Flexibility Products in Markets and Operations

ESIG Fall Technical Workshop
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Agenda

- CAISO Overview
- Challenges
- Uncertainty Tools

California ISO

As a federally regulated nonprofit organization, the ISO manages the high-voltage electric grid.

52,061 MW record peak demand (Sept. 6, 2022)

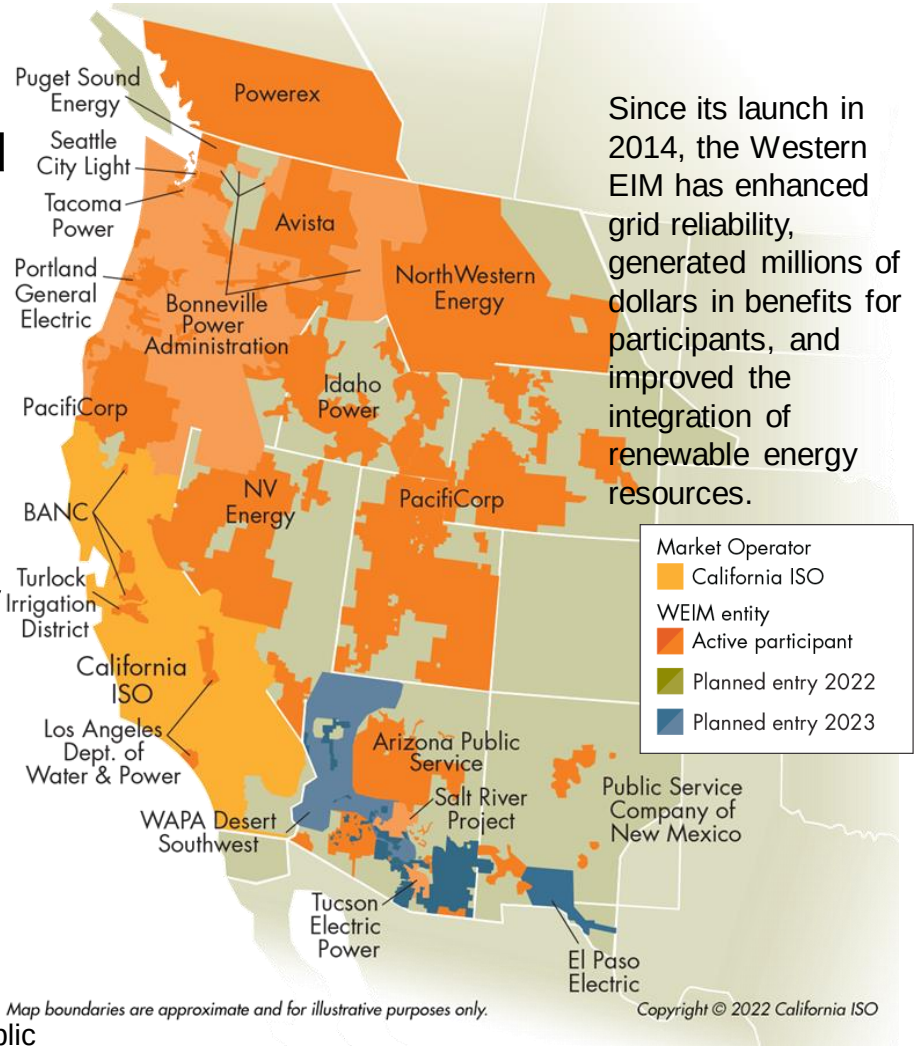
224.8 million megawatt-hours of electricity delivered (2020)

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.

Current Renewable Penetration Facts

Historical statistics and records *(as of 10/01/2022)*

Solar peak
14,352 MW
June 7, 2022 at 12:16 p.m.
Previous record:
14,136 MW, May 16, 2022

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 at 4:57 p.m.
Second highest:
50,270 MW, July 24, 2006

Steepest ramp over 3-hour period
17,660 MW
March 11, 2022 starting at 2:59 p.m.
Second highest:
17,298 MW, April 24, 2022

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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	500
MW Capacity Large Scale Renewables	21,500 MWs
MW Capacity Behind-the-Meter Solar	11,000 MWs

*Values are approximate as of November 2021

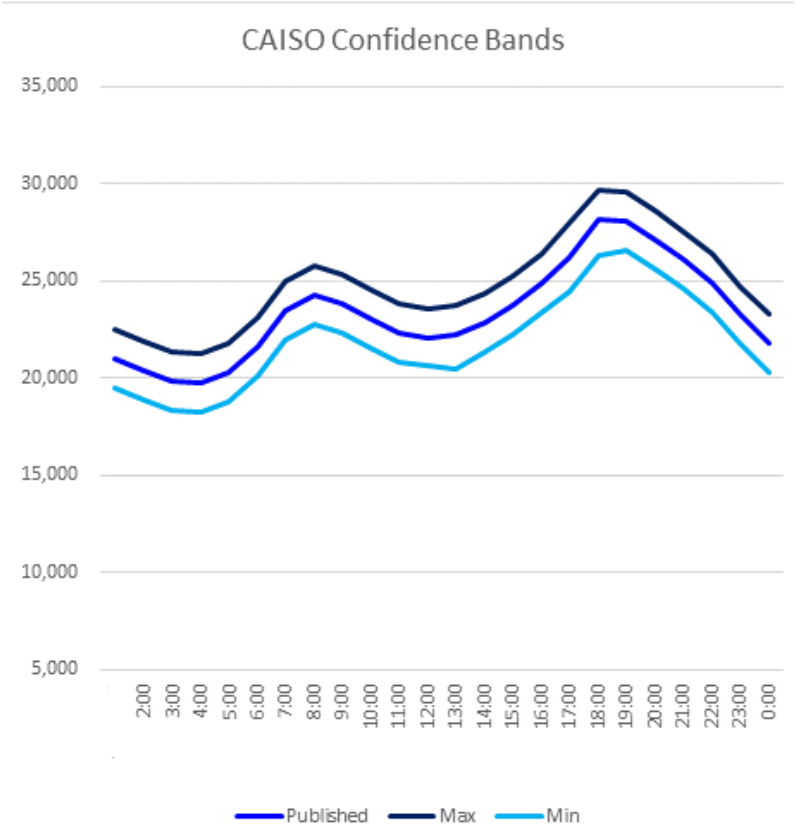
CHALLENGES

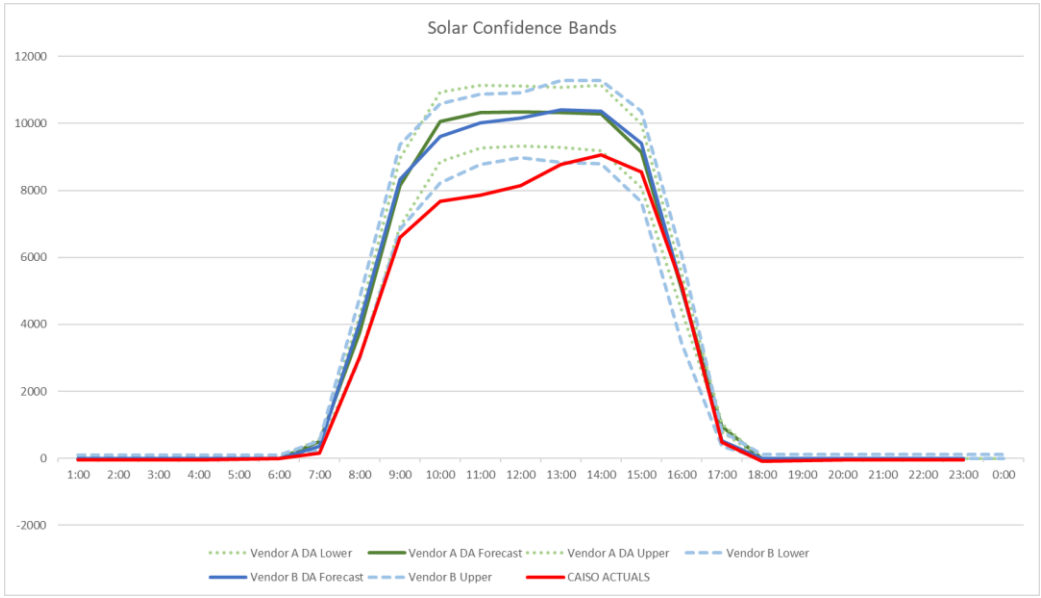
System and markets are evolving towards a non-deterministic environment

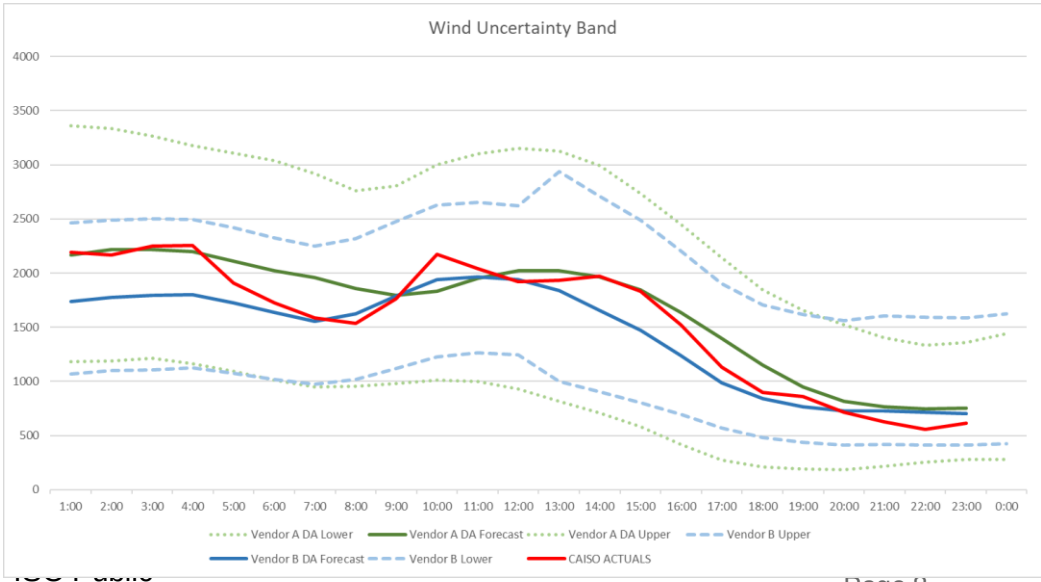
- Weather variables, such as temperatures, introduce uncertainty components to multiple variables in the power system, including
  - Load forecast
  - Behind the meter generation
  - Large scaled wind and solar production
  - Regulation requirements
- CAISO still uses a deterministic market clearing process with deterministic inputs
- Different products and procedures are developed to then “factor in” uncertainty

UNCERTAINTY TOOLS

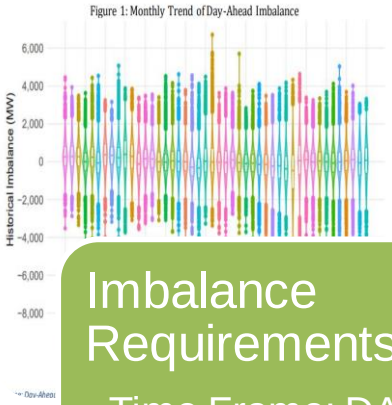
Use of Uncertainty information into Load Conformance





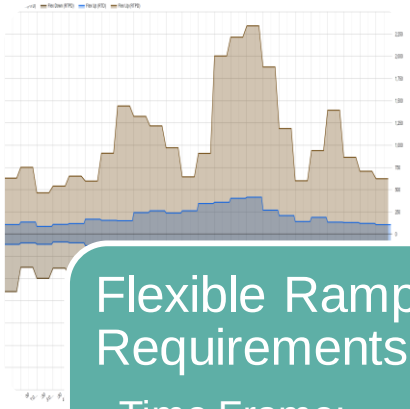


Net-Load Uncertainty Requirements



Imbalance Requirements

- Time Frame: DA to FMM
- Method: Quantile Regression



Flexible Ramp Requirements

- Time Frame: FMM to RTD
- Method: Quantile Regression

Regulation Requirements

- Time Frame: RTD to Actual
- Method: Combination

Imbalance Reserves vs. Real-Time Flexible Ramping Product

Imbalance Reserves

- Hourly Product
- 15-minute dispatchable
- Biddable
- Covers granularity difference and uncertainty between DAM and FMM
- All awards are co-optimized and settled simultaneously

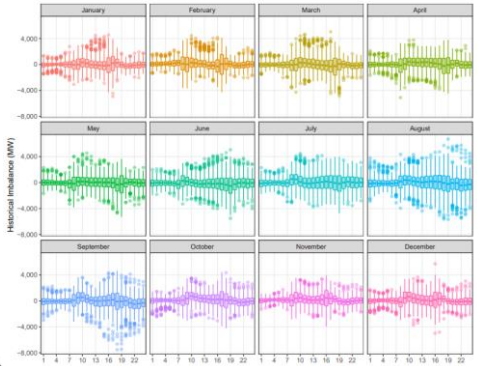
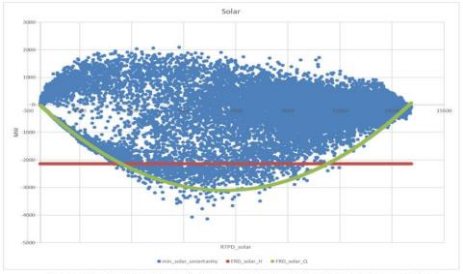


Figure 2: Hourly trend of Day-Ahead Imbalance Reserve.

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



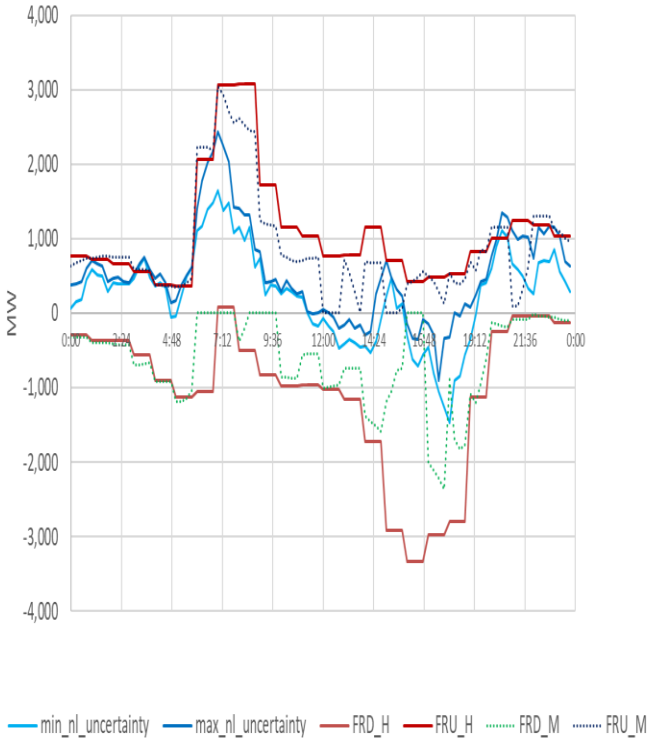
Proposed methodology (green line) tracks more closely the solar production conditions, while current methodology (red line) is constant at any level of solar production

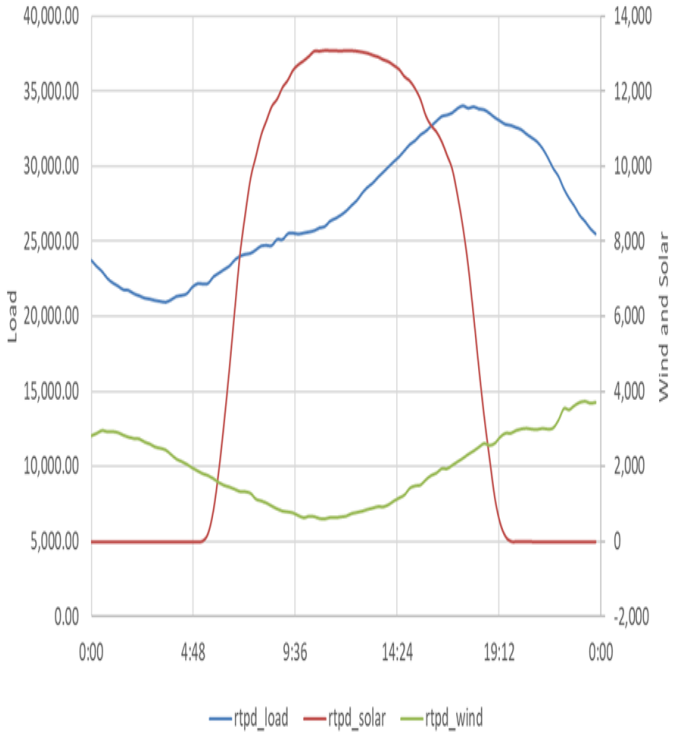
FRP requirement calculation- enhancements utilizing quantile regression

Enhancement to the Flexible Ramp Product Uncertainty Requirement Calculation

- The ISO proposes the Mosaic model incorporating weather information into estimation of uncertainty requirement.
  - The mosaic model utilizes quantile regression; where load, wind, and solar data are regressors.
- Compared to the Histogram approach, the Mosaic approach has:
  - Similar coverages
  - Less requirement on average
  - Closer proximity to the observed uncertainty
  - Comparable exceeding number
  - Less impact of seasonality

Daily Graph (CISO) showing the adaptive nature of M vs H with differing weather patterns





How do we assess the performance of the proposed approach? M *vs.* H

- Four criteria in measurements
  - Coverage: 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.
  - Requirement: This is the average of the estimated requirement over a period of time.
  - Closeness: This is defined as the average distance between the observed uncertainty and the estimated requirement.
  - Exceeding: This is the average MW difference when the observed uncertainty is exceeding the estimated requirement.

The enhanced quantile approach provides marginal improvements to the uncertainty requirement calculation

BAA	FRU_H	FRU_M	FRD_H	FRD_M
APS	150.68	135.89	-127.24	-117.99
BANC	60.52	41.45	-49.14	-43.81
BCHA	157.49	151.57	-169.00	-161.67
CISO	1142.37	1042.13	-943.51	-850.52
IPCO	105.89	101.74	-132.72	-124.42
LADWP	152.43	147.32	-148.52	-135.85
NEVP	165.02	141.58	-139.53	-129.69
NWMT	81.15	77.15	-98.52	-91.95
PACE	250.80	241.12	-286.39	-273.01
PACW	112.55	106.14	-98.53	-92.13
PGE	130.70	121.66	-118.67	-112.25
PNM	136.49	137.04	-166.43	-161.23
PSEI	94.00	90.04	-101.46	-98.19
SRP	113.68	102.66	-109.17	-97.01

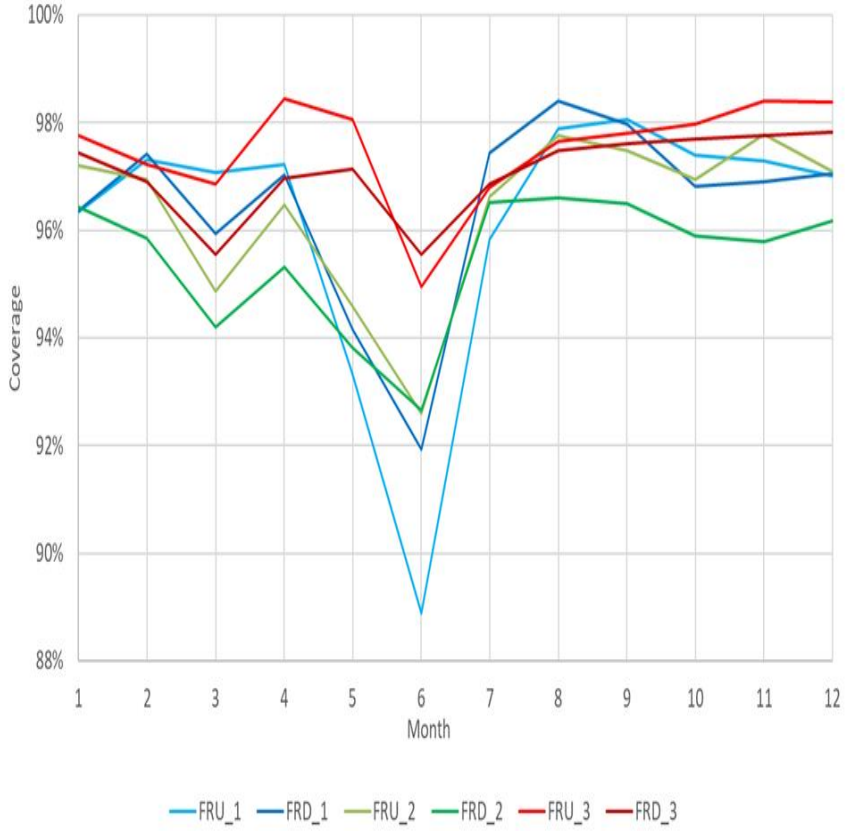
Requirement with proposed approach is lower than with current approach

Other Considerations: Sampling of historical data set

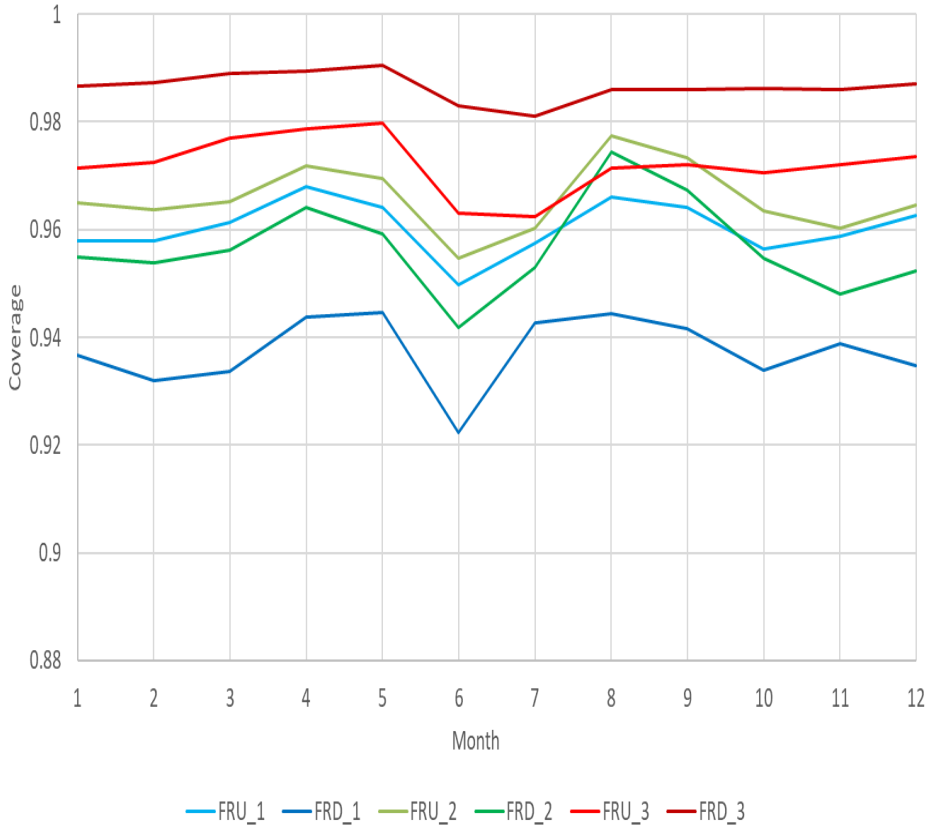
- **Sampling Scheme 1:** Rolling previous 40 days matching weekdays and 20 matching weekends. This is the sampling used in the ISO's current Histogram approach.
- **Sampling Scheme 2:** A fixed 180 rolling days with varying number of weekdays and weekend (holidays included). The increased sample size will bolster the robustness of regression computation.
- **Sampling Scheme 3:** In addition to the sampling scheme 1, use 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.

Sampling scheme 3 performs the best throughout the year for both M & H

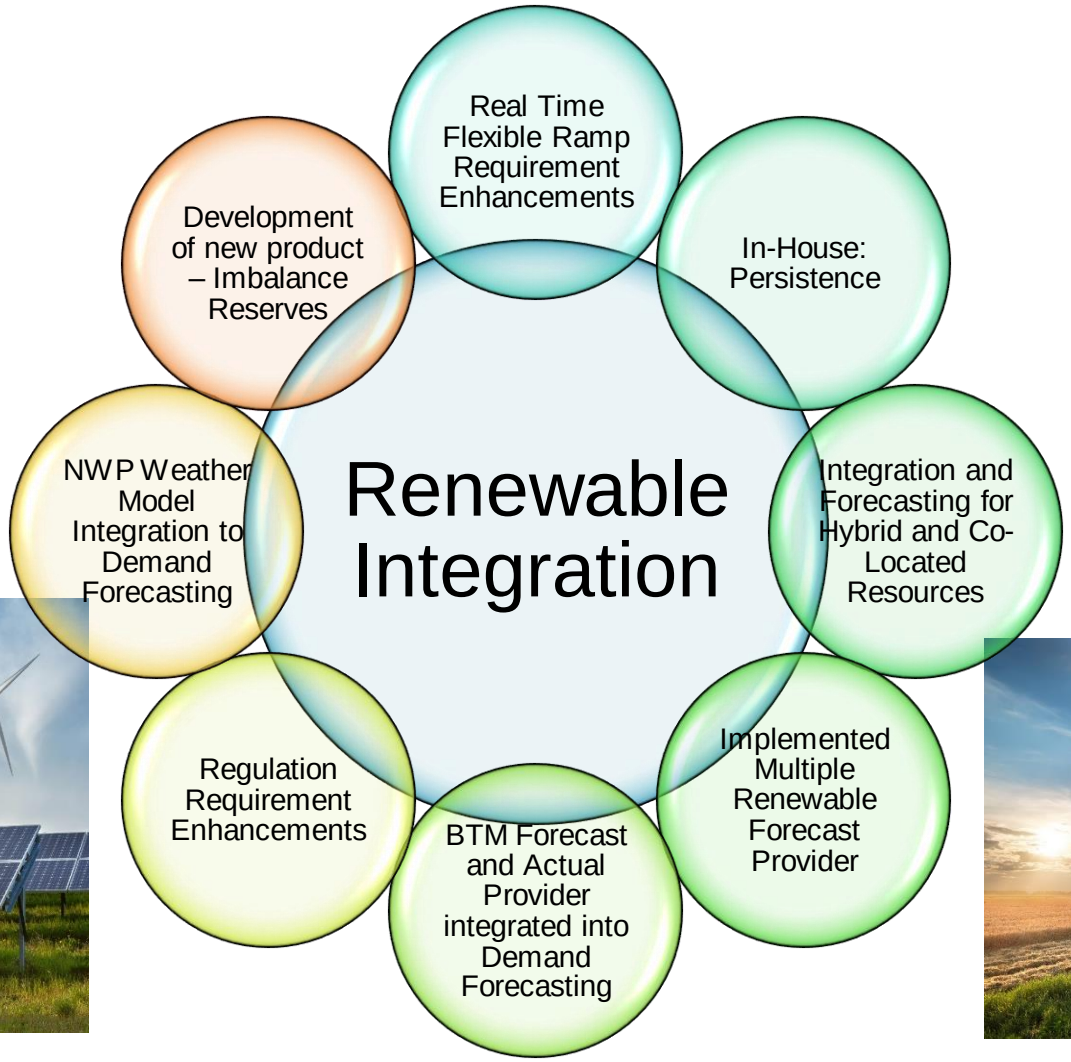
Histogram



Mosaic



CAISO Forecasting Advancements in Support of High Penetrations of Renewable Resources

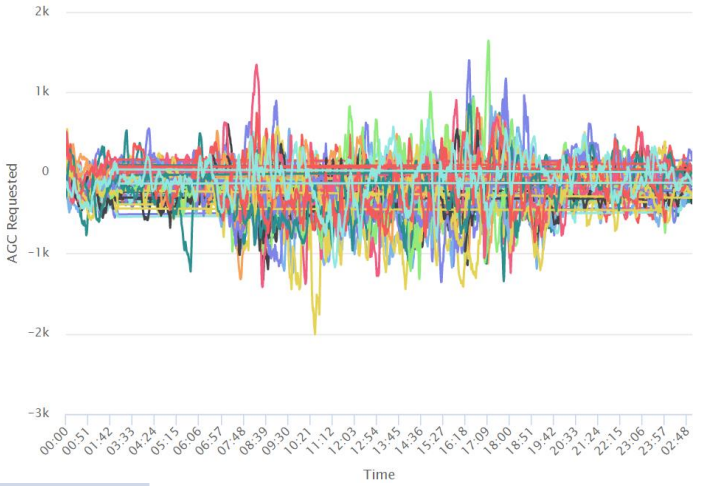


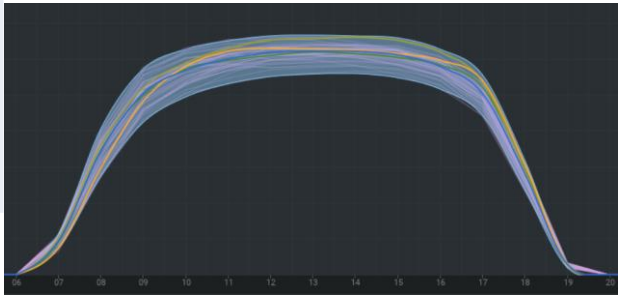
APPENDIX

Regulation Requirement Enhancements

	Current
Tag used for **Actual/Historical Data**	ACE*, i.e. ACE combined with Regulation Dispatched
Historical Data **Granularity**	1 minute average data (extremes are not muted)
Historical **Dataset**	Monthly analysis run for 2 datasets: • Same month last year + most recent 30 days • Only most recent 30 days The max of both results is then taken for the recommendation during sunlight hours. This is intended to focus on the recent behavior without eliminating seasonal patterns from last year.

Unchanged	• Hourly values are determined by percentiles
	  • 95th percentile for Sunny (less volatility forecasted)
	  • 2.5% off each tail - 97.5% Up and 2.5% Down
	  • 98th percentile for Cloudy (more volatility forecasted)
	  • 1% off each tail – 99% up and 1% down
	• Base numbers updated at minimum monthly
	• 95th/98th recommendation updated daily according to forecasted VER Volatility
	• Operations can adjust as needed
	  • Due to weather, outages, software updates, AGC performance, last few days operational issues, etc.



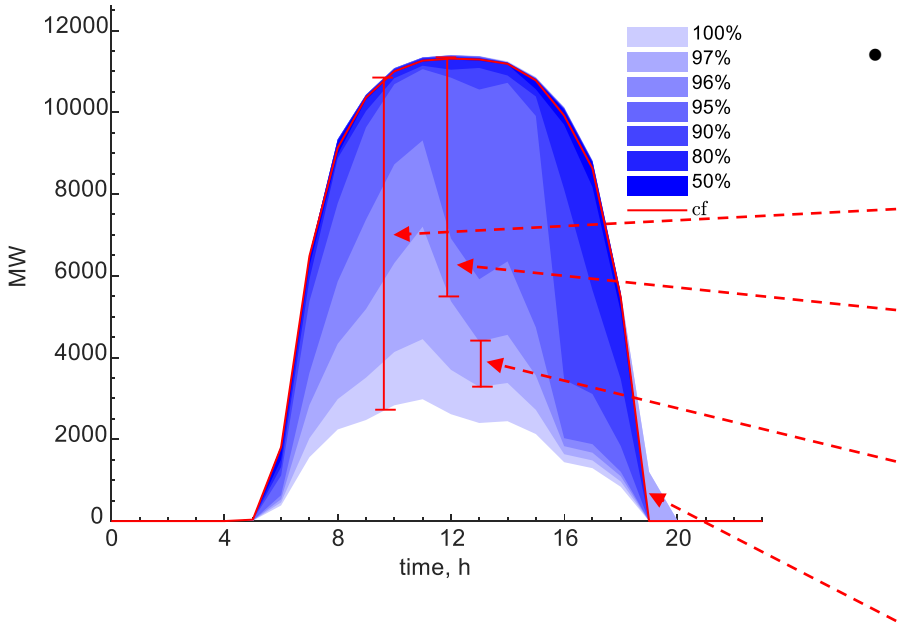


Detailed Description of the Requirement Calculation

- In order to increase transparency on the proposed Quantile methodology and enable interested parties to replicate the calculation, CAISO posted the step-by-step description of the methodology. The document is available at

  http://www.caiso.com/Documents/BusinessRequirementsSpecifications10-FlexibleRampProduct-RequirementsEnhancements.pdf

Anatomy of a Probabilistic Forecast

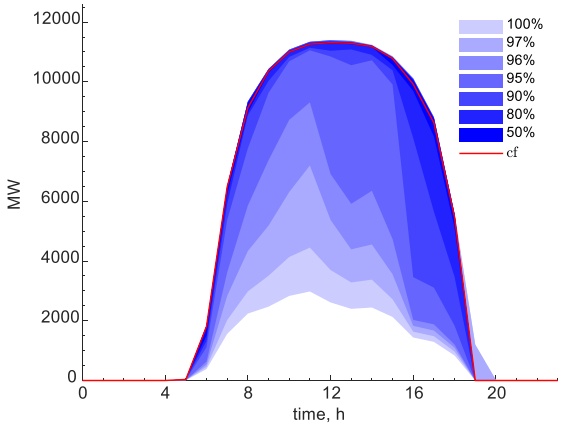


- Probabilistic forecasts provide users with valuable information on the possible scenarios of wind/solar generation
- It provides probabilistic thresholds in which the variables are expected to materialize:
  - A 100% threshold indicates total certainty of the variable being within the band
  - Lower probability thresholds indicate that the likelihood of the variable being within a narrower band (e.g., 90%)
  - Area between thresholds represent the probability of the variable materializing only in that space (e.g., (100-95)/2 = 2.5%)
  - The redline represents the central expected forecast

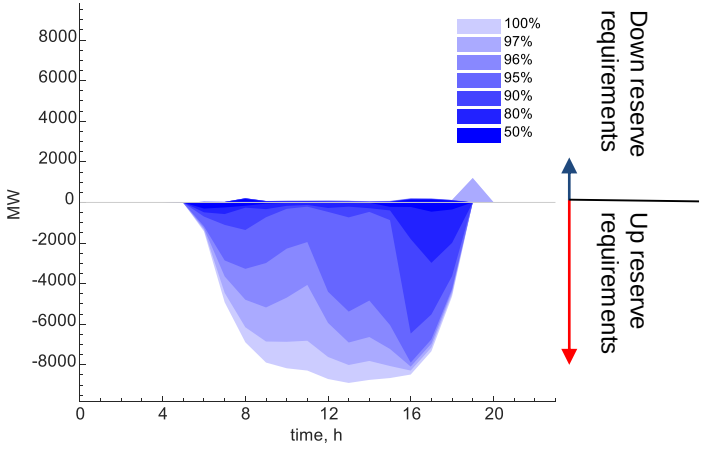
Solar Probabilistic Forecasts

- Probabilistic forecasts for solar produced by UL as part of DOE-funded OPTSUN*
- Methods have been applied to the California ISO

July 1st, 2019



Uncertainty Envelope



* https://www.energy.gov/sites/prod/files/2018/10/f56/Solar-Forecasting-2-Kickoff-EPRI.pdf

Additional Material: Stakeholder Initiatives, Research, and Publications

- Stakeholder Initiatives:
  - Day Ahead Market Enhancements
  - Flexible Ramp Product Enhancements
  - Resource Sufficiency Evaluation Enhancements (Phase 1B)
- Research and Publications:
  - N. Costilla-Enriquez, M. A. Ortega-Vazquez, A. Tuohy, A. Motley, and R. Webb, "Operating Dynamic Reserve Dimensioning Using Probabilistic Forecasts," *IEEE Trans. Power Syst.*, Vol. XX, Issue X, pp., XXX. 2022. [DOI] [arXiv]
  - DOE (EERE) funded projects “Operational Probabilistic Tools for Solar Uncertainty (OPTSUN)”
    - https://www.energy.gov/sites/prod/files/2018/10/f56/Solar-Forecasting-2-Kickoff-EPRI.pdf
    - https://www.energy.gov/sites/default/files/2019/10/f67/9%20Solar-Forecasting-2-Annual-Review_The-Johns-Hopkins-University.pdf