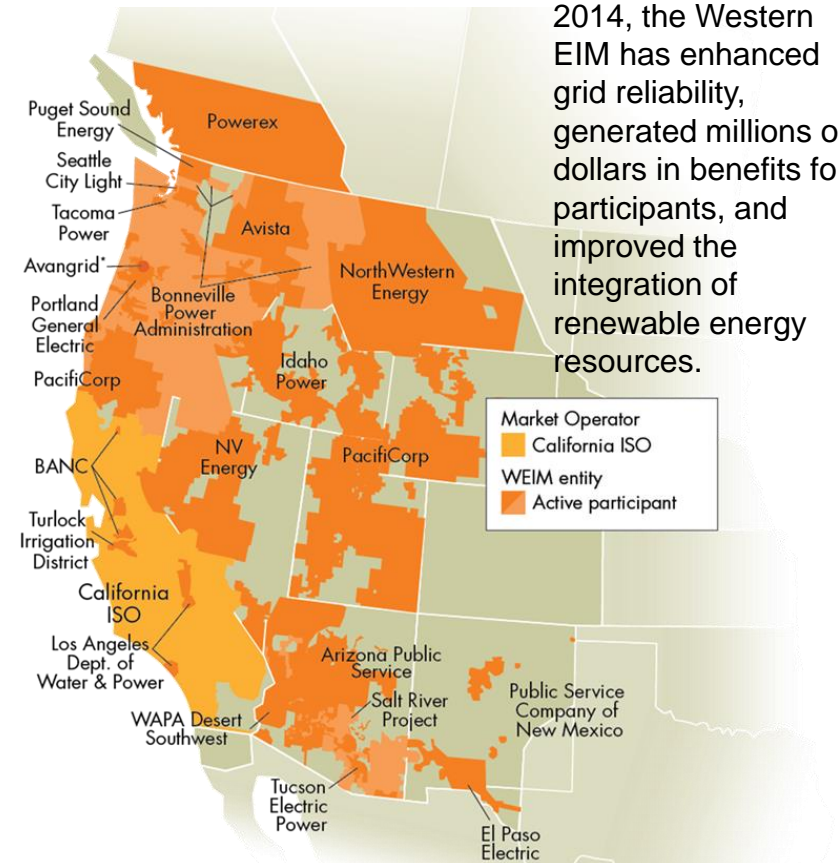
52,061 MW record peak demand (Sept. 6, 2022)

224.8 million megawatt-hours of electricity delivered (2020)

75,747 MW power plant capacity
Source: California Energy Commission

1,119 power plants
Source: California Energy Commission

Since its launch in 2014, the Western EIM has enhanced grid reliability, generated millions of dollars in benefits for participants, and improved the integration of renewable energy resources.

Puget Sound Energy
Seattle City Light
Tacoma Power
Avangrid*
Portland General Electric
PacifiCorp
BANC
Turlock Irrigation District
California ISO
Los Angeles Dept. of Water & Power
WAPA Desert Southwest

Powerex
Avista
NorthWestern Energy
Bonneville Power Administration
Idaho Power
NV Energy
PacifiCorp
Arizona Public Service
Salt River Project
Public Service Company of New Mexico
Tucson Electric Power
El Paso Electric

Market Operator
California ISO
WEIM entity
Active participant

*Avangrid office; generation-only BAA with distribution across multiple states.
Map boundaries are approximate and for illustrative purposes only.

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Current Renewable Penetration Facts

Historical statistics and records *(as of 5/12/2023)*

☀ Solar peak NEW!
14,812 MW
May 12, 2023 at 2:28 p.m.

Previous record:
14,774 MW, April 27, 2023

〜 Wind peak
6,465 MW
May 28, 2022 at 5:39 p.m.

Previous record:
6,265 MW, March 4, 2022

🍃 Peak percentage of renewables compared to demand
103.5%
May 8, 2022 at 3:39 p.m.

Previous record:
99.87%, April 30, 2022

⇄ Peak net imports
11,894 MW
Sept. 21, 2019 at 6:53 p.m.

📅 Peak demand
52,061 MW
Sept. 6, 2022 at 4:57 p.m.

Second highest:
50,270 MW, July 24, 2006

↗ Steepest 3-hour average ramp
20,326 MW
Feb. 15, 2023 starting at 3:00 p.m.

Second highest:
19,699 MW, Jan. 23, 2023

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[1] Based on 1-minute averages, and includes dynamic transfers. Values are subject to revision as data is refined.
[2] Indicates the highest amount of renewables serving peak electricity demand on any given day.

Currently Installed	Capacity
Number of Renewable Resources	507
MW Capacity Large Scale Renewables	23,094 MWs
MW Capacity Behind-the-Meter Solar	13,700 MWs

*Values are approximate as of April 2023

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Net-Load Uncertainty Requirements

Figure 1: Monthly Trend of Day-Ahead Imbalance
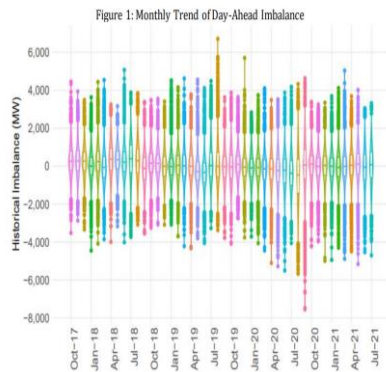
¹⁴ Day-Ahead Market Enhancements Analysis, page 7

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How do we assess the performance of probabilistic forecasts?

- Four criteria in measurements
  - <u>Coverage</u>: This is used to check the validity of a model, and is the coverage of observed uncertainty against the estimate requirement. The uncertainty requirement is targeted for 95%, which is achieved with 97.5% for upward and 2.5% for downward requirement.
  - <u>Requirement</u>: This is the average of the estimated requirement over a period of time.
  - <u>Closeness</u>: This is defined as the average distance between the observed uncertainty and the estimated requirement.
  - <u>Exceeding</u>: this is the average MW difference when the observed uncertainty is exceeding the estimated requirement.

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Current Process: Definition of Observed (Realized) Uncertainty

<u>Observed (realized) Uncertainty is:</u>

*Uncertainty_{RUC} = Max Net $\text{Load}_{RTD\ Binding}$ − Net Load_{DA}
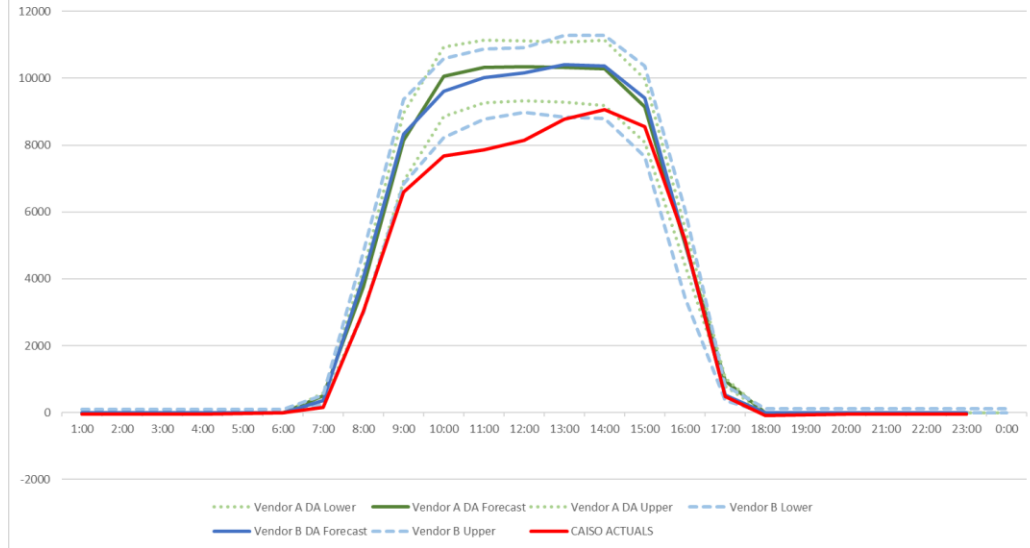
Captures model bias, movement and uncertainty in one coherent metric

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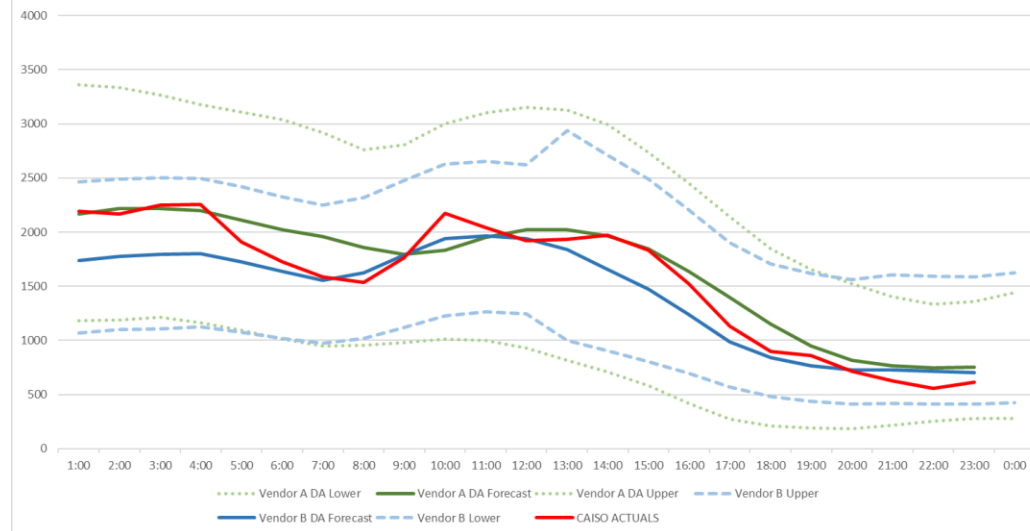# Additive Approach: Use of Uncertainty information into Load Conformance

CAISO Copyright © 2023
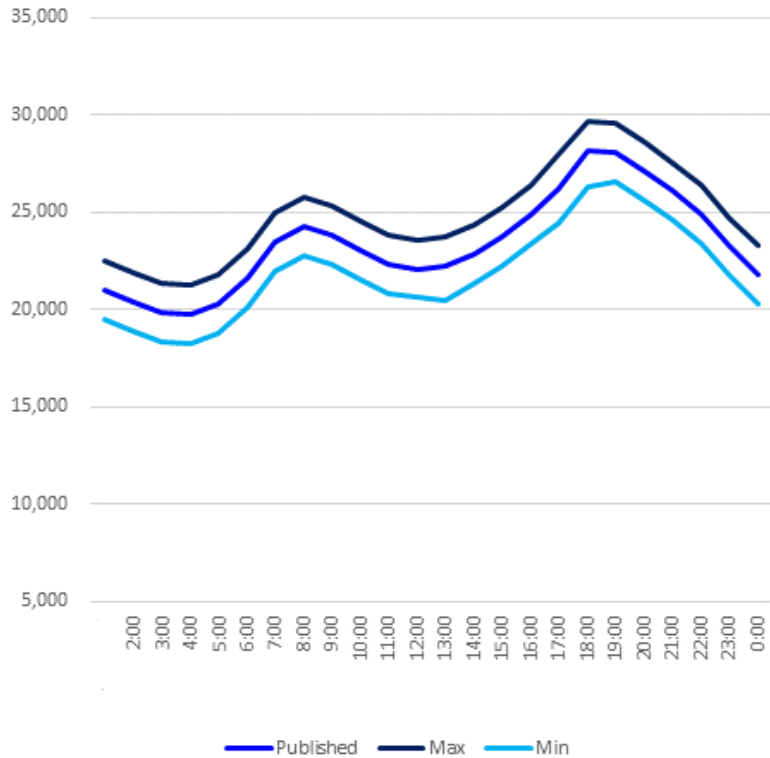
Additive Approach described

- Load Uncertainty:
  - guided by an upper confidence band.
  - Confidence band uses historical days to assess the maximum load forecast that could be exhibited under similar weather conditions.

- Renewable Uncertainty:
  - Guided by forecasting recommended value
  - Recommended value guided by historical vendor forecast performance under similar weather conditions and low probabilistic band provided by renewable providers

- Solar net movement:
  - Account for intra-hour ramp due to solar (sun-rise/sun-set)

- Other (non-forecasted) additions by operators such as risk of fires

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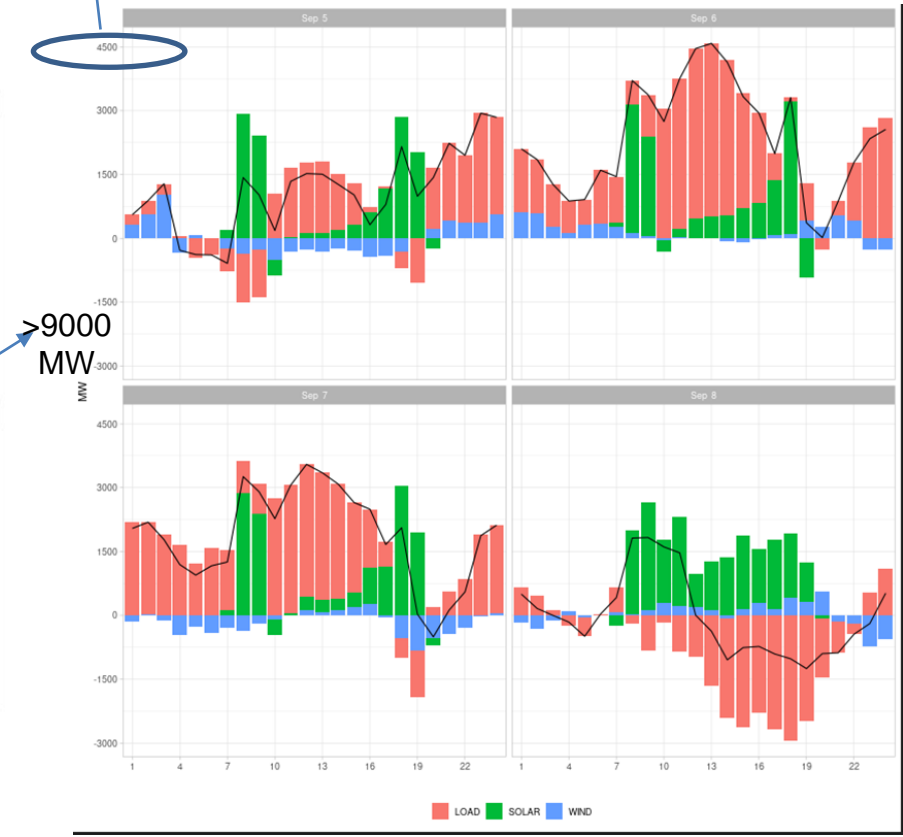# Additive approach resulted in too high of RUC uncertainty requirements

RUC Requirement Utilized

7500 MW
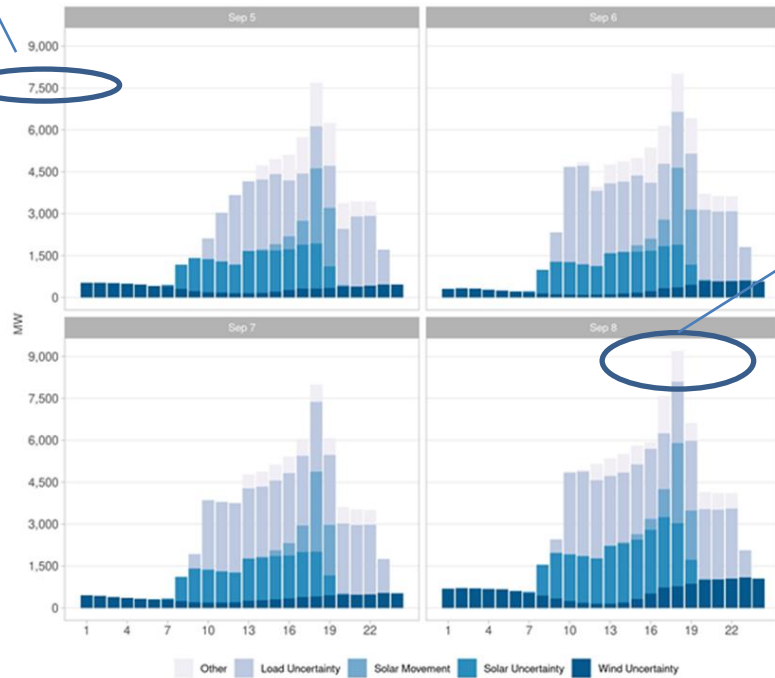
Realized Uncertainty Observed

4500 MW

>9000 MW

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http://www.caiso.com/Documents/SummerMarketPerformanceReportforSeptember2022.pdf

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Proposed Change: Utilize Imbalance Requirements (*similar* to DAME approved design)

- Simulation of performance over the last ~500 days, with highlighted periods (e.g., 2022 heat wave, Summer, >35,000 MW days

- Trialed Methodologies

  - Mosaic methodology
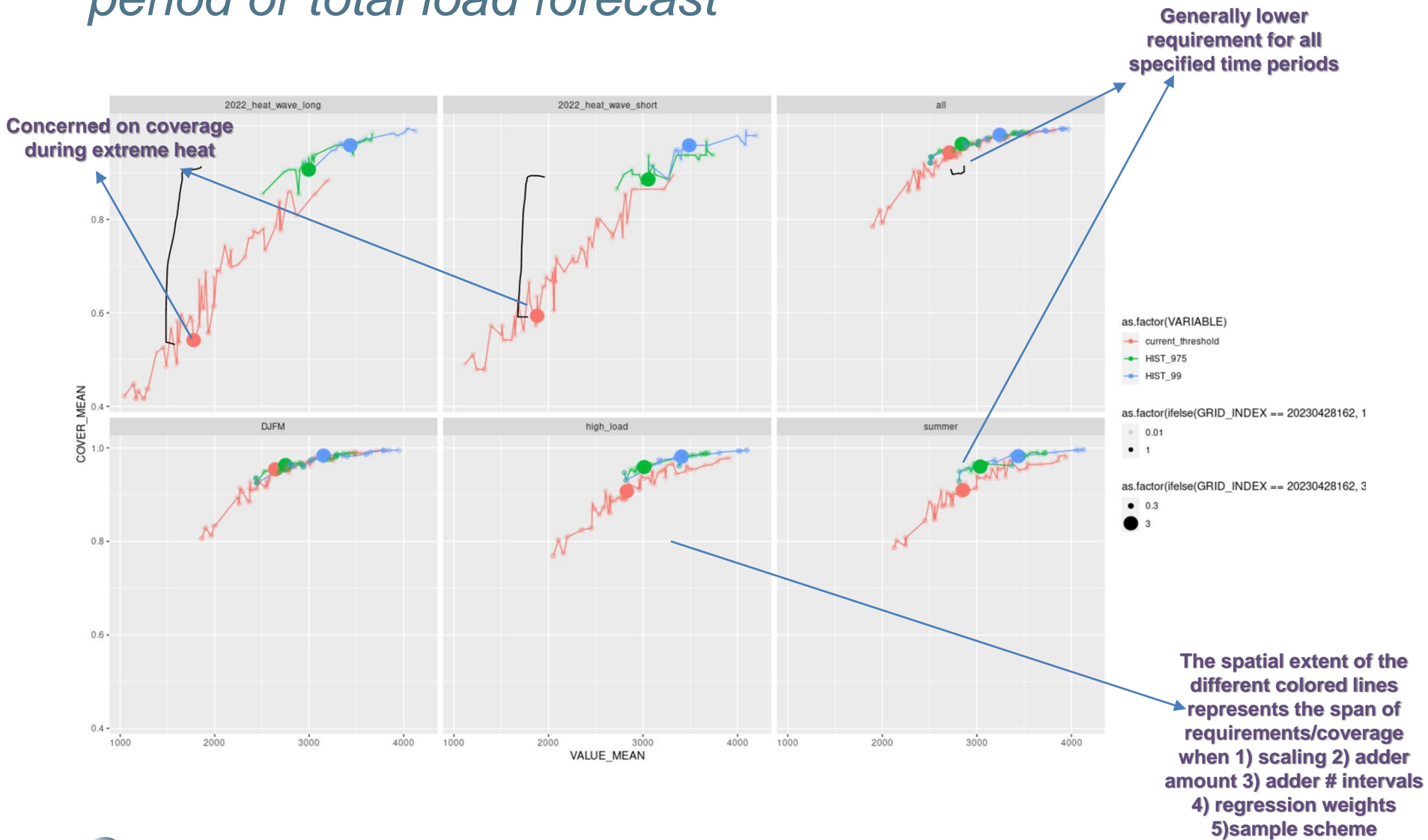
  - 97.5% Net Load Histogram

  - 99% Net Load Histogram

Trialing Multiple Options: *Assessing different methodologies with different "configurations"*

The historical data utilized is critical to success of probabilistic forecast.

- **Sampling Scheme 1**: Rolling previous 90 days matching weekdays and 20 matching weekends.

- **Sampling Scheme 2**: A fixed 180 rolling days with varying number of weekdays and weekend (holidays included). The increased sample size will bolster the robustness of regression computations. This is the sampling scheme currently utilized for FRP.

- **Sampling Scheme 3**: In addition to the sampling scheme 1, us the forward historical data in last year anchored from a date similar to the current day with matching weekday/weekend. The scheme balances out backwards and forward data for any given day.

*Forms of Sampling Scheme 3 perform the best; next slides show 130 unique combinations trialed.

Trialing Multiple Options: *All results binned by time period or total load forecast*

Generally lower requirement for all specified time periods

Concerned on coverage during extreme heat

The spatial extent of the different colored lines represents the span of requirements/coverage when 1) scaling 2) adder amount 3) adder # intervals 4) regression weights 5)sample scheme

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Trialing Multiple Options: Broad takeaways

- When considering the most extreme (supply-constrained) days, a large departure in coverage between mosaic and histogram is evident

- When considering broader periods of time, mosaic has comparable coverage with a lower average requirement

- It is found that changing default configuration can assist in coverage during critical uncertainty days

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Next Steps

- As the ISO continues to evolve the assessment of uncertainty and how it could guide RUC adjustments, the ISO is working to incorporate Imbalance Reserve Requirement Design during all non **Weather Extreme** days.

- Upon results work towards process too allow **change to the percentile** utilized to protect coverage **during weather extremes**.

  – This is similar to the process ran for regulation requirements.

- Continue to further assess non-heat driven events coverage

APPENDIX

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Imbalance Reserves vs. Real-Time Flexible Ramping Product

Imbalance Reserves

- Hourly Product

- 15-minute dispatchable (30-minutes of ramp)

- Biddable

- Covers granularity difference <u>and</u> uncertainty between DAM and FMM

- All awards are co-optimized and settled simultaneously

RT Flexible Ramping Product

- 15-minute product

- 5-minute dispatchable

- Not biddable

- Cover uncertainty from FMM to RTD

- Awards are calculated in successive runs and are only settled from the binding to the first advisory interval

- Demand Curve for uncertainty
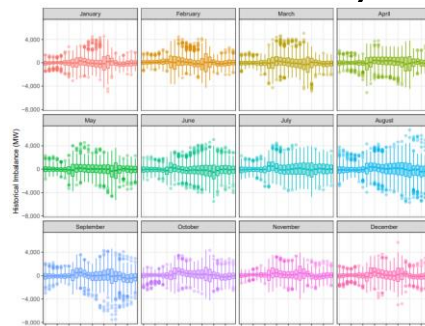
Figure 2: Hourly trend of Day-Ahead Imbalance Reserve.
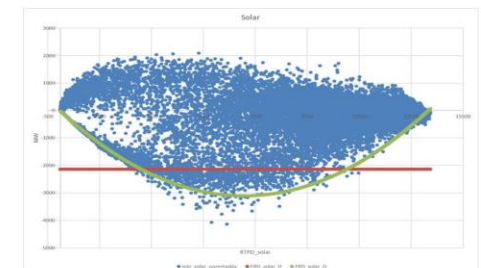
Proposed methodology (green line) tracks more closely the solar production conditions, while current methodology (red line) is constant at any level of solar production.
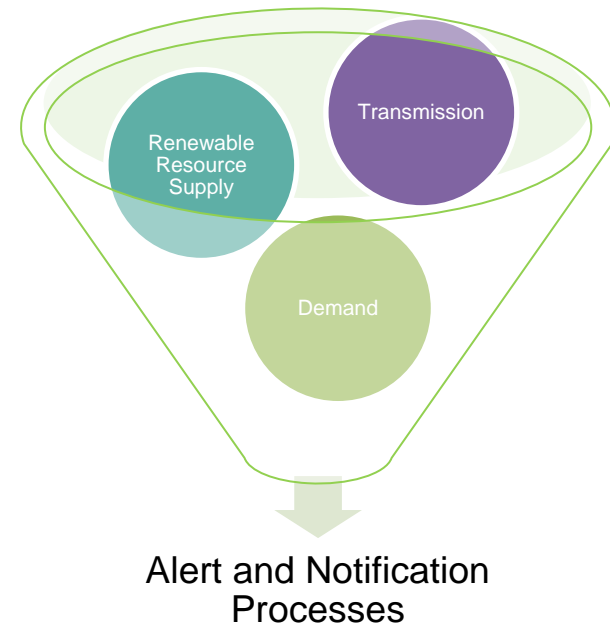
Forecasting and Monitoring Extreme Weather Conditions

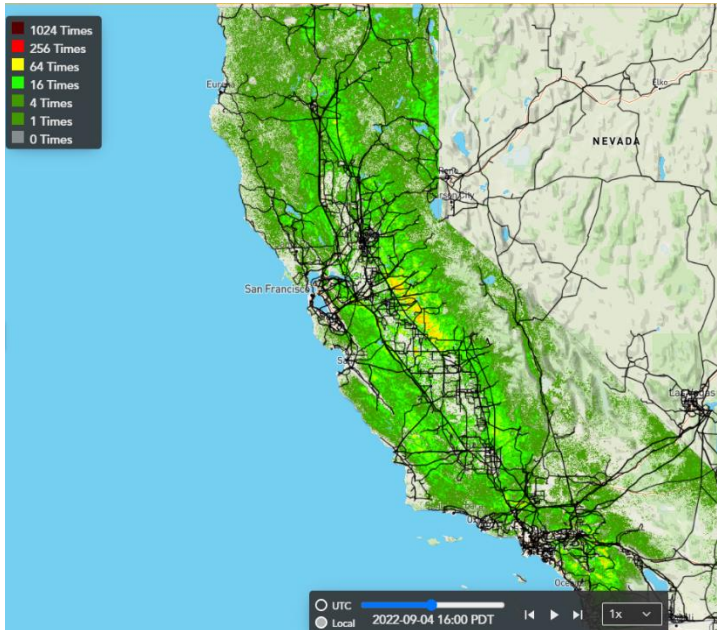# Forecasting Awareness and Transparency

- **Forecasting alerts** generated from **team of trained meteorologists** to identify extreme weather conditions up to 365 hours ahead of the event.

  - Weather, load, renewable, and fire forecasting/alerts

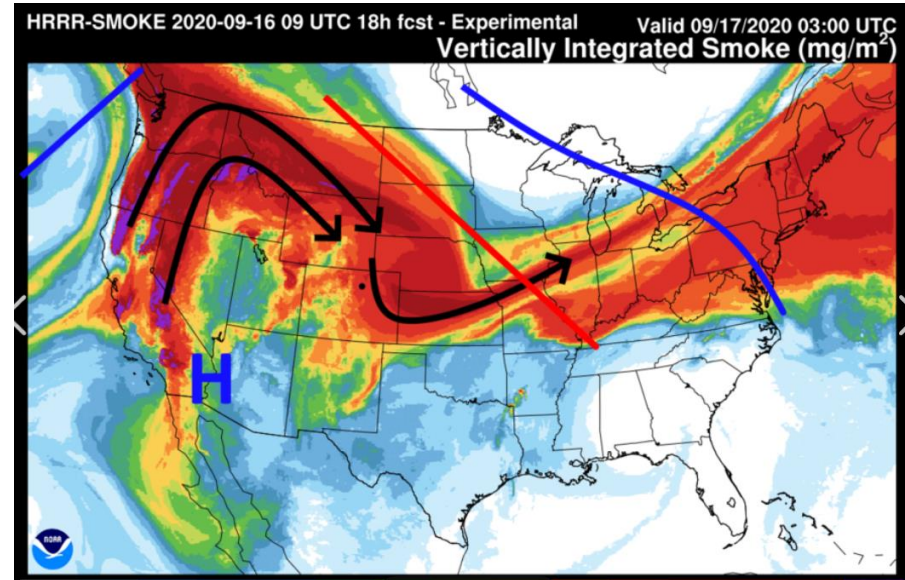 - Forecasting and alerts cover CAISO area, WEIM areas, and the West at large

Available RA capacity + RA credits | Demand + reserve req. | Day-ahead forecast* + reserve req.
Available net RA capacity + RA credits | Net demand + reserve req. | Day-ahead net forecast* + reserve req.

California ISO - Today's Outlook (caiso.com)
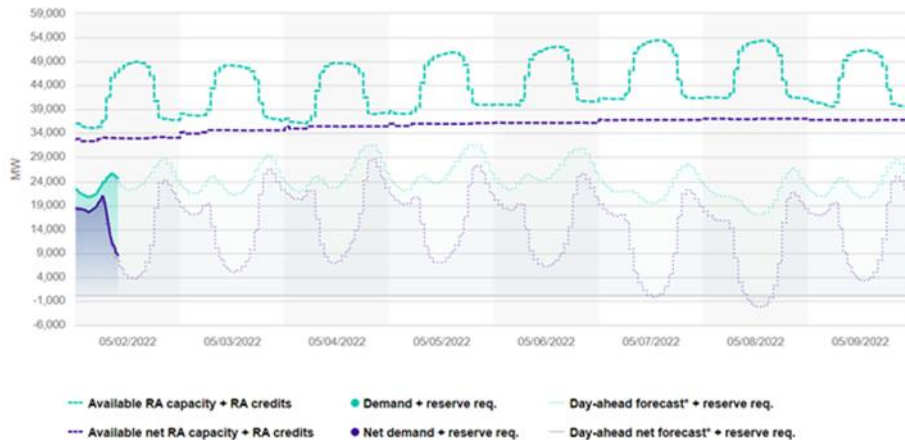
Assessing Weather Uncertainty Impact

Alert and Notification Processes

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Fire Forecasting Tools and Alerts

Wildfire Forecasts (pyrecast.org)

High-Resolution Rapid Refresh (HRRR) (noaa.gov)

Fire Weather Forecast:
Monitoring SoCal Interior during extended period of hot/dry conditions.

Value	Fire Risk
1	Normal
2	Elevated
3	Extreme

Fire Risk Matrix										
	Region	Thu 9-1	Fri 9-2	Sat 9-3	Sun 9-4	Mon 9-5	Tue 9-6	Wed 9-7	Thu 9-8	Fri 9-9	Region
PG&E	Bay	1	1	1	1	1	1	1	1	1	Bay
PG&E	Non-Bay	1	1	1	1	1	1	1	1	1	Non-Bay
SCE	Coast	1	1	1	1	1	1	1	1	1	Coast
SCE	Inland	2	2	2	2	2	2	2	1	1	Inland
SDG&E	Coast	1	1	1	1	1	1	1	1	1	Coast
SDG&E	Inland	2	2	2	2	2	2	2	1	1	Inland

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