Capturing Net Load Uncertainty:

A brief introduction to Imbalance Reserve and Real-Time Flexible Ramp Products

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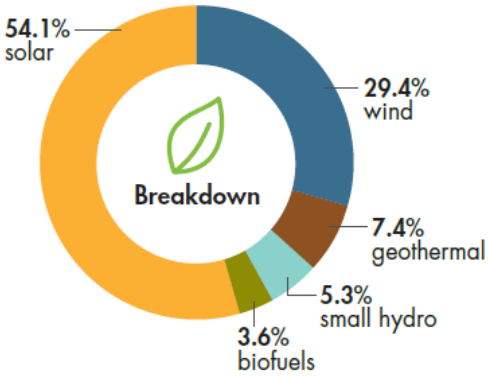
Presentation Overview

- CAISO Overview
- Flexible Resource Adequacy
- Net Load Uncertainty Requirement
  - Imbalance Reserve
  - Real Time Flexible Ramping Requirement
- Convolution Challenge
- Summary and Next Steps

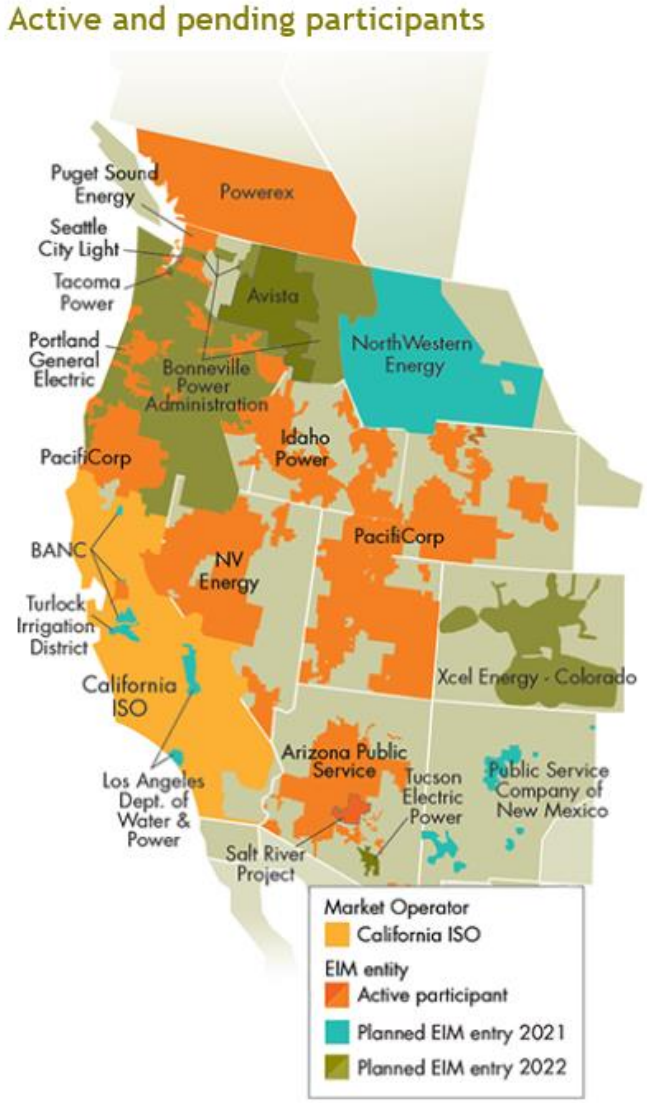
CAISO Background

CAISO Installed renewable resources (as of 3/01/2020)



	Megawatts
Solar	12,875
Wind	6,991
Geothermal	1,773
Small hydro	1,256
Biofuels	862
TOTAL	**23,757**

See Today's Outlook



Resource Adequacy Product to Procure Resources for uncertainty requirements

CURRENT METHODOLOGY: FLEXIBLE RESOURCE ADEQUACY

Overview

- Each LSE SC shall make a year-ahead and month-ahead showing of flexible capacity for each month of the compliance year
  - All resources participating in the ISO markets under an RA contract will have an RA must-offer-obligation
  - Required to submit economic bids into the ISO's real-time market consistent with the category of flexible capacity for which it is shown
- The ISO calculates an Effective Flexible Capacity (EFC) value for all resources that have a Net Qualifying Capability (NQC).
  - The EFC value is what can be used for Flex RA Showings to meet the Annual Flexible RA requirement.

INTRODUCTION TO NET LOAD UNCERTAINTY

CAISO Proposed to use a Quantile Regression to Calculate Net Load Uncertainty Requirements

- Currently, a histogram methodology is used to procure capacity products like real-time flexible ramping product.
- Using a regression model based on forecasted amounts of load, wind, and solar will result in a more accurate requirement amount.
  - This model can be shaped to better capture variation of requirement to forecasted values

What is Quantile Regression?

- Quantile Regression estimates quantiles of a dependent variable, conditional on the values of a set of independent variables
- Preferred in Imbalance Reserve and RT Flex Ramp Requirement scenario to standard linear regression because the requirement is based on relatively extreme high and low (i.e. 2.5 and 97.5 percentile) observations of net load imbalances, as opposed to the average net load imbalance
- The Regressors (independent variables) include forecasted load, solar, and wind values, as well as operating hour and month.

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

RT Flexible Ramping Product

- 15-minute product
- 5-minute dispatchable
- Not biddable
- Cover uncertainty from FMM to RTD to Real Time
- Awards are calculated in successive runs and are only settled from the binding to the first advisory interval
- Demand Curve for uncertainty

Net Load Uncertainty Requirement between Day Ahead (DA) and Fifteen Minute Market (FMM)

IMBALANCE RESERVE

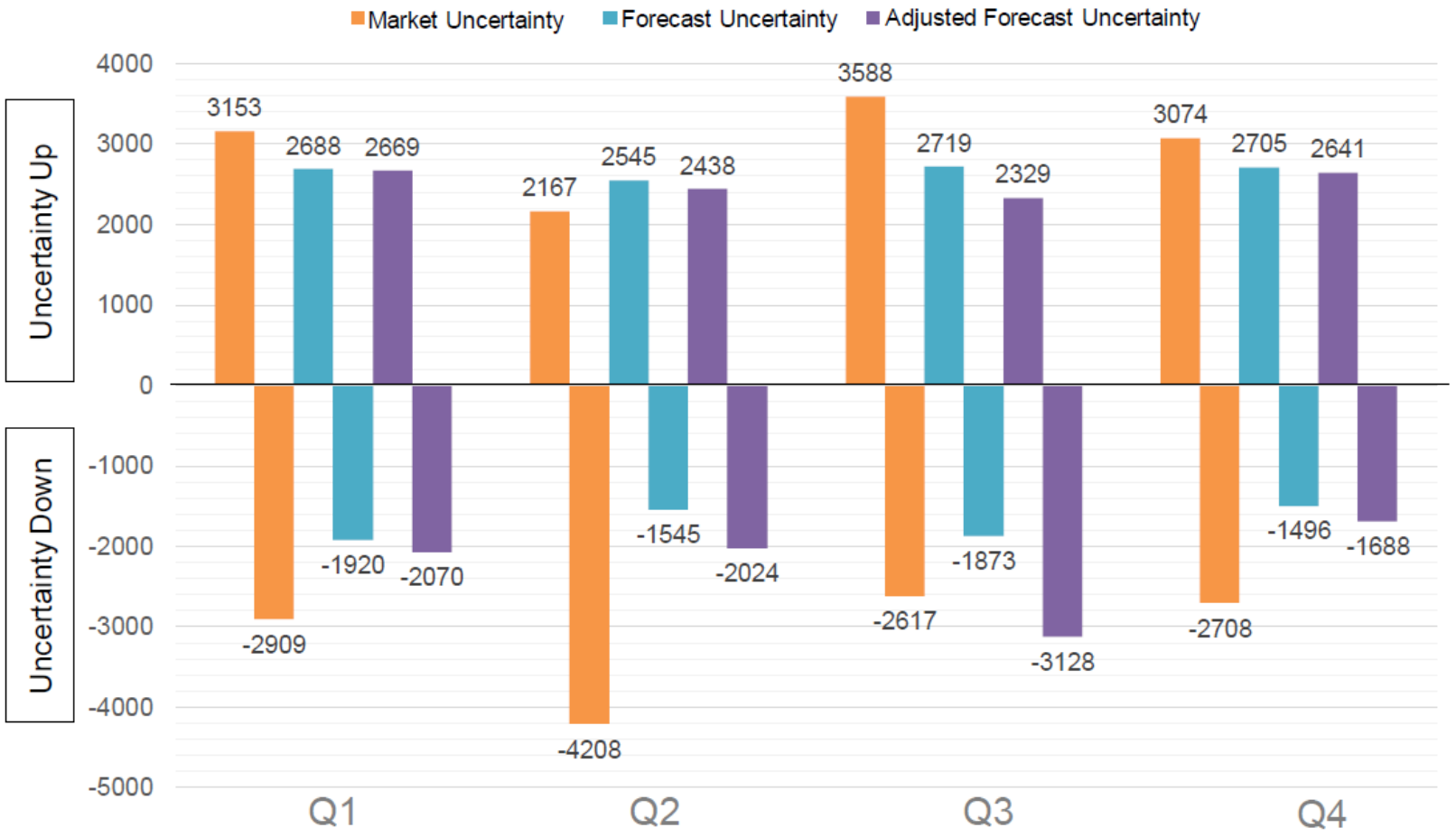
Imbalance forecast adjustments and out-of-market actions are not co-optimized with energy in the day-ahead market

- CAISO operators need to address uncertainty needs
  - Currently accomplished with imbalance adjustments and exceptional dispatches
- The imbalance adjustment process is a blunt and inefficient tool to meet reliability needs
  - May not commit additional resources, may merely increase the RUC schedule for a resource that is already online
  - RUC doesn’t ensure sufficient ramping speed
- A market product priced at marginal cost will more efficiently recognize the value of capacity thereby appropriately compensating flexible resources.
  - Can be co-optimized with other day-ahead products.

Net load uncertainty is measured in relation from the day-ahead market runs to the fifteen-minute market

- **Uncertainty Down:** Negative values indicate the Day-Ahead Market cleared higher than the Fifteen Minute Market
  - Need for imbalance reserves down
- **Uncertainty Up:** Positive values indicate the Day-Ahead Market cleared lower than the Fifteen-Minute Market
  - Need for imbalance reserves up

Amount of historical uncertainty varies seasonally



Note: Uncertainty Up is measured at the 97.5% percentile, Uncertainty Down is measured at the 2.5% percentile.
Data set encompasses January 2017 – March 2019.

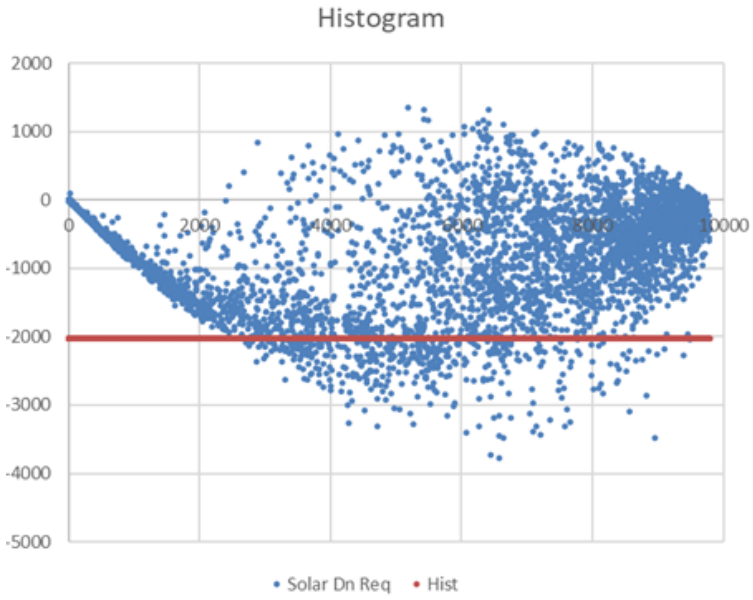
Benefits of regression vs. histogram approach for determining the imbalance reserve procurement target

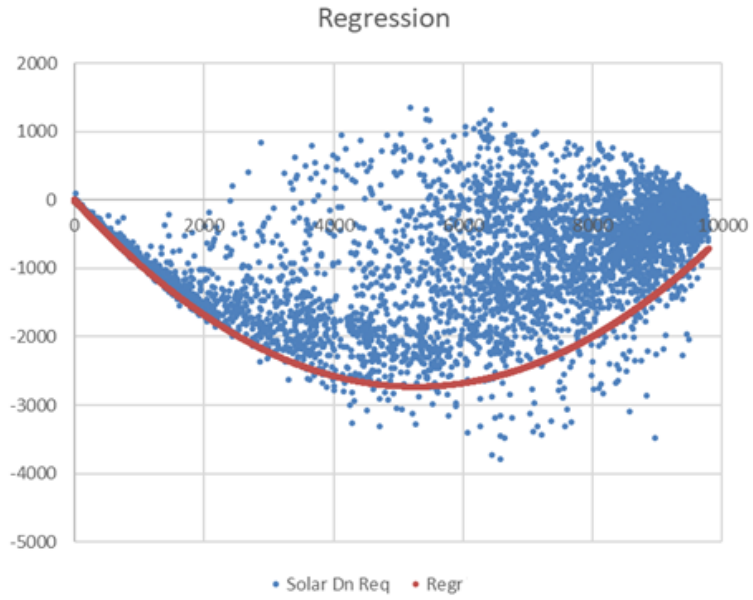
Imbalance reserve up requirement: histogram vs. regression for 2017 for HE 17

Regression approach more closely follows materialized imbalance

Benefits of regression vs. histogram approach for determining the imbalance reserve procurement target

Solar imbalance down values compared to day-ahead solar forecast



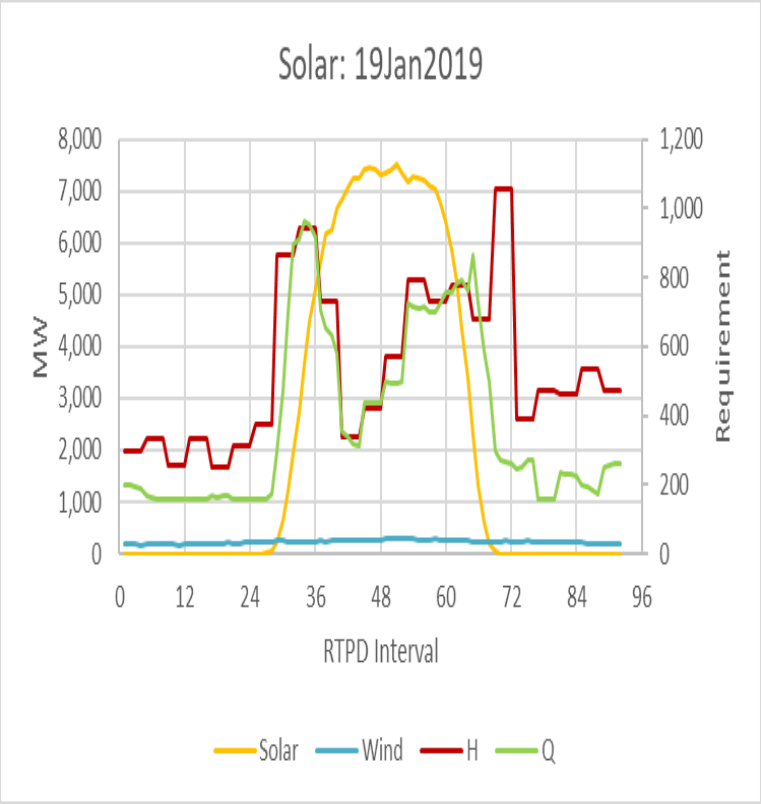


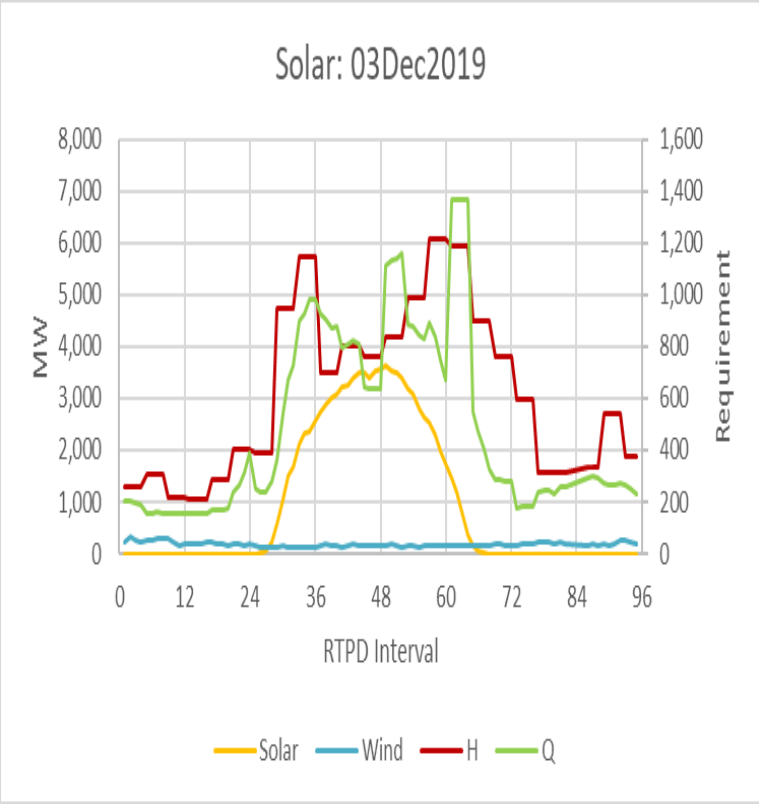
Quantile regression approach is shaped to better capture variance of imbalance to forecast values

Net Load Uncertainty Requirement between FMM and RTD

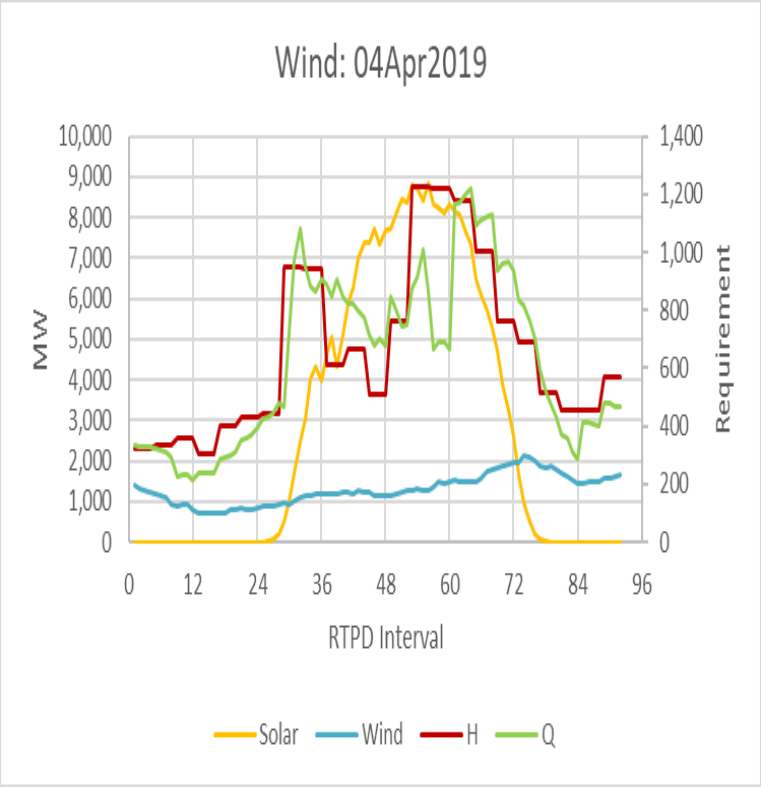
REAL TIME FLEXIBLE RAMP PRODUCT

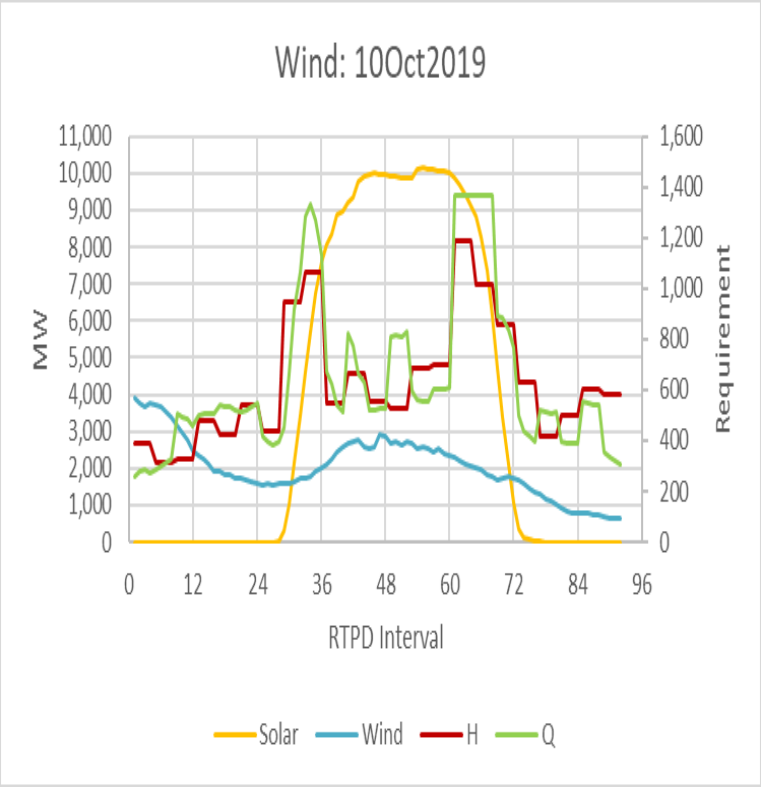
Day to Day Operation: Solar





Day to Day Operation: Wind





Performance Measures

- Criteria for performance measurements:
  - Coverage (e.g., 97.5%): accuracy rate
  - Average Requirement
  - Closeness with actual uncertainty profile
  - Average MW when imbalance exceeding requirement

Simulation Results (H vs. Q)

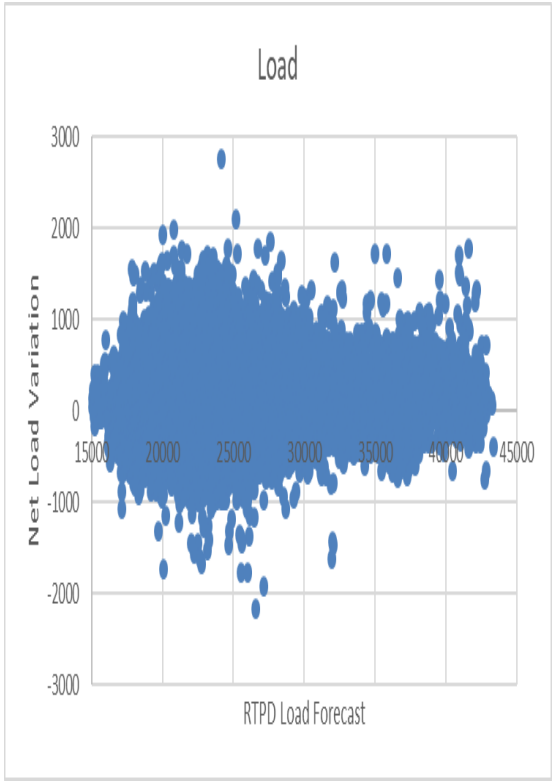
	Coverage		Requirement		Closeness		Exceeding	
BAA	H	Q	H	Q	H	Q	H	Q
AZPS	96.87%	96.17%	122.72	117.17	144.24	139.08	49.56	45.65
CISO	96.71%	96.10%	602.85	547.13	595.46	540.99	175.07	163.74
IPCO	97.16%	96.80%	66.02	61.58	67.61	63.08	24.84	20.75
NEVP	97.00%	96.08%	70.63	62.02	78.05	69.79	29.10	26.77
PACE	96.99%	96.57%	108.79	107.11	110.65	109.08	36.86	33.97
PACW	97.19%	96.86%	59.33	53.81	58.40	52.70	23.51	18.35

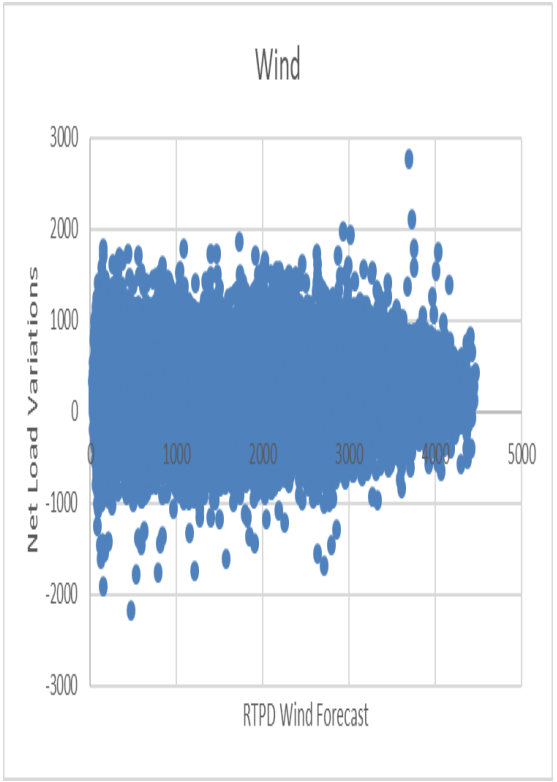
How do you get to Net Load?

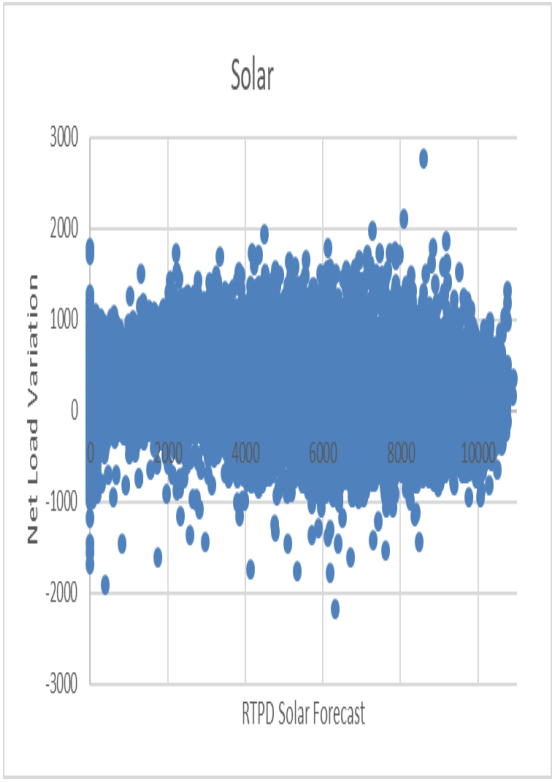
CONVOLUTION CHALLENGE

Net Load Variation by Components: Challenge of Convolution Methods

- Statistical fit is nearly muted when net load uncertainty is of interest
- Modeling interactions between Load, Wind, and Solar are complicated







The MOSAIC Model

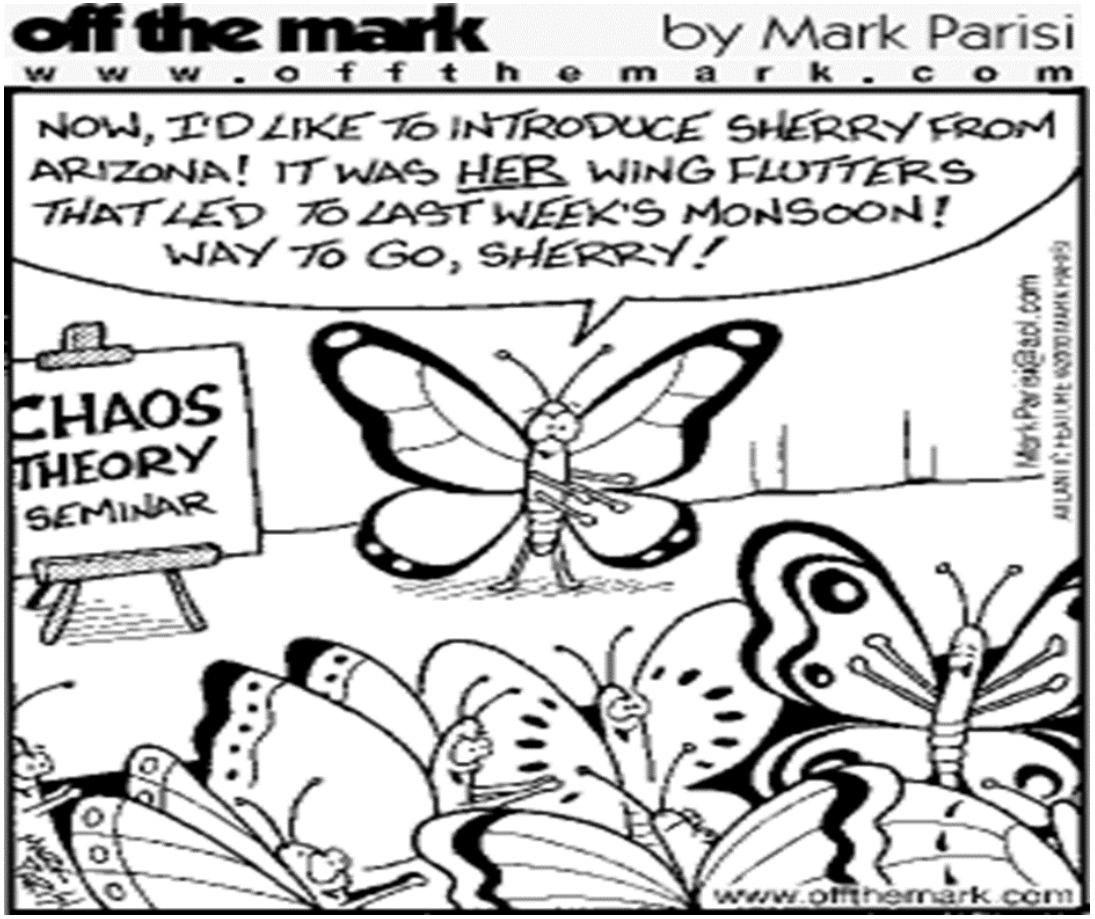
- What is MOSAIC made of?
  - L_H, W_H, S_H, and NL_H for histogram:
  - L_Q, W_Q, and S_Q for quadratic models:
  - NL_H is the ISO current requirement

- Let $\text{MOSAIC} = NL_H - (L_H - W_H - S_H) + (L_Q - W_Q - S_Q)$

- Quantile Regression Model $NL_Q = \text{MOSAIC}$

Summary and Next Steps

- It has been observed in simulation that use of Quantile Regression for the Imbalance Reserve and enhancing RT Flex Ramp Requirements provided nice curvature for RTPD Solar, Wind, Load, as well as along Net Load.
- Use of Quantile Regression and proposed methodologies allows ability to incorporate probabilistic forecasts in the future.
  - Further analysis and research continuing in this area.
- Ongoing Policy Initiatives: (http://www.caiso.com/StakeholderProcesses/)
  - Day Ahead Market Enhancements
  - Flexible Ramp Product Refinements
  - Resource Adequacy Enhancements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