Flexible ramping product performance discussion

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Market Surveillance Committee Meeting
General Session
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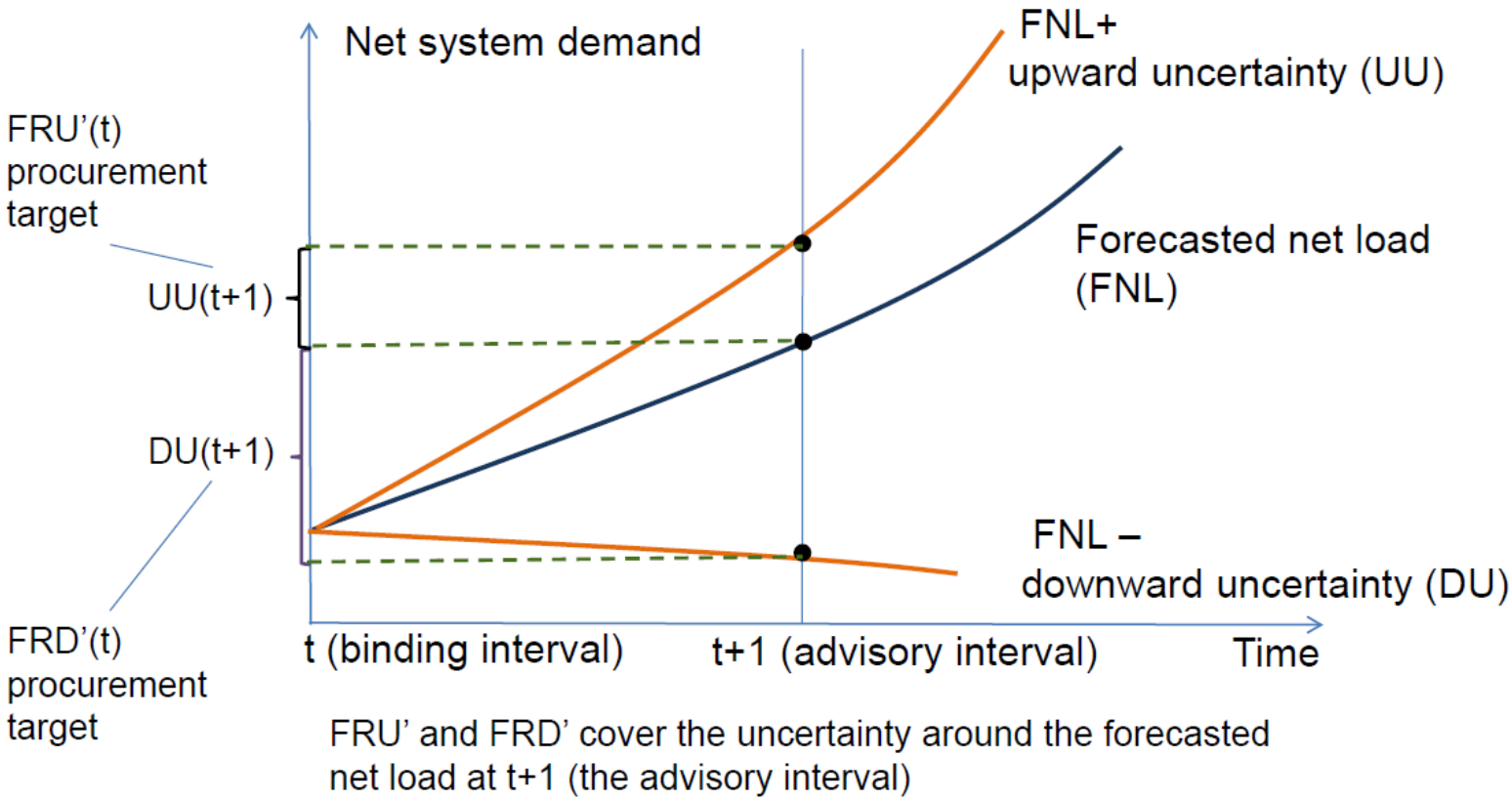
Agenda

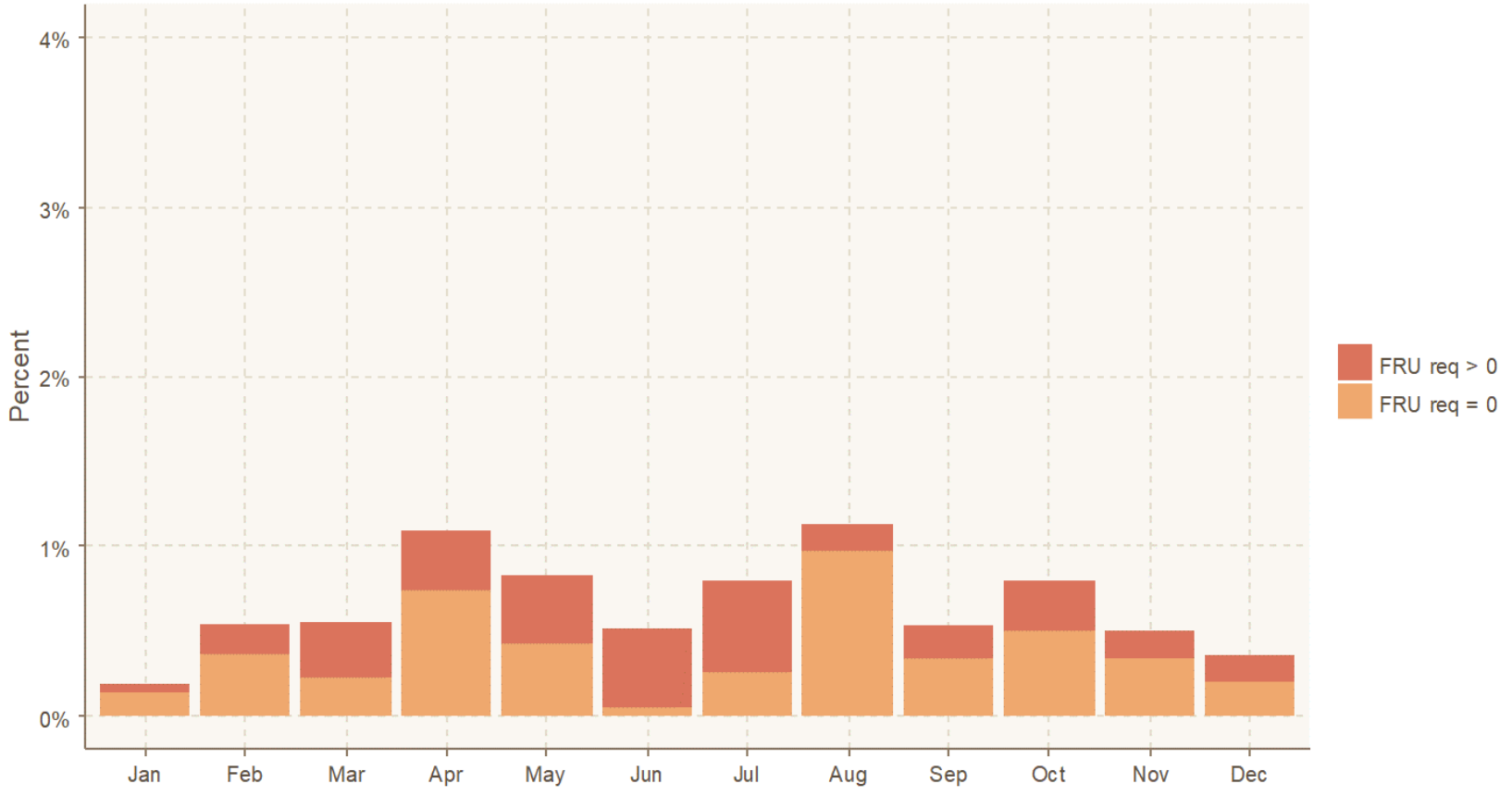
- Flex ramp Product and Real-Time Price Spikes
- Item 1: FRP Procurement bounding
- Item 2: FRP Requirements methodology
- Item 3: FRP price formulation.

Flexible Ramping Product-Market Design



FRU'(t) is procured to meet the expected net forecast error within a 95% confidence interval.

Percentage of Intervals in Five Minute Market with SMEC above $500



Item 1: Current FRP procurement Equations

$$\sum FRU_i(t) + FRUS_j(t) \geq FRUR_i(t) - BF_j NIC_i(t) \ldots.1$$

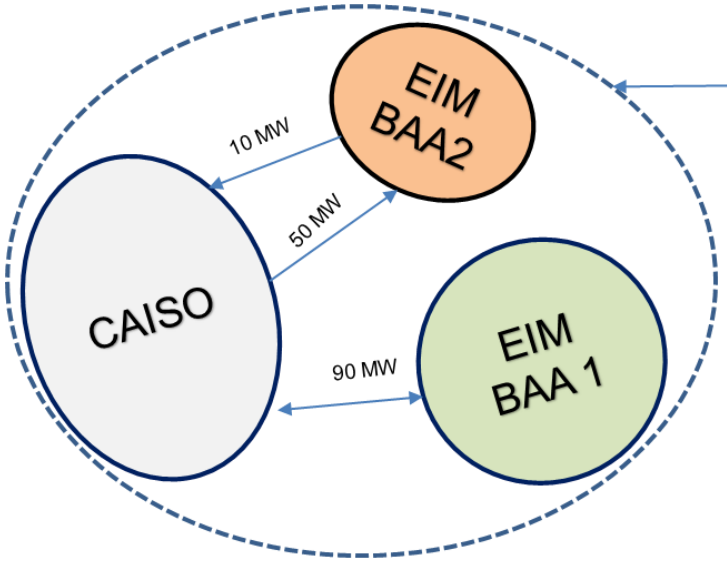
$$\sum FRU_i(t) + FRUS_j(t) \geq FRUR_i(t) - BF_j FRUC_i(t) \ldots.2$$

$$\sum FRU_i(t) + \sum FRUS_j(t) - FRUS_{EIM}(t) \geq FRUR_{EIM}(t) \ldots.3$$

Where	
$FRU_i(t)$	Flex ramp up Uncertainty resource award at node i
$FRUR_j(t)$	Flex ramp up Uncertainty requirement for BAA j.
$FRUS_j(t)$	Flex ramp up surplus variable for BAA j
$FRUS_{EIM}(t)$	Flex ramp up surplus variable for EIM Area
NIC_i	Available Net Import Capability into BAA j
$FRUC_j(t)$	Flex ramp up credit for BAA j
BF_j	Configurable EIM diversity benefit factor for BAA j ($0 \leq BFj \leq 1$)

Equation 1 is enforced for BAA that pass the upward flex test
equation 2 is enforced for BAA that fail the flex test

Flex Ramp Up procurement
Current Scenario with stranded FRU



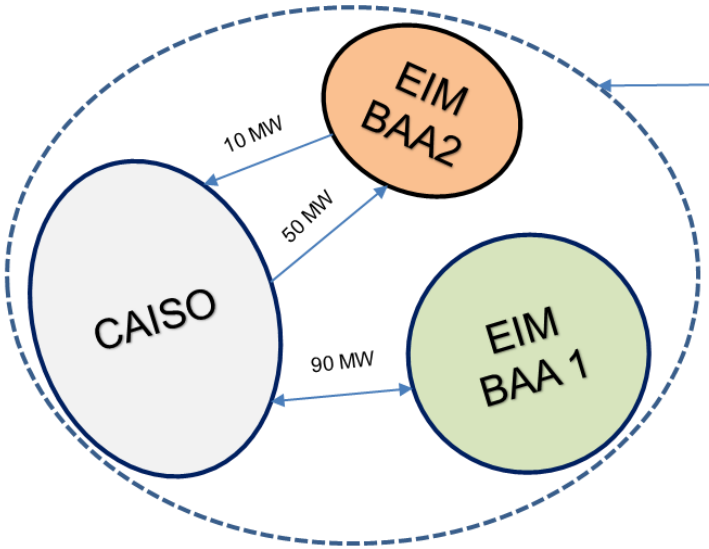
EIM Area

$$\sum FRU_i(t) + FRUS_j(t) \geq FRUR_i(t) - BF_j NIC_i(t)$$

Lower bound of procurement

BAA	Requirement	NIC	Procurement
CAISO	50	100	0
BAA1	30	90	0
BAA2	30	50	80
EIM Area	80		80

Flex Ramp Up procurement
New proposal



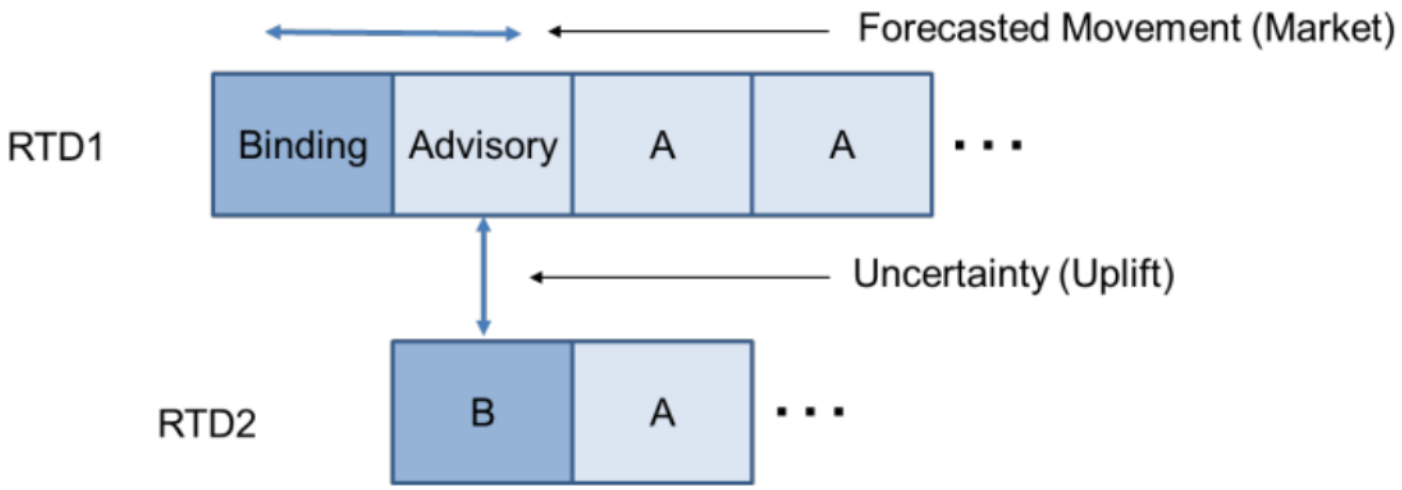
EIM Area

$$\sum FRU_i(t) + FRUS_j(t) \leq FRUR_j(t) + NEC_j(t)$$

upper bound of procurement

BAA	Requirement (FRUR)	NIC	NEC	Current Procurement	New Max Procurement
CAISO	50	100	140	0	190
BAA1	30	90	90	0	120
BAA2	30	50	10	80	40
EIM Area	80				

Item 2: Flexible Ramping Uncertainty Requirement Five minute Real-Time Dispatch (RTD)



RTD Net Load Forecast Error is difference between the binding interval net load forecast and the prior market run first advisory net load forecast

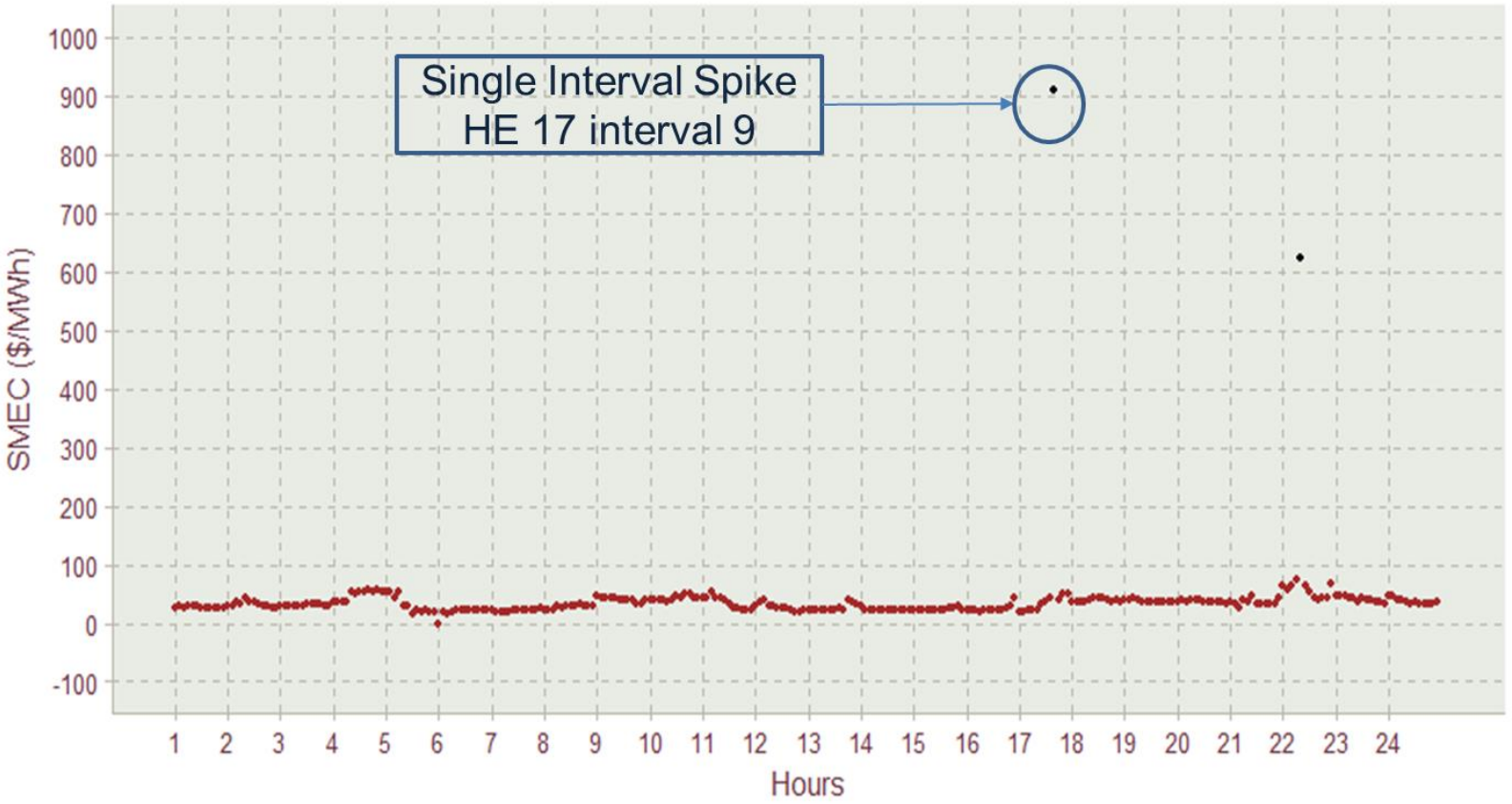
Flex Ramp Product Uncertainty Calculation Methodology

- The uncertainty requirements are hourly values calculated every day using the BARR tool
- Uncertainty requirements are based on net load forecast differences
  - Net Load = Load – Wind – Solar
  - RTD Uncertainty: Forecast difference between advisory and binding intervals.

Current Flex Ramp Product Uncertainty Calculation Methodology

- Flex Up and Down Uncertainty Requirement are calculated as follows:
  - For each hour, gather the set of recent net load forecast differences for the appropriate market uncertainty
  - Group weekdays and weekends separately due to characteristic differences
    - Weekdays use last 40 days of net load forecast difference
    - Weekends use last 20 days of net load forecast difference
  - The flex up uncertainty requirement is the 97.5 percentile
  - The flex down uncertainty requirement is the 2.5 percentile

RTD SMEC for December 16, 2017

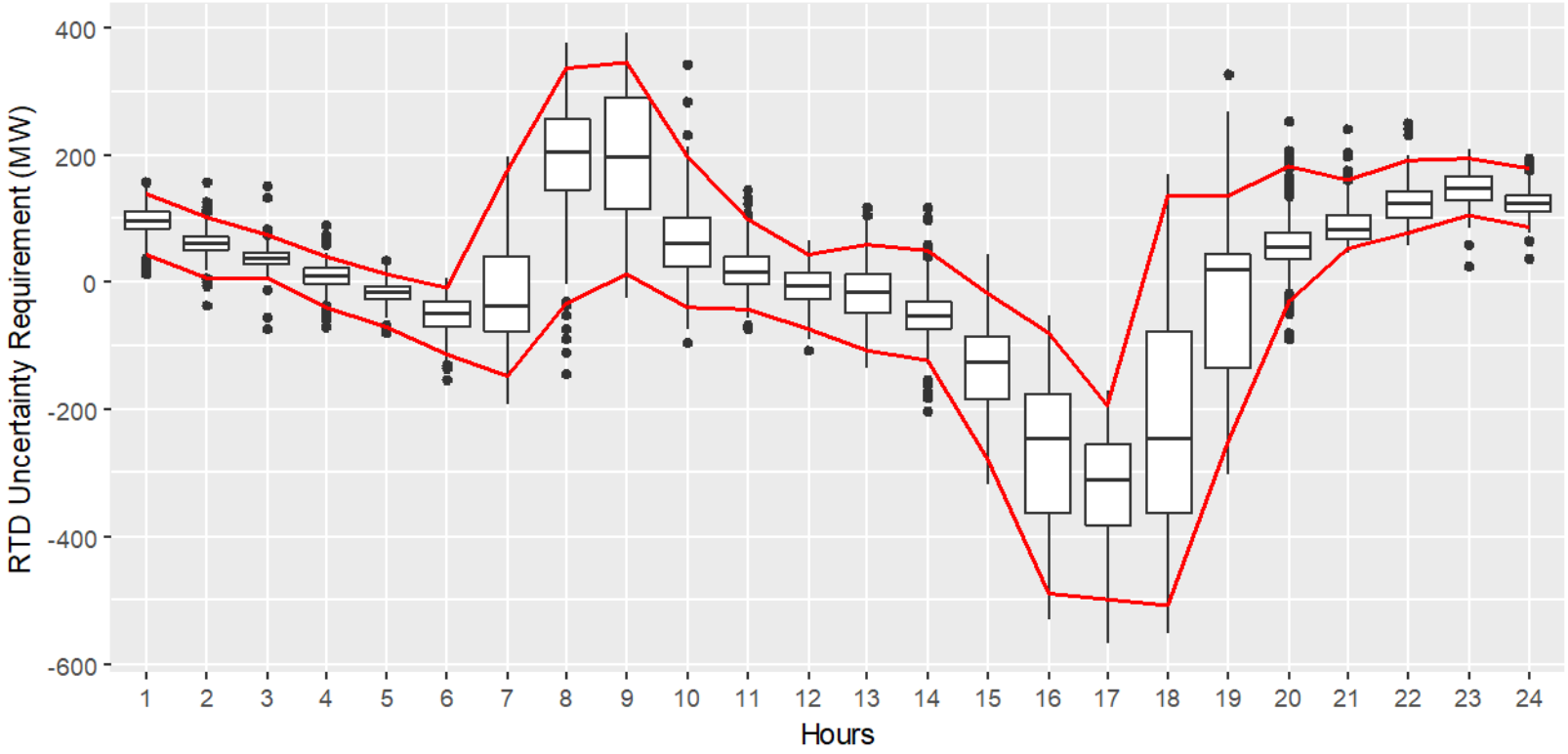


RTD Spike Analysis
December 16 Hour Ending 17 Interval 9

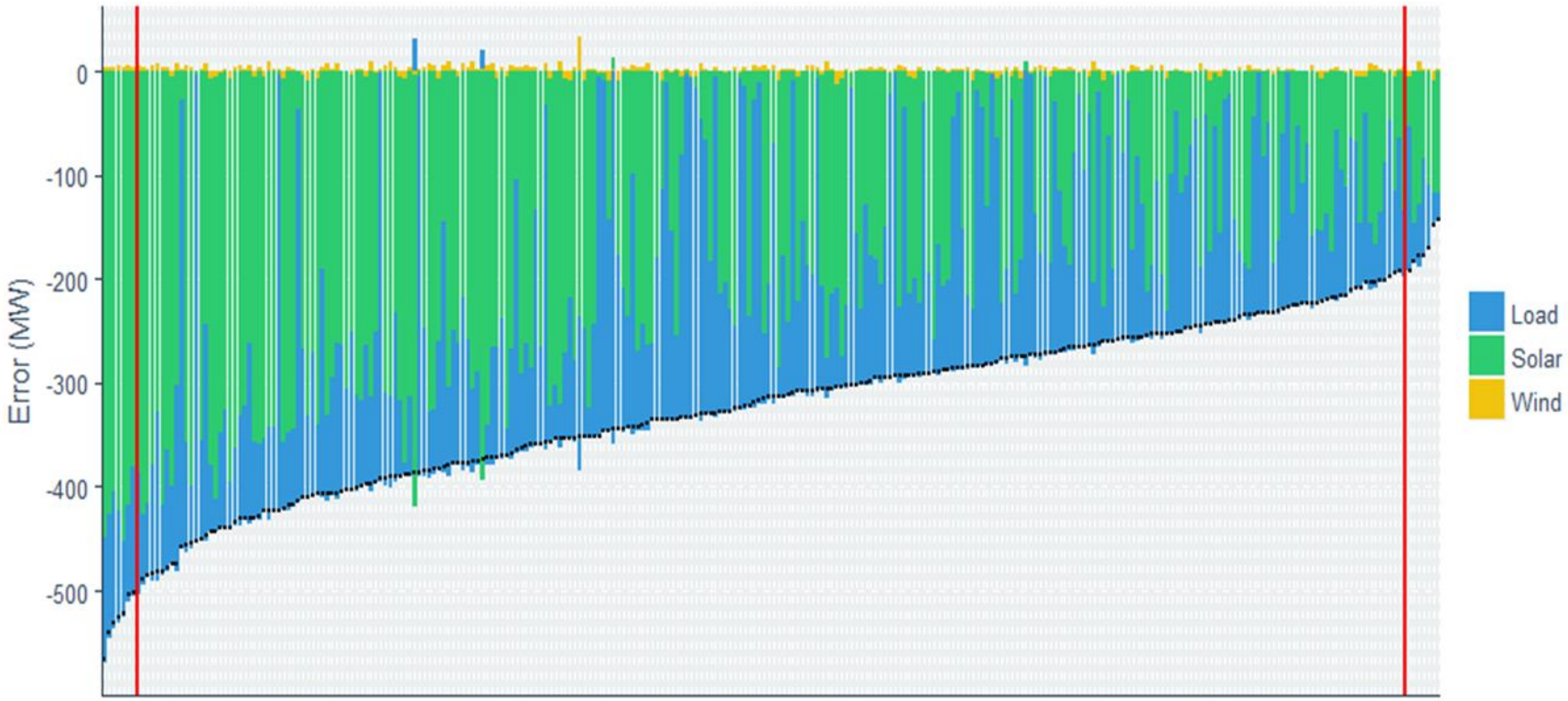
- SMEC was $908.9/MWh
- Reasons for RTD spike
  - Non VER Resource deviation
    - Slow to respond to DOT
    - Delay in start-up
  - Wind resource deviation
- FRP Requirements

CAISO	EIM_AREA
0	0

Hourly Distribution of Net load error and the Calculated Percentiles (Red Lines) for CAISO - December 16, 2017



Histogram Sample used to Calculate Uncertainty Requirement for December 16, 2017 HE 17



Observations

- If the systematic delta is negative then the flex up requirement is 0 MW
- Min Value for flex up and max value for flex down in 0 MW
- Typically happens during periods when there is consistent net load ramp
- Price Spikes have occurred during the hours with 0 MW of Flex Up Capacity requirements
  - Indicated net load is not the sole indicator of capacity need in the binding interval
  - As a result, we are currently in the process of identifying and evaluating modifications to the calculation of the flex ramp requirement

Item 3: FRP price formation- Slack Variable upper bound

- BAA FRP surplus variable has no upper bound
- Optimization will chose the most economic surplus variable based on demand curve.
- FRP price is set by cheapest demand curve segment

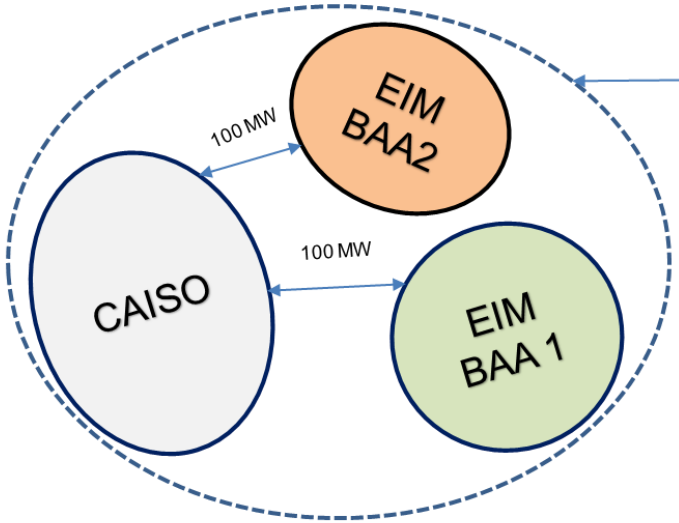
$$\sum FRU_i(t) + FRUS_j(t) \geq FRUR_i(t) - BF_j NIC_i(t) \ldots.1$$

$$\sum FRU_i(t) + FRUS_j(t) \geq FRUR_i(t) - BF_j FRUC_i(t) \ldots.2$$

$$\sum FRU_i(t) + \sum FRUS_j(t) - FRUS_{EIM}(t) \geq FRUR_{EIM}(t) \ldots.3$$

Revisit the requirements constraints below

Flex Ramp Clearing Price



Demand Curves

BAA	MW	Price
BAA1	10	$10
BAA2	10	$15
CAISO	10	$25
EIM Area	10	$20

BAA	Requirement	NIC	Relaxation	Shadow Price	Expected Shadow Price	Demand Curve Price	Resource Price (BAA price+ EIM_AREA Price)
BAA1	10	100	10	0	$0	$10	$15
BAA2	10	100	8	0	$0	$15	$15
CAISO	50	100	0	0	$0	$25	$15
EIM Area	60	-	0	$15	$20	$20	$15

On July 13, 2018 Introduced an upper bound to slack variable

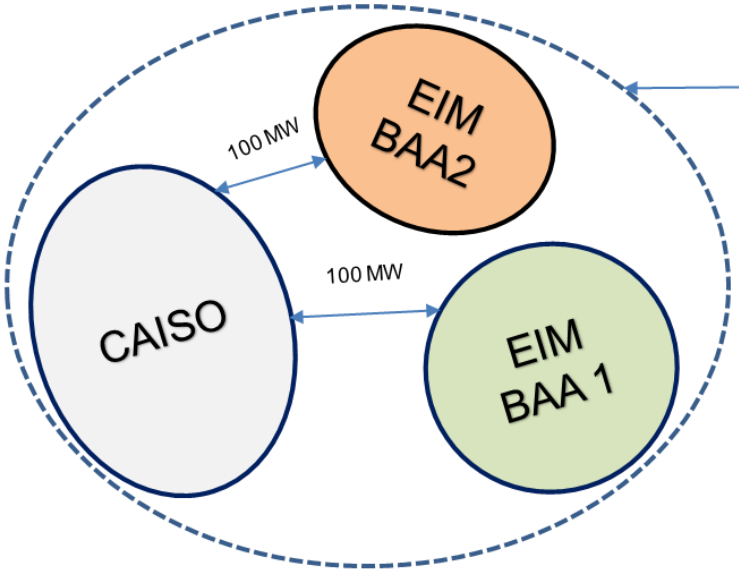
$$0 \leq FRUS_j(t) \leq max\left(0, FRUR_j(t) - BF_j \times FRUC_j(t)\right) \ldots 1$$

$$0 \leq FRUS_j(t) \leq max\left(0, FRUR_j(t) - BF_j \times NIC_j(t)\right) \ldots 2$$

Equation 1 is implemented for EIM BAA that fail the flex tests.

Equation 2 is implemented for EIM BAA that pass the flex ramp sufficiency tests.

Flex Ramp Clearing Price



Demand Curves

BAA	MW	Price
BAA1	10	$10
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CAISO	10	$25
EIM Area	10	$20

BAA	Requirements	NIC	Relaxation	Shadow Price	Demand Curve Price	Resource Price (BAA price+ EIM_AREA Price)
BAA1	10	100	0	-$10	$10	$10
BAA2	10	100	0	-$5	$15	$15
CAISO	50	100	0	$0	$25	$20
EIM Area	60	-	18	$20	$20	$20

FRP demand curve co-ordination- Summary

- In procurement of FRP in fifteen minute market there was no upper bound for the individual EIM BAA surplus variable
- The cheapest Demand curve always sets the price instead of the system demand curve
- An upper bound was introduced on July 13, 2017 to set an upper bound for each EIM BAA demand curve limiting the surplus variable by requirement minus import capability
- Since this change, market has observed negative shadow price for EIM BAA but overall resource price was always positive
- ISO is working with its Vendor on a proposed enhancement to fix this issue.

Flex Ramp Clearing Price – with upper bound Proposed Change

$$FRUR_j(t) - BF_j\ FRUC_j(t) \leq \sum_{i \in S_{FRC} \cap BAA_j} FRU_i(t) + \gamma_j(t) FRUS_j(t)$$

$$FRUS_j(t) \leq FRUR_j(t) - BF_j\ FRUC_j(t)$$

$$\gamma_j(t) = \{0,1\} \ \therefore \begin{cases} FRUR_j(t) - BF_j\ FRUC_j(t) > 0 \rightarrow \gamma_j(t) = 1 \\ FRUR_j(t) - BF_j\ FRUC_j(t) \leq 0 \rightarrow \gamma_j(t) = 0 \end{cases}$$

$$\notin P_U(T)$$

$$\sum_{i \in S_{FRC}} FRU_i(t) + \sum_{j \in EIM} \gamma_j(t)\ FRUS_j(t) + FRUS_{EIM}(t) \geq FRUR_{EIM}(t)$$

FRP Summary

- Continue to Monitor frequency of RTD price spikes
- Review Market Performance after implementation of software enhancements
  - FRP Deliverability
  - FRP Price formation
- Review FRP requirement calculations

THANK YOU

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