



Day Ahead Market Enhancements: Revised Straw Proposal

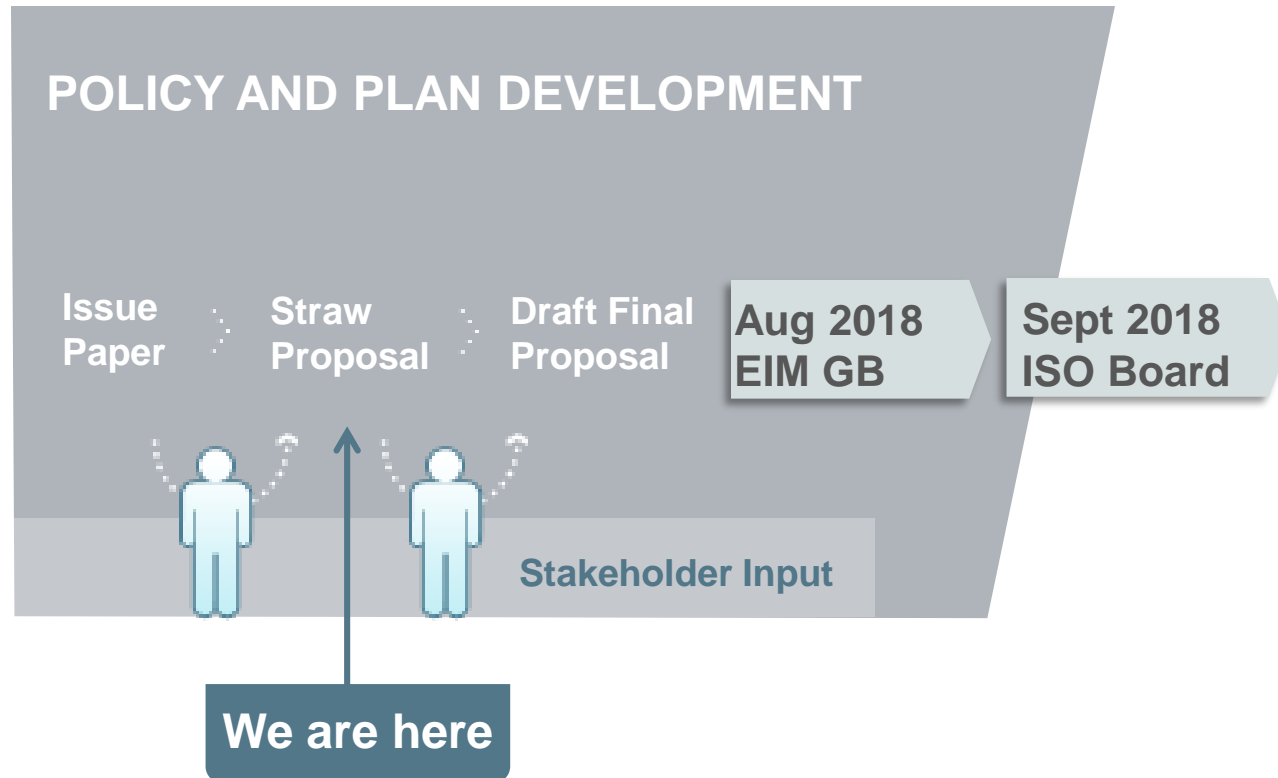
April 18, 2018

ISO PUBLIC

Agenda

Time	Topic	Presenter
10:00 – 10:15	Welcome and Introductions	Kristina Osborne
10:15 – 11:00	General Overview	Megan Poage
11:00 – 12:00	Market Formulations	George Angelidis
12:00 – 1:00	LUNCH	
1:00 – 2:00	Data Analysis	Don Tretheway
2:00 – 2:30	Imbalance Reserve Requirement Options	Amber Motley
2:30 – 3:00	Corresponding EIM Changes	Don Tretheway
3:00 – 3:50	Open Issues	Don Tretheway
3:50 – 4:00	Next Steps	Kristina Osborne

ISO Policy Initiative Stakeholder Process



Day-Ahead Market Enhancements

GENERAL OVERVIEW

Megan Poage

Sr. Market Design Policy Developer

Market Design Policy

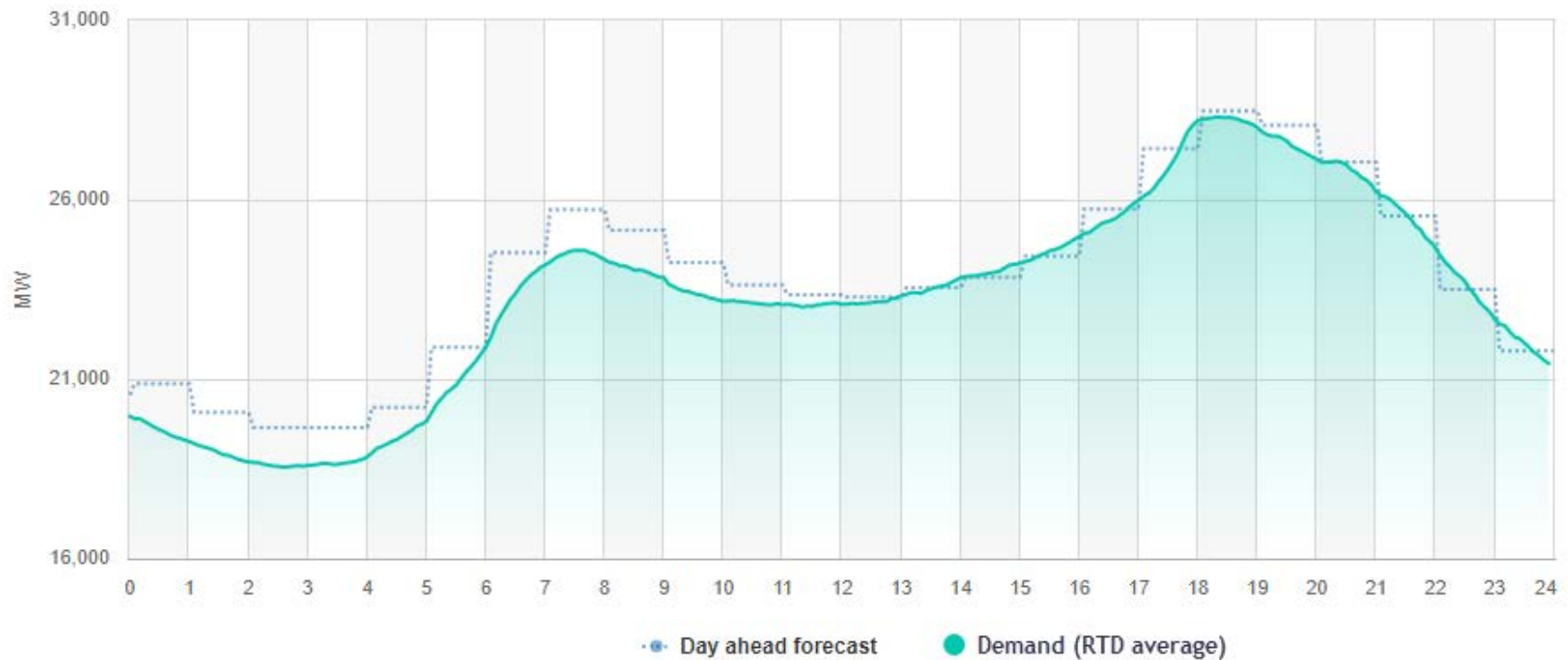
Day-ahead market enhancements address net load curve and uncertainty previously left to real-time market

- 15-minute scheduling granularity in IFM
- Day-ahead imbalance reserve product
- Combined Integrated Forward Market and Residual Unit Commitment

Why these three elements are dependent on each other?

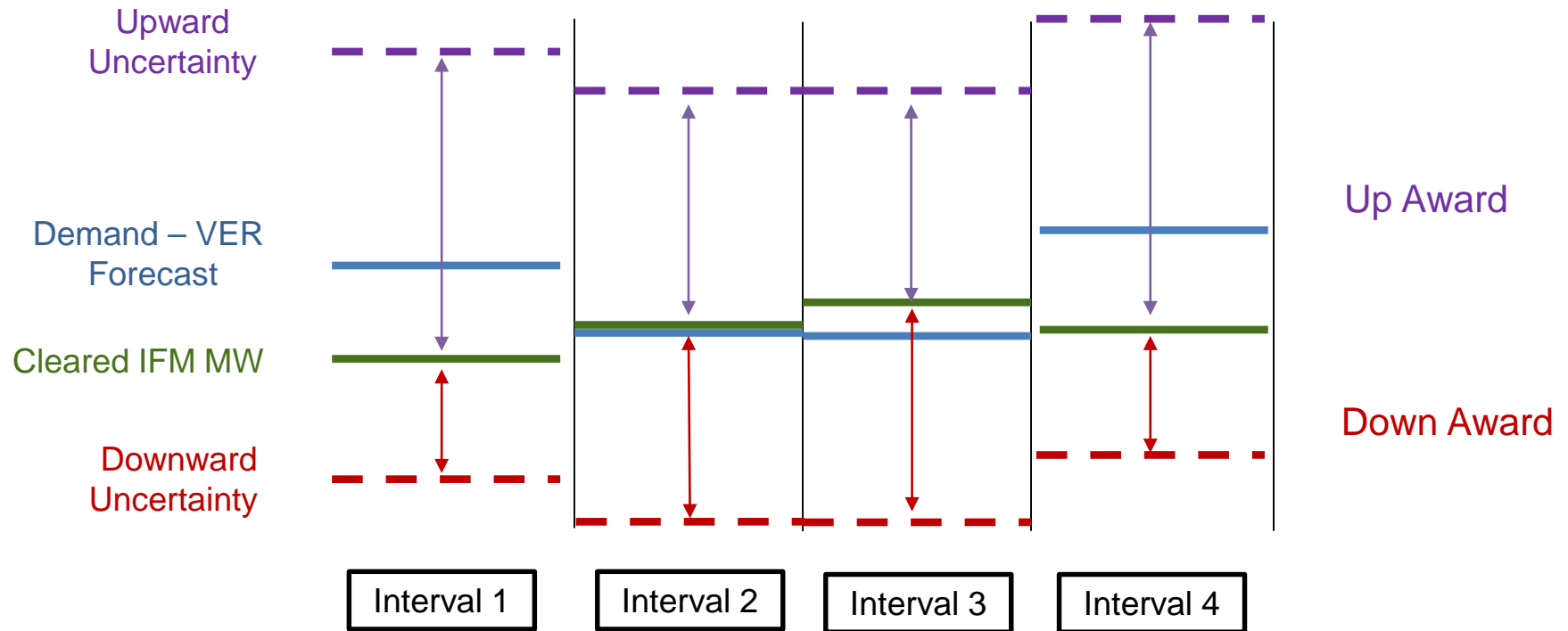
- 15 minute scheduling addresses granularity issues between day-ahead market and FMM
- DA imbalance reserves ensure sufficient real-time bids to meet imbalances that materializes in RTM
- Integrated IFM/RUC allows the DA imbalance reserve to be procured relative to ISO net load forecast, not bid in demand

The CAISO's current DAM is limited due to day-ahead hourly scheduling



- Downward uncertainty occurs HE01 – HE12
- Granularity difference occurs HE20 – HE24

Up and down awards can be used to address upward and downward uncertainty



Imbalance reserves can be used for all services in the real-time market

Day-Ahead Market	Bid-in Demand	ISO Net-Load Forecast	Contingency Reserves	Regulation	Corrective Capacity	Imbalance Reserves	
	Financial	Reliability	6.3% of the load forecast	Forecast error between RTD and Actual	System able to meet line limits after contingency	Forecast difference between IFM and RTM for all day-ahead market products	
Real-Time Market	Bid-in Demand	ISO Net - Load Forecast	Contingency Reserves	Regulation	Corrective Capacity	FRP Forecasted Movement	FRP Uncertainty Awards
	Not Applicable	Imbalance energy	Incremental	Incremental	Re-dispatch, if necessary	Ramp between market intervals in the same run	Forecast difference between binding and advisory intervals between runs

The CAISO proposes the following design features for imbalance reserves (1 of 4):

- Imbalance reserve procurement features:
 - Single upward and downward product
 - DAM will procure 100% of requirement
 - Can be procured in sub-regional zones to meet 5-minute needs
 - Procured based on operational characteristics & ramp capability

The CAISO proposes the following design features for imbalance reserves (2 of 4):

- Scarcity in DAM is rare
- If there are inadequate imbalance reserve bids, a penalty price will be used to allow the market to reach a solution
 1. Penalty price will be based on the real-time flexible reserve product penalty price
 2. Penalty price will be tiered based on the deficient amount of imbalance reserve bids.

The CAISO proposes the following design features for imbalance reserves (3 of 4):

- Imbalance reserves can be used in the RTM for energy, certified AS, flexible ramping product, forecasted movement/uncertainty awards, or corrective capacity.
- RA resources will not be required to bid \$0
- Resources without imbalance reserve awards can elect not to bid into the real-time market
 - Can still be exceptionally dispatched

The CAISO proposes the following design features for imbalance reserves (4 of 4):

- Performance evaluation options for imbalance reserve resources:
 1. Minimum performance threshold and disqualification from providing the service in the future
 2. Modification to the no-pay rules to further penalize non-performance
- Imbalance reserve bid cost and revenues will be allocated to the DAM bid cost recovery (BCR).

Additional design considerations (1 of 2):

- **Congestion revenue rights (CRR)** – settled based on 15-minute DAM schedules instead of hourly schedules.
- **RAAIM** - simplified to only consider compliance with day-ahead must offer obligations.
- **Inter-SC trades** – Move to 15-minute scheduling intervals instead of hourly. Inter-SC trading of imbalance reserves will not be considered at this time.

Additional design considerations (2 of 2):

- **Virtual Bidding** – No longer allocated BCR because the costs will be allocated to imbalance reserves.
- **Contingency Modeling Enhancement (CME)** – Will now be awarded in 15-minute granularity in the DAM
- **15 Minute Load Aggregation Point (LAP)** – Currently, this is an hourly calculated value. Move to a 15-min LAP based on weighted average of the FMM and the three relevant RTD prices.

Settlement and Cost Allocation Worksheet

	A	B	C	D	E	F	G
1	Generator 1	EMIN/PMIN	40	EMAX/PMAX	100		
2		IFM ENERGY	IMB UP	IMB DOWN	RT ENERGY		
3	Self Schedule	50			0		
4	Bid MW 1	60	60	40	40		
5	BID PRICE 1	\$ 15.00	\$ 10.00	\$ 5.00	\$ 20.00		
6	Bid MW 2	75			65		
7	BID PRICE 2	\$ 25.00			\$ 30.00		
8	Bid MW 3	100			80		
9	BID PRICE 3	\$ 50.00			\$ 75.00		
11	Market Prices for Hour X (\$/MWh)						
12		Interval 1	Interval 2	Interval 3	Interval 4		
13	IFM Energy	\$ 38.00	\$ 40.00	\$ 45.00	\$ 80.00		
14	FMM Energy	\$ 30.00	\$ 50.00	\$ 60.00	\$ 75.00		
15	Imbalance Reserve Up	\$ 14.00	\$ 14.00	\$ 9.00	\$ 10.00		
16	Imbalance Reserve Down	\$ 8.00	\$ 6.00	\$ 6.00	\$ 6.00		
18	AWARDS (MW)						
19	GENERATOR 1						
20		Interval 1	Interval 2	Interval 3	Interval 4	Hourly Average	
21	IFM Energy	75	75	75	100	81.25	
22	FMM Energy	65	40	40	40	46.25	
23	Imbalance Reserve Up	25	25	0	0	12.5	
24	Imbalance Reserve Down	35	35	35	40	36.25	

<http://www.caiso.com/Documents/APPENDIXD-ImbalanceReserveSettlementWorksheet.xlsx>

Two-Tier Cost Allocation

- Performed in 15-min intervals at the scheduling coordinator level
 - Netting of load, generation, VERs, imports, exports and virtuals

Allocation for upward imbalance reserves:

- Tier 1 = $\text{MIN}(\text{Up price, Net negative imbalance reserve deviation rate}) \times \text{SC Up billing determinant}$
- Tier 2 = Measured demand (metered load and exports)

Allocation for downward imbalance reserves:

- Tier 1 = $\text{MIN}(\text{Down price, Net positive imbalance reserve deviation rate}) \times \text{SC Down billing determinant}$
- Tier 2 = Measured demand (metered load and exports)

Day-Ahead Market Enhancements

MARKET FORMULATIONS

George Angelidis, Ph.D.

Principal

Power Systems Technology Development

What is changing?

■ Current DAM

- ◆ MPM pass
- ◆ IFM pass
- ◆ RUC pass
- ◆ D+2 run
- ◆ D+3 run

■ Hourly intervals

■ RUC Capacity

■ New DAM

- ◆ MPM pass
- ◆ IFM/RUC pass
- ◆ D+2 run
- ◆ D+3 run

■ 15min intervals

■ Imbalance Reserve

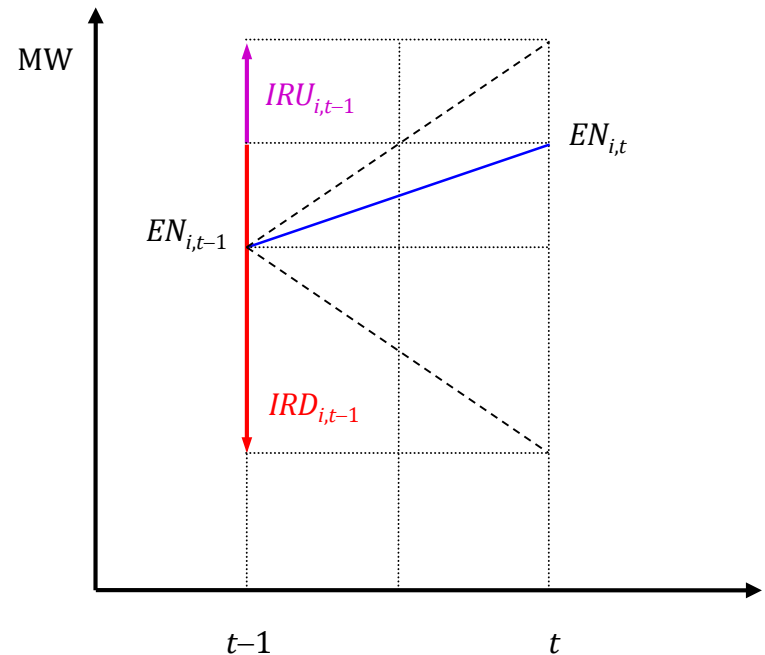
- ◆ Up/Down

Co-optimized market commodities

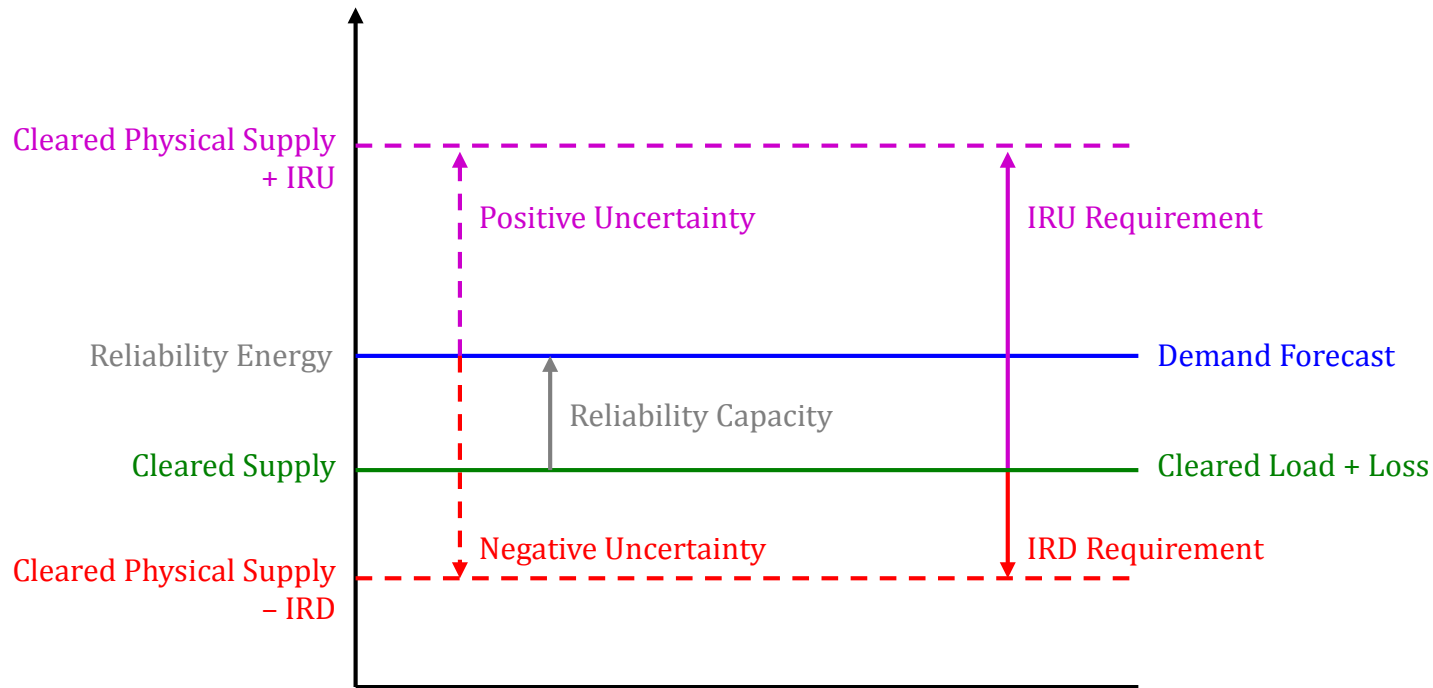
- Day-Ahead Energy schedules (physical/virtual)
- Day-Ahead Regulation Up and Down awards
- Day-Ahead Mileage Up and Down awards
- Day-Ahead Spinning Reserve awards
- Day-Ahead Non-Spinning Reserve awards
- Day-Ahead Corrective Capacity awards
- **Imbalance Reserve Up and Down awards**
- ~~Reliability Energy Schedule (meeting demand)~~

What is Imbalance Reserve?

- Reserved upward and downward ramping capacity procured at $t-1$ to be delivered if needed at t to meet the demand forecast plus upward and downward uncertainty



Day-Ahead Market targets



Power balance and Imbalance Reserve procurement constraints

$$\sum_i EN_{i,t} + \sum_j EN_{j,t} = \sum_i L_{i,t} + \sum_j L_{j,t} + LOSS_t$$

$$\sum_i EN_{i,t} + \sum_i IRU_{i,t-1} \geq D_t + IRUR_{t-1}$$

$$\sum_i EN_{i,t} - \sum_i IRD_{i,t-1} \leq D_t - IRDR_{t-1}$$

$$\sum_i REN_{i,t} \equiv \sum_i EN_{i,t} + \sum_i RC_{i,t-1} = D_t$$

Energy and Imbalance Reserve capacity and ramping constraints

■ Capacity Constraints

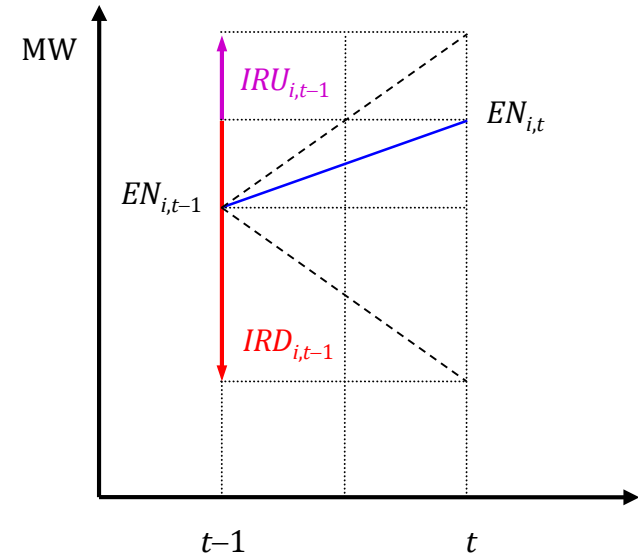
$$EN_{i,t} + IRU_{i,t-1} \leq UEL_{i,t}$$

$$EN_{i,t} - IRD_{i,t-1} \geq LEL_{i,t}$$

■ Ramping constraints

$$EN_{i,t} + IRU_{i,t-1} \leq EN_{i,t-1} + RRU_i(EN_{i,t-1})$$

$$EN_{i,t} - IRD_{i,t-1} \geq EN_{i,t-1} - RRD_i(EN_{i,t-1})$$



Day-Ahead Market Enhancements

DATA ANALYSIS

Don Tretheway

Sr. Advisor

Market Design Policy

Data analysis uses reliability forecast to determine imbalance between DAM and RTM

Data to Determine ISO Reliability Forecast		
	HE8	HE9
IFM	20,000	22,000
RUC Delta	+ 1,000	+ 1,000
Net Virtuals	-500 (supply)	-500 (supply)
VER Forecast Delta	-800	-800
ISO Reliability Forecast	19,700	21,700

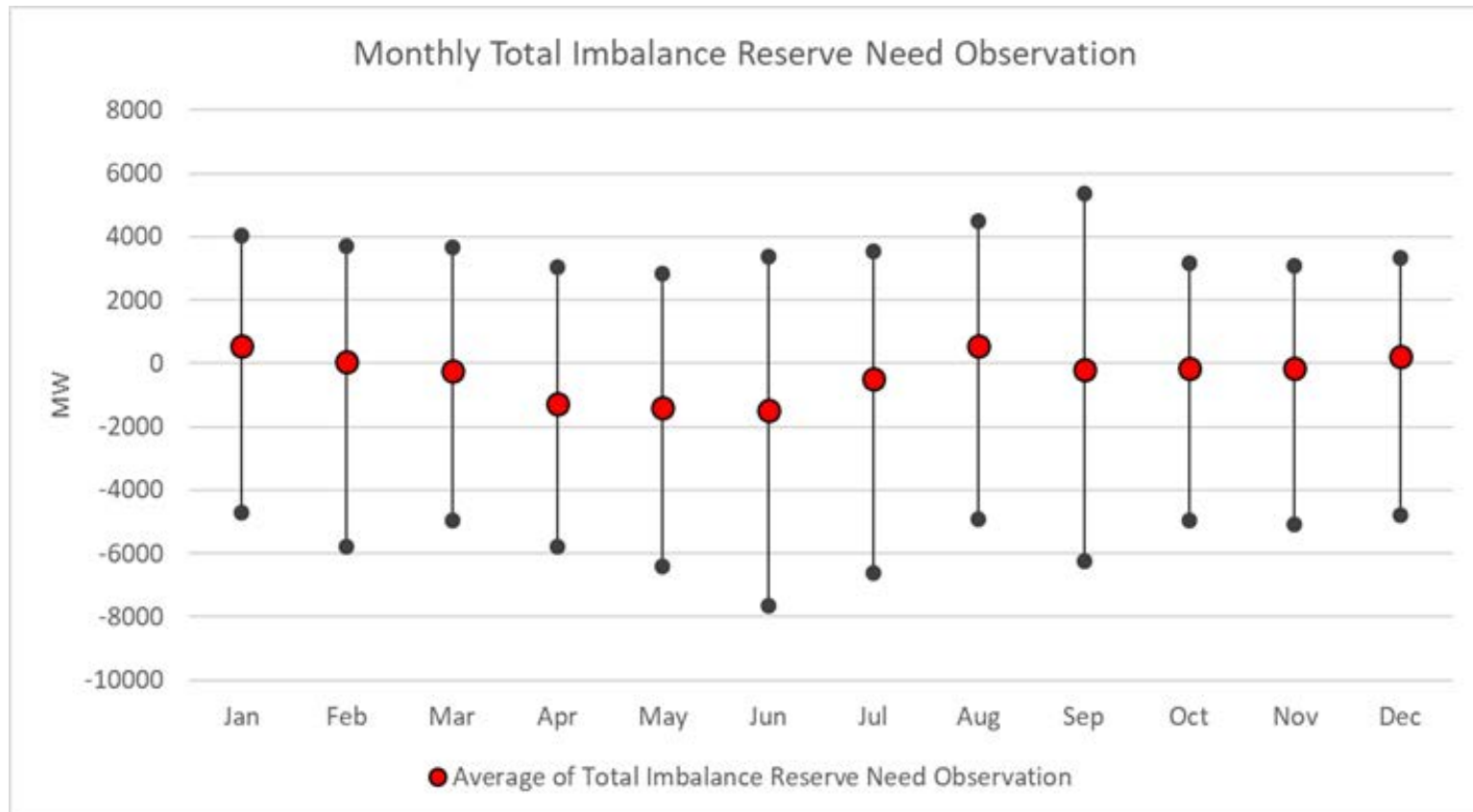
Create 15-minute reliability forecast by linearizing between hourly mid points

Observed imbalance reserve need is calculated for each 15-minute interval

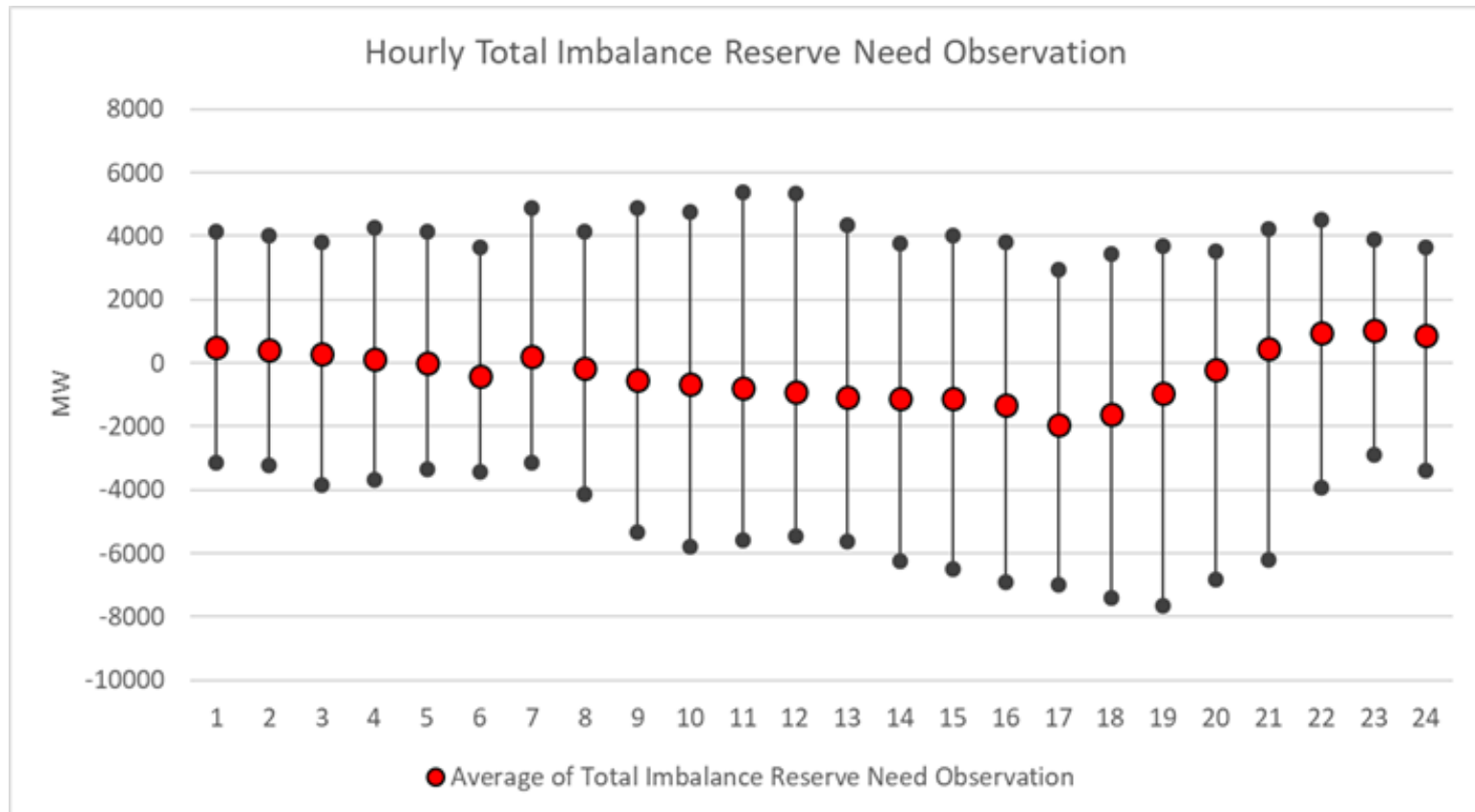
1. FMM load - reliability forecast
 - If positive, increases upward imbalance need
 - If negative, increases downward imbalance need
2. Adjust for EIM transfers
 - If EIM transfers in, increases upward imbalance need
 - If EIM transfer out, increases downward imbalance need
3. Add FMM flexible ramping product requirement
 - If 1+2 upward imbalance need, then add FRU
 - If 1+2 downward imbalance need, then add FRD

Captures load, VER IFM forecast difference, and convergence bids

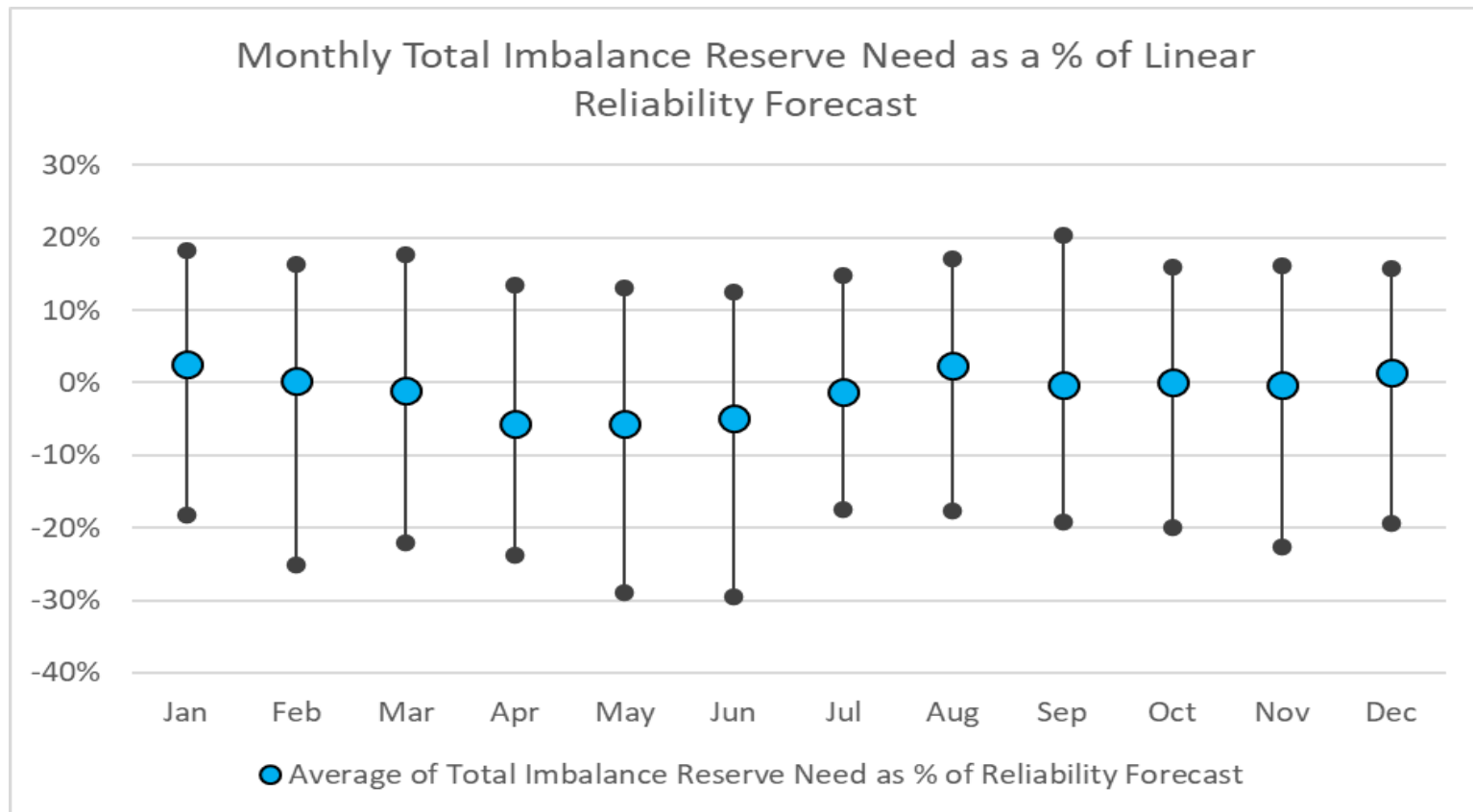
Comparing reliability forecast to FMM load adjusted for EIM transfers - Monthly



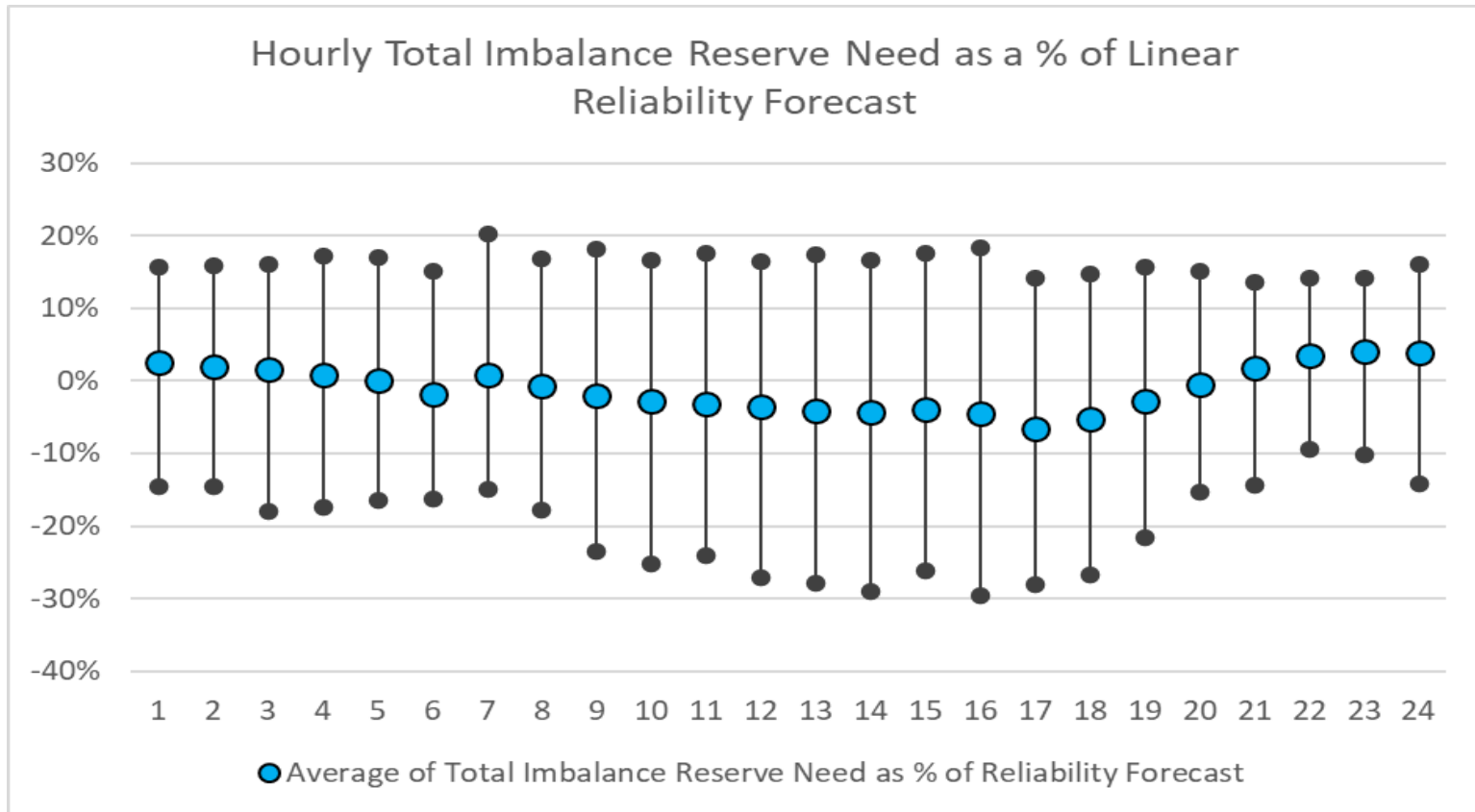
Comparing reliability forecast to FMM load adjusted for EIM transfers - Hourly



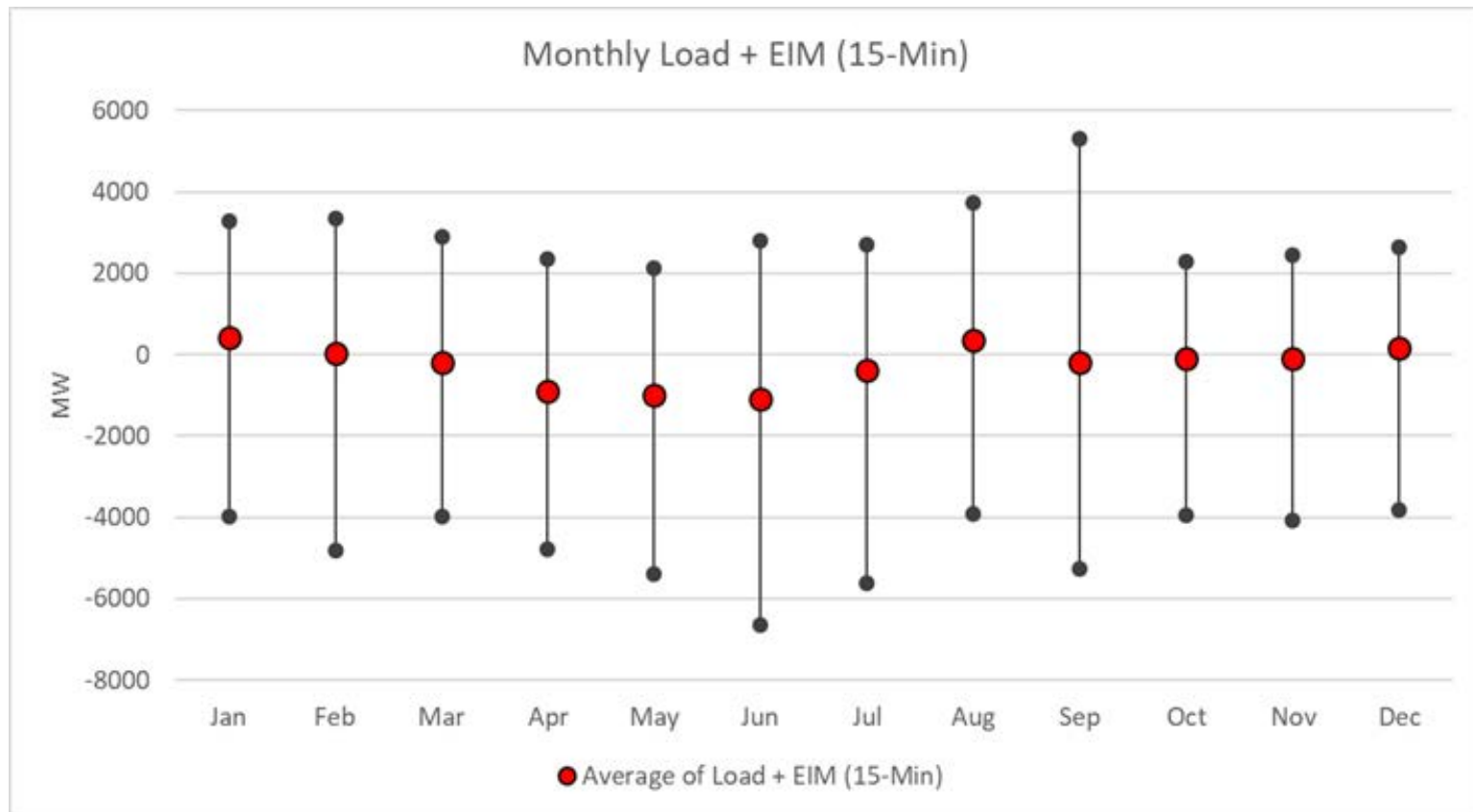
Percentage of reliability forecast to observed imbalances - Monthly



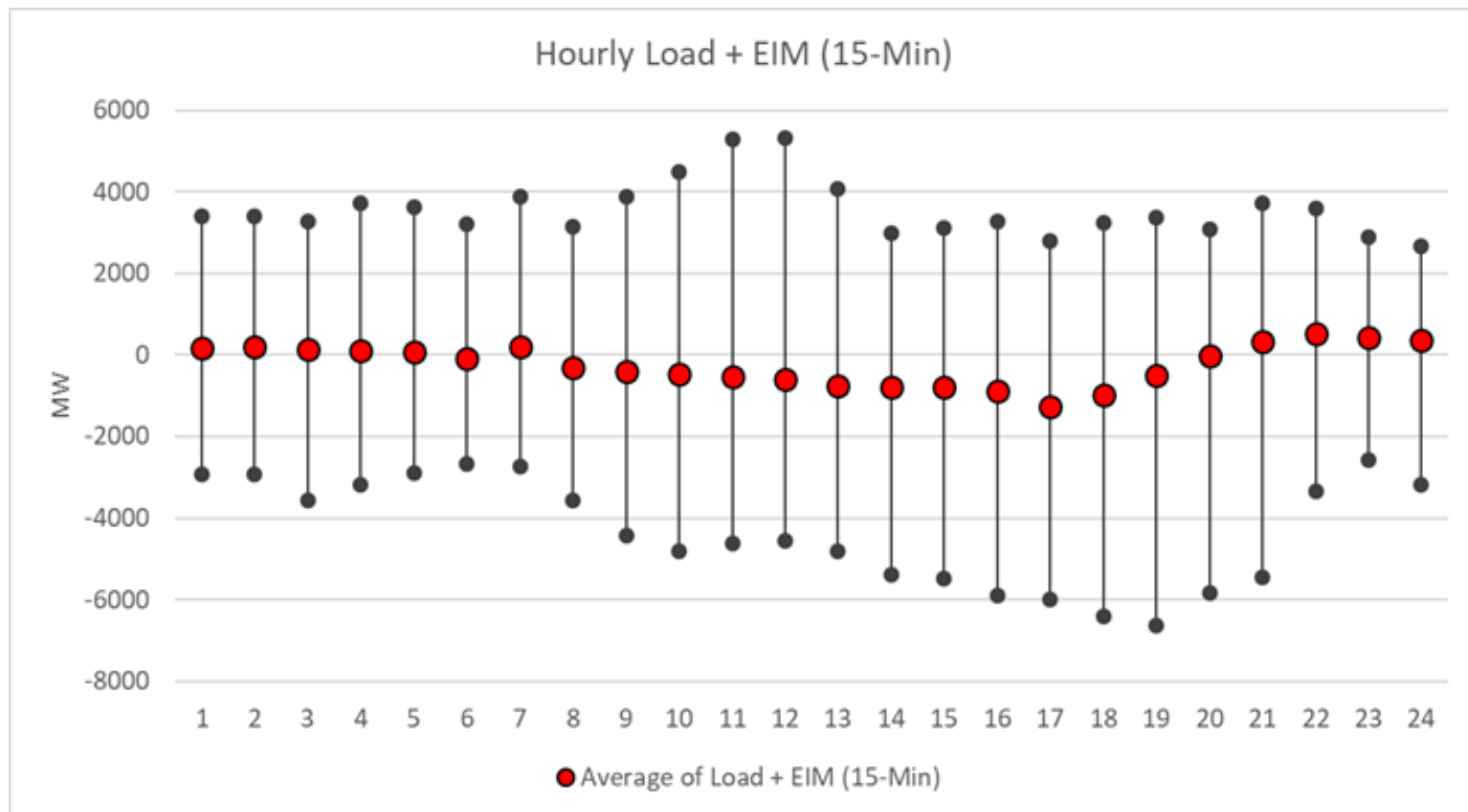
Percentage of reliability forecast to observed imbalances - Hourly



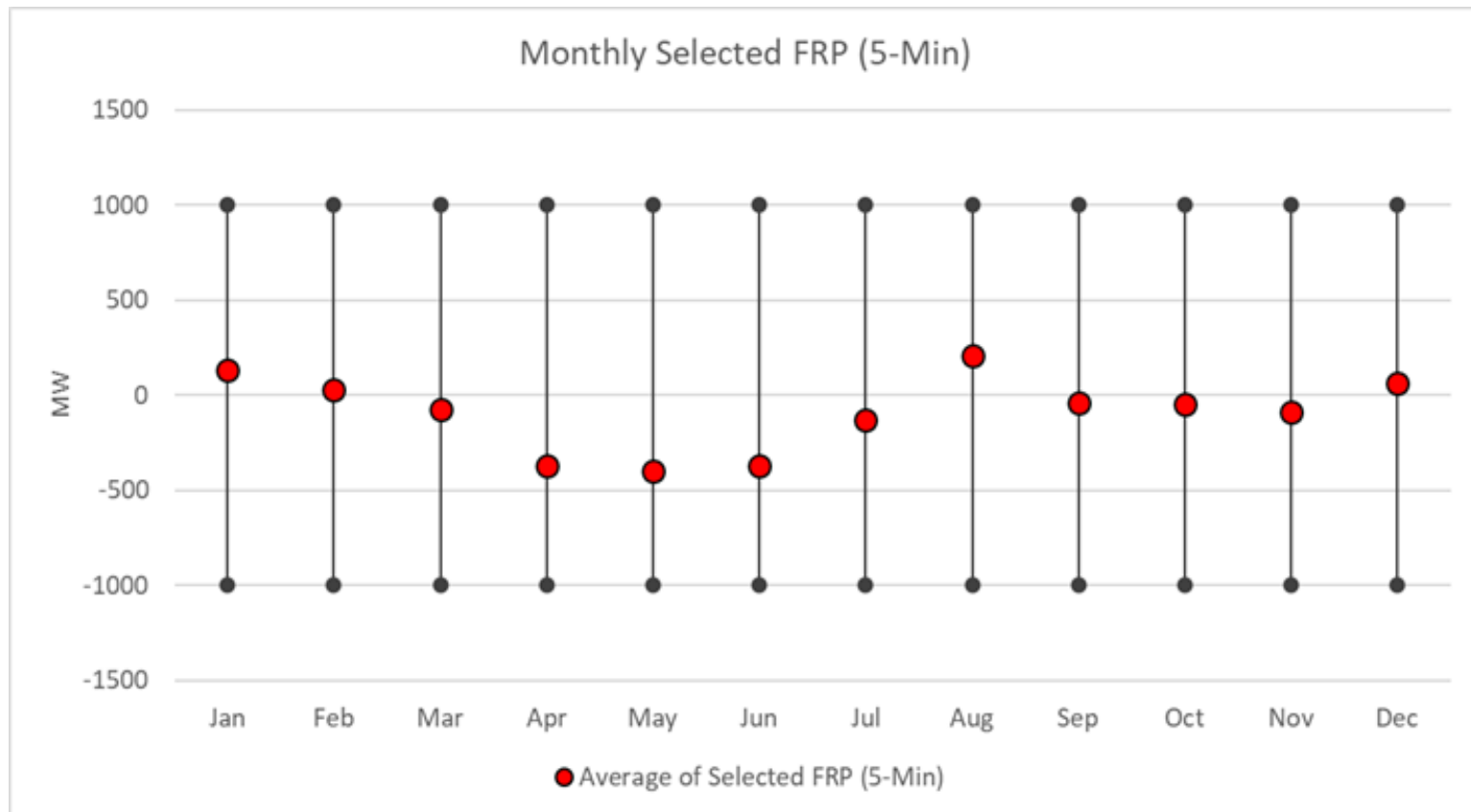
FMM imbalance observed can be met by 15-minute and 5-minute dispatchable resources - Monthly



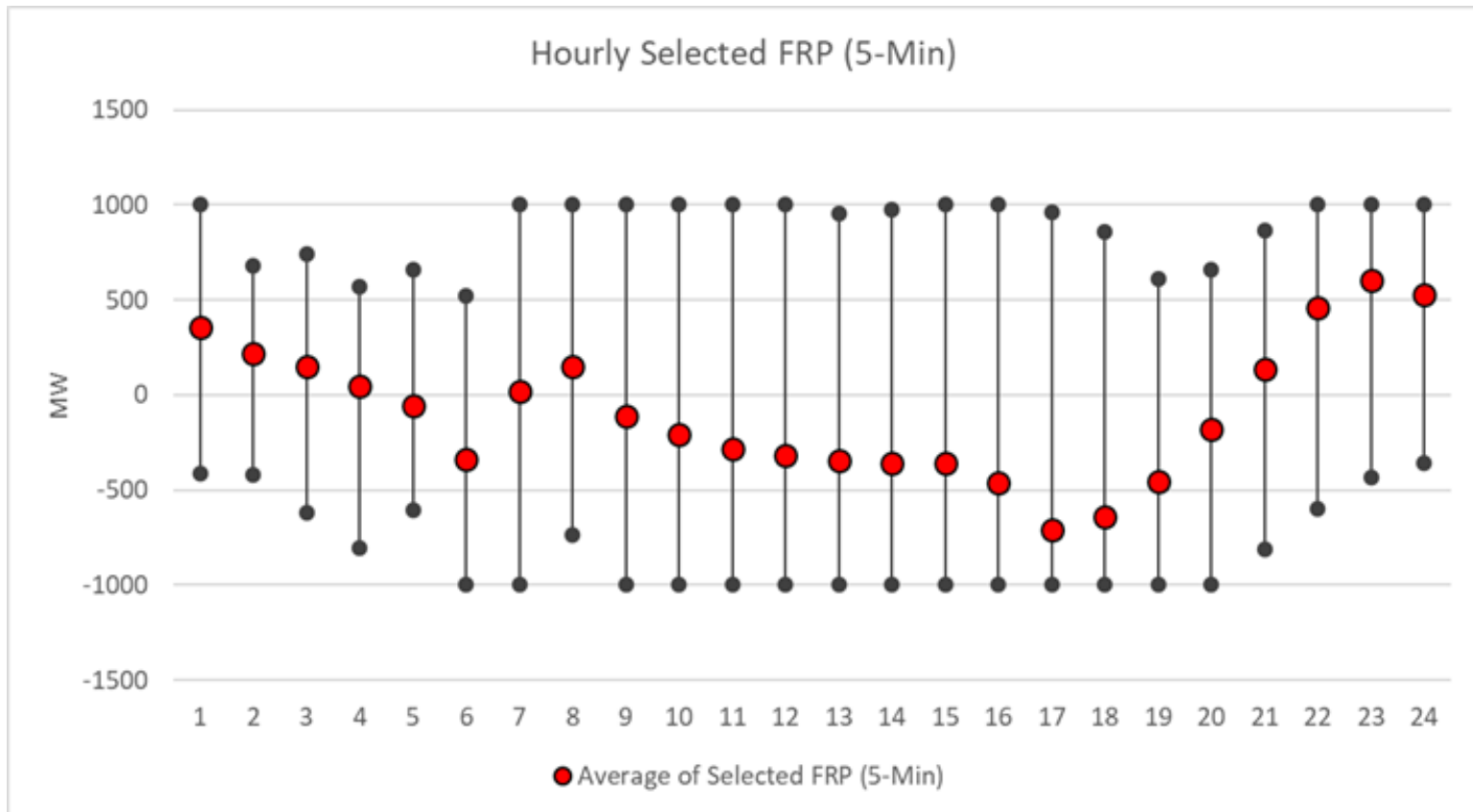
FMM imbalance observed can be met by 15-minute and 5-minute dispatchable resources - Hourly



Flexible ramping product FMM requirement met by 5-minute dispatchable resources - Monthly



Flexible ramping product FMM requirement met by 5-minute dispatchable resources - Hourly



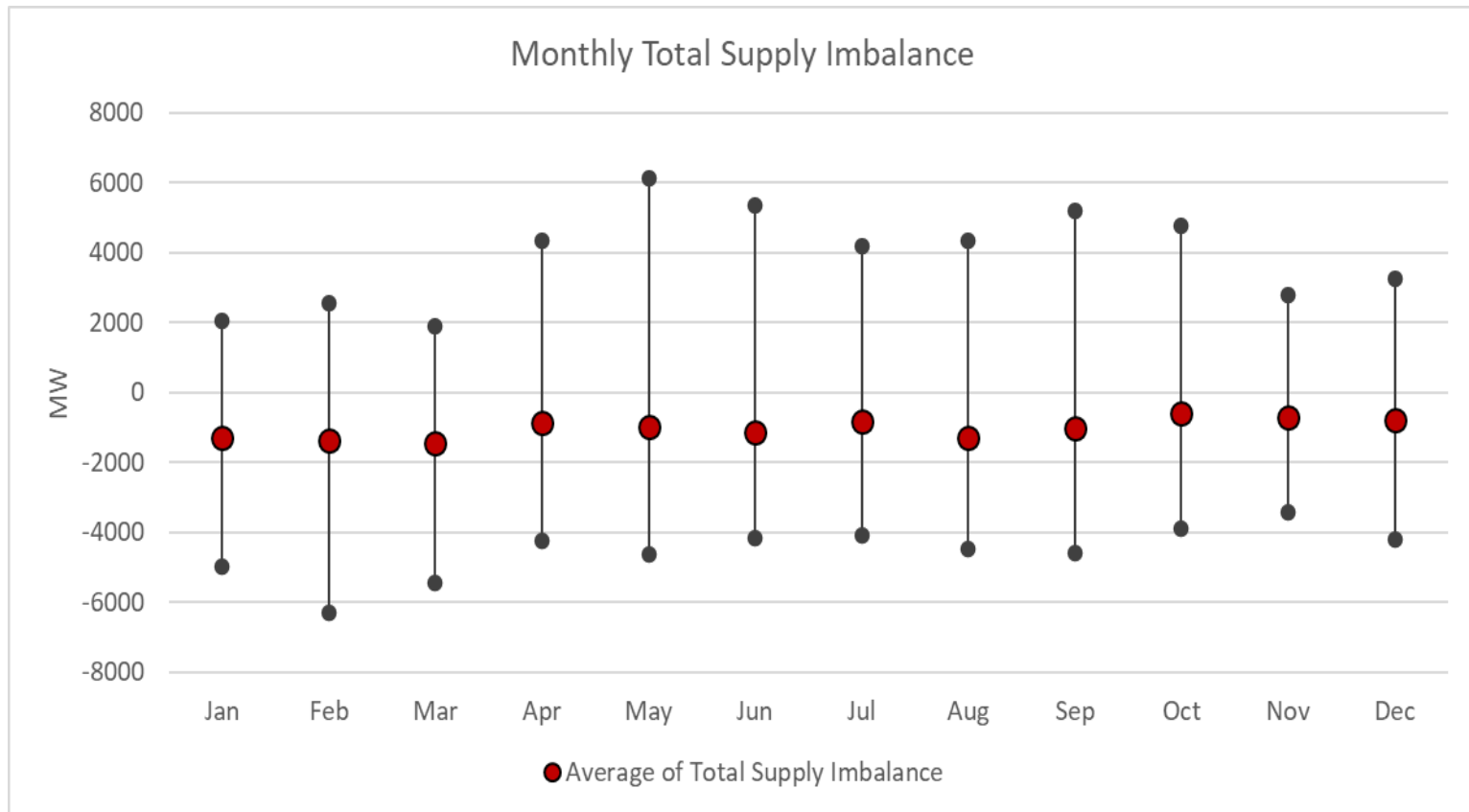
Supply creates imbalance reserve need if real-time market must accommodate an inflexible schedule change (1 of 2)

- Drivers of upward imbalance reserves include:
 - Conventional generators that are unable to meet their IFM schedule
 - VERs that are unable to meet their IFM schedule
 - Imports that don't tag their IFM schedule
 - Exports that self-schedule above their IFM schedule
 - Virtual supply

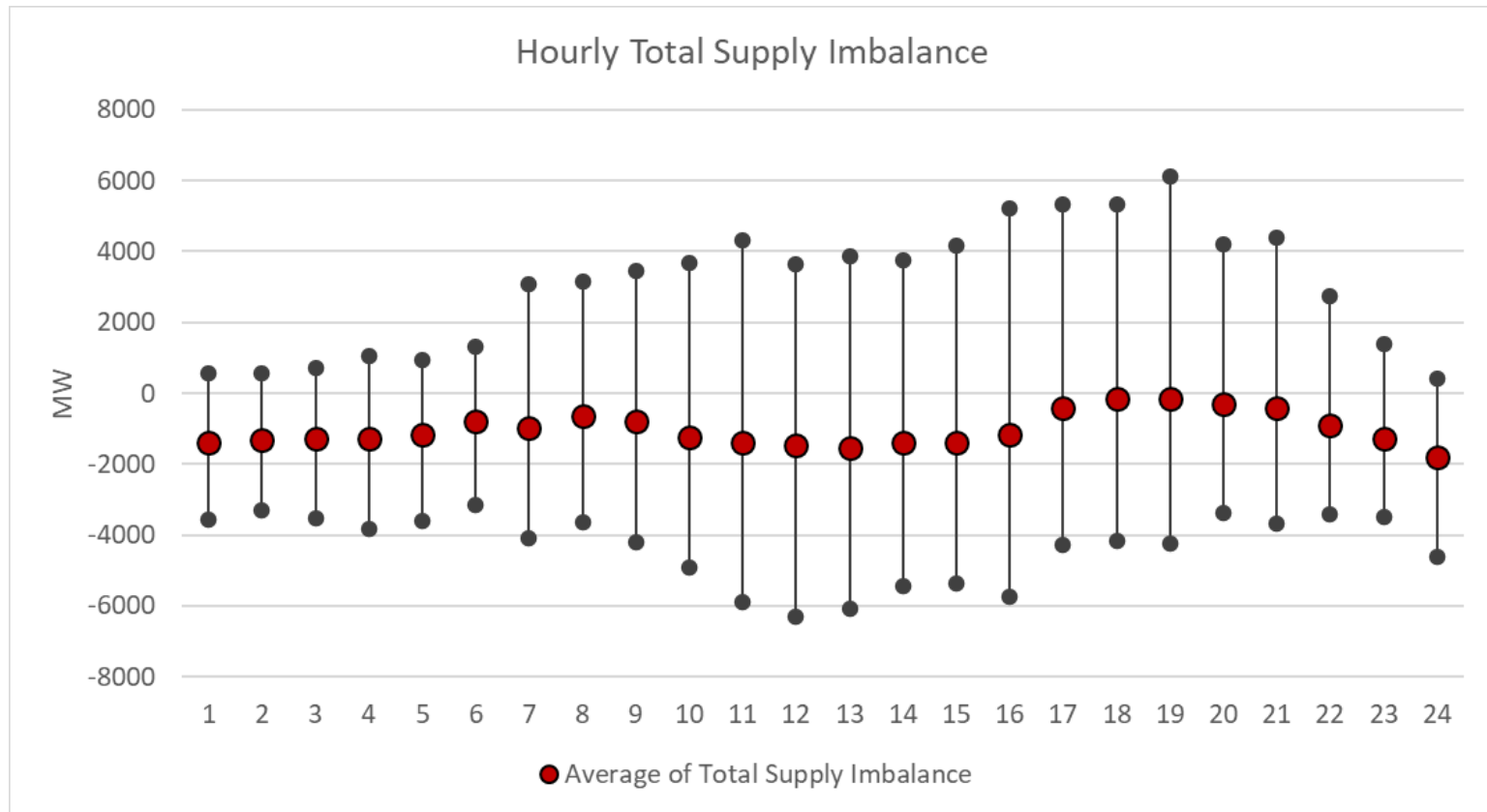
Supply creates imbalance reserve need if real-time market must accommodate an inflexible schedule change (2 of 2)

- Drivers of downward imbalance reserves include:
 - Conventional generators that self-schedule above their IFM schedule
 - VERs that self-schedule above their IFM schedule
 - Imports that self-schedule above their IFM schedule
 - Exports that don't tag their IFM schedule
 - Virtual demand

Supply FMM imbalances - Monthly



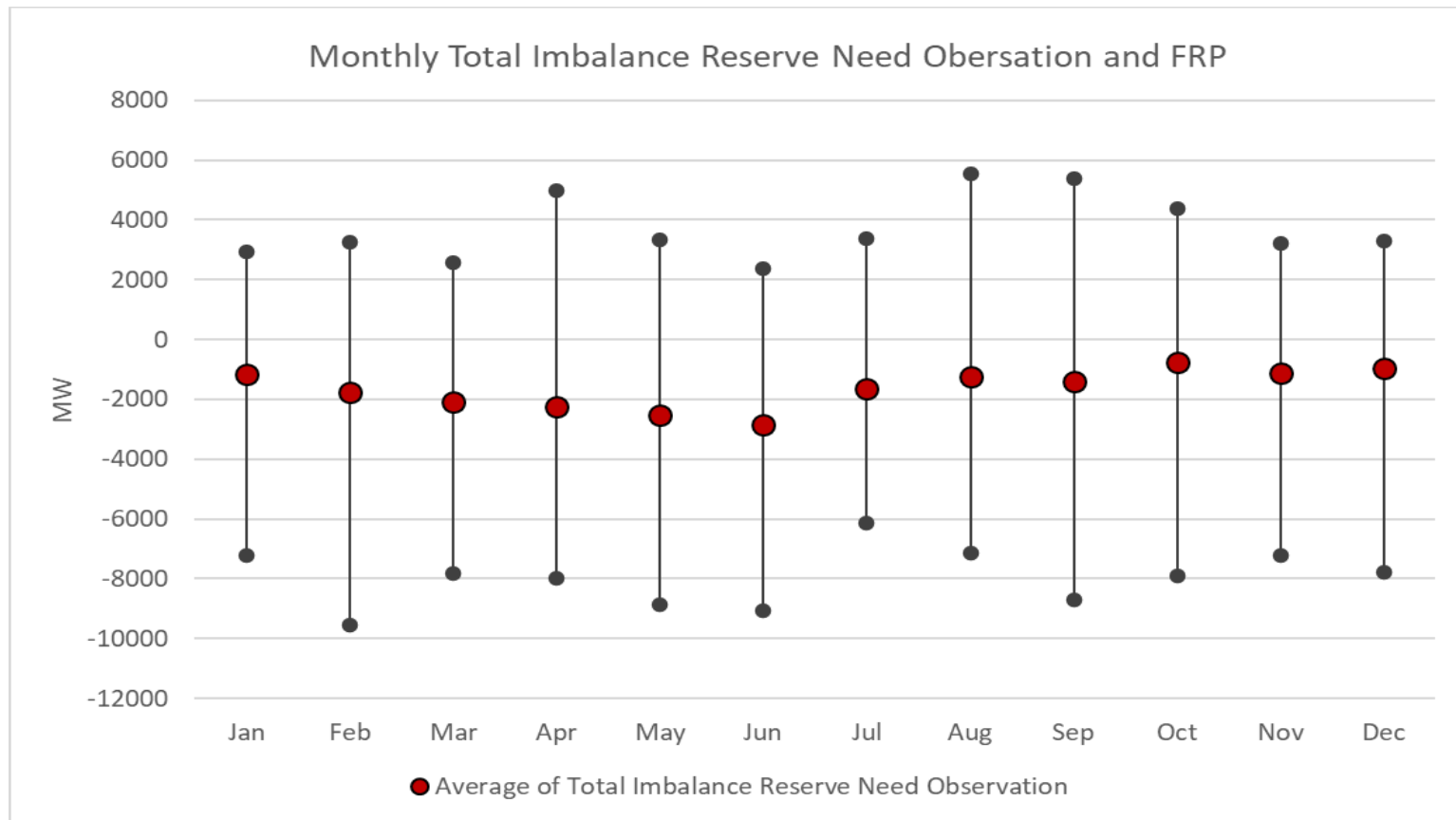
Supply FMM imbalances - Hourly



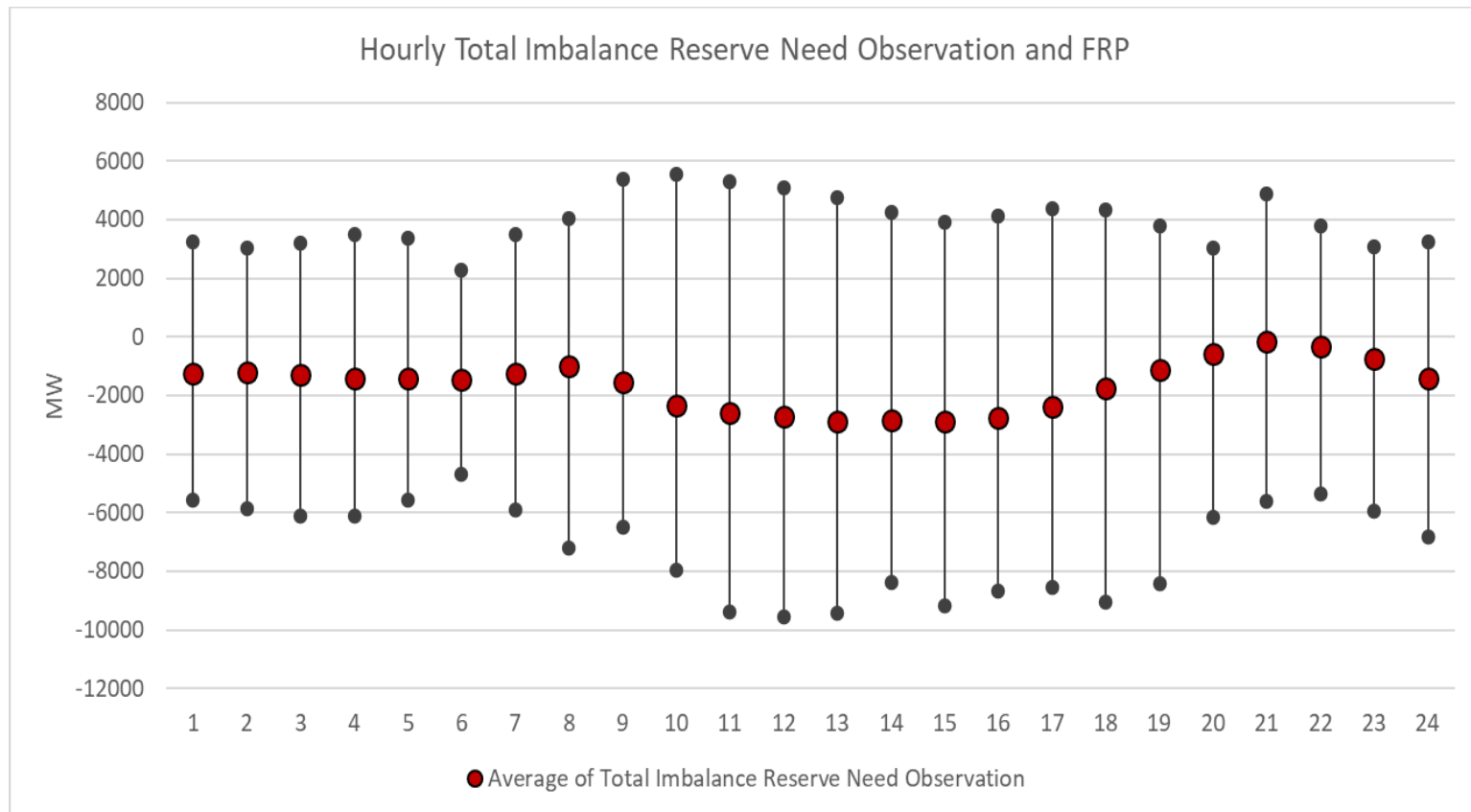
Total observed imbalance reserve need is calculated for each 15-minute interval

1. FMM load - reliability forecast
2. Adjust for EIM transfers
3. Add supply imbalance
4. Add FMM flexible ramping product requirement
 - If 1+2+3 upward imbalance need, then add FRU
 - If 1+2+3 downward imbalance need, then add FRD

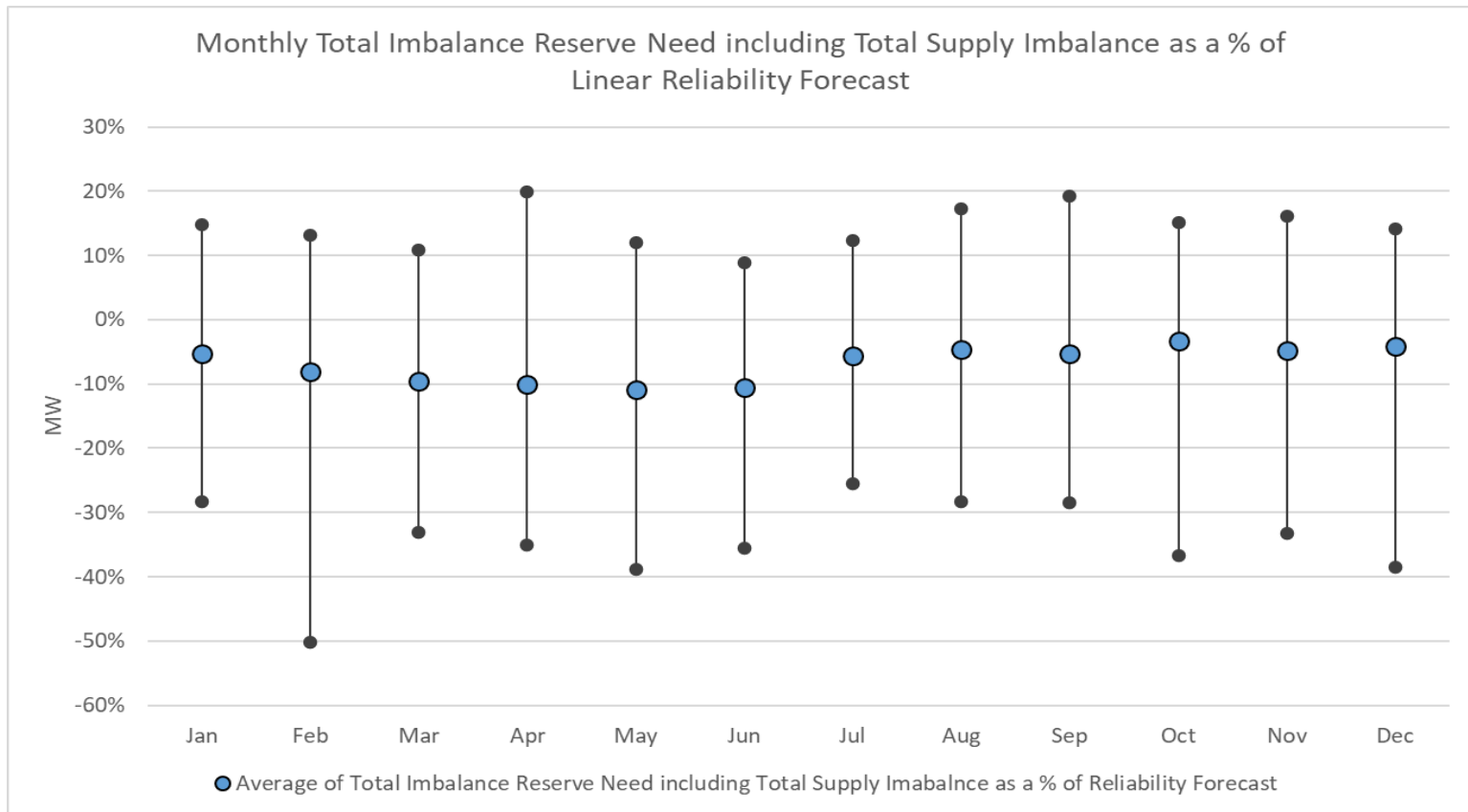
Total observed imbalance and FRP - Monthly



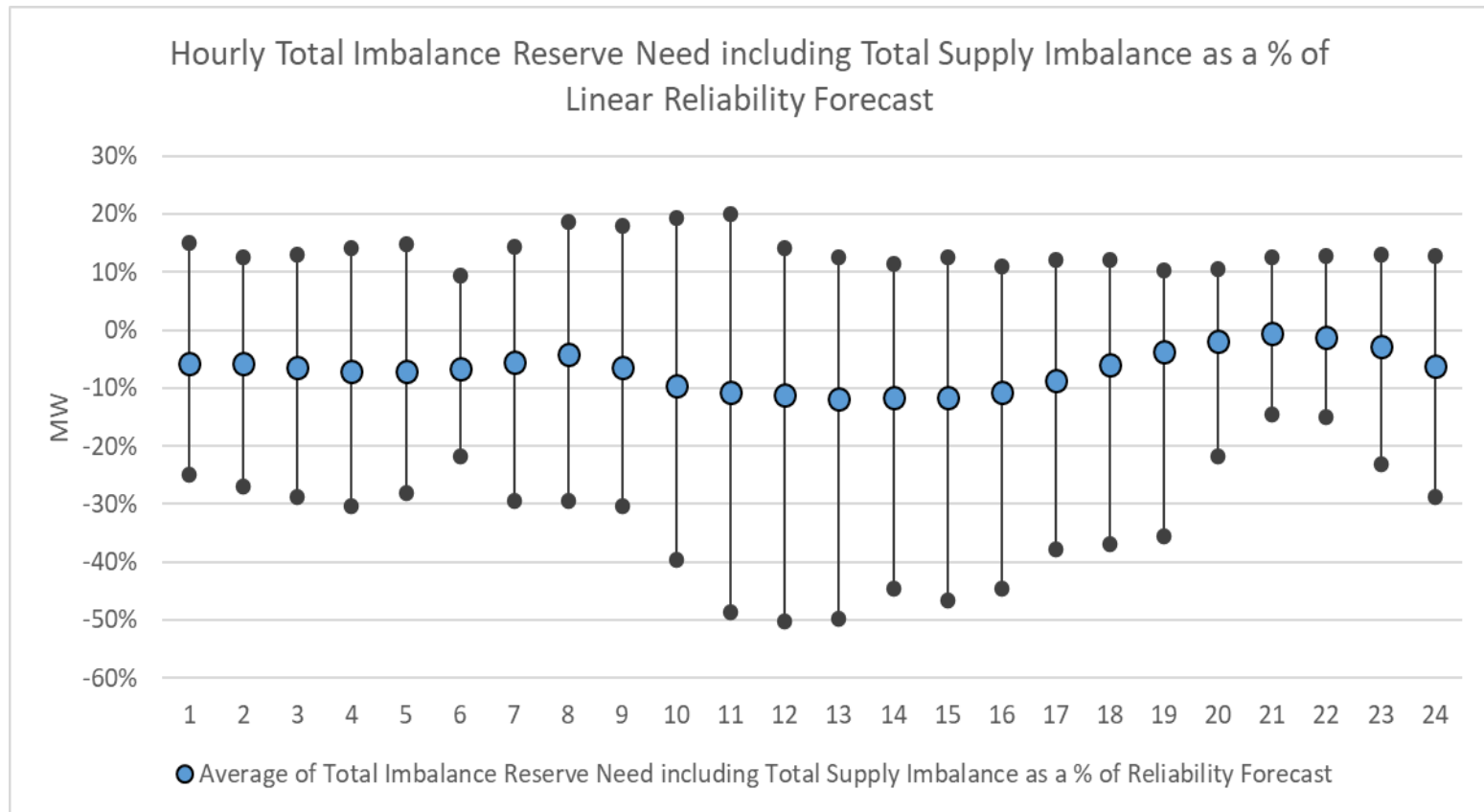
Total observed imbalance and FRP - Hourly



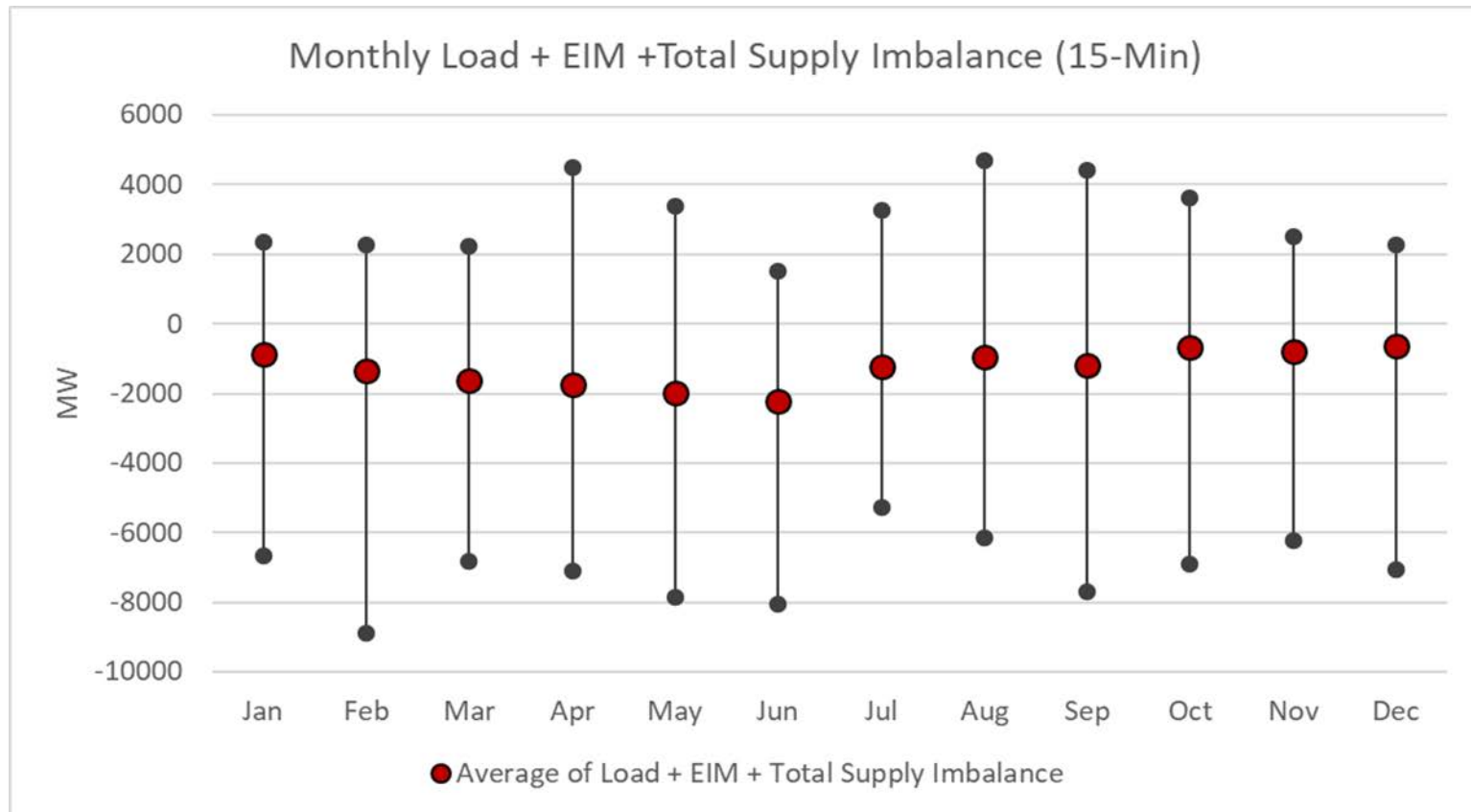
Total observed imbalance as a percentage of reliability forecast - Monthly



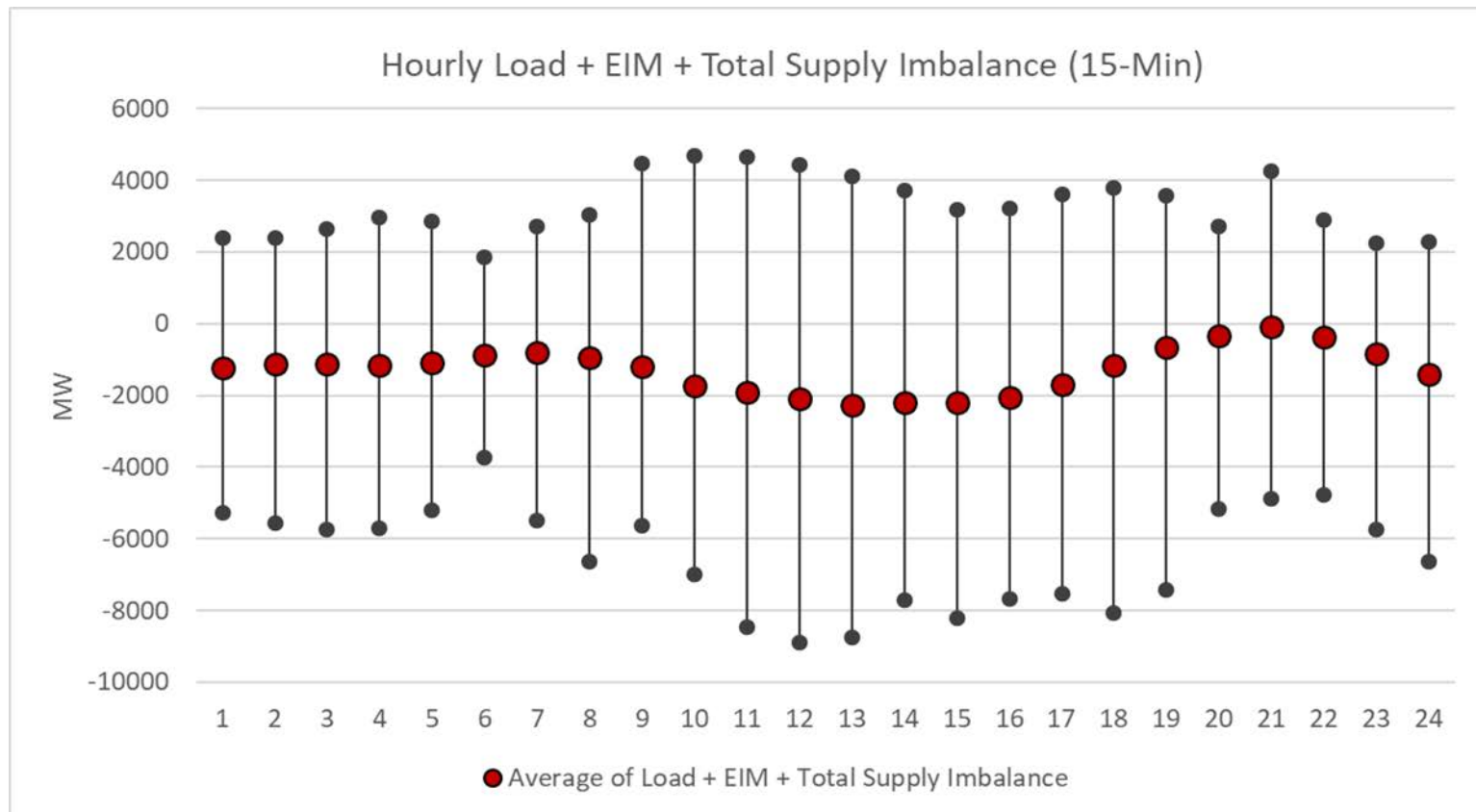
Total observed imbalance as a percentage of reliability forecast - Hourly



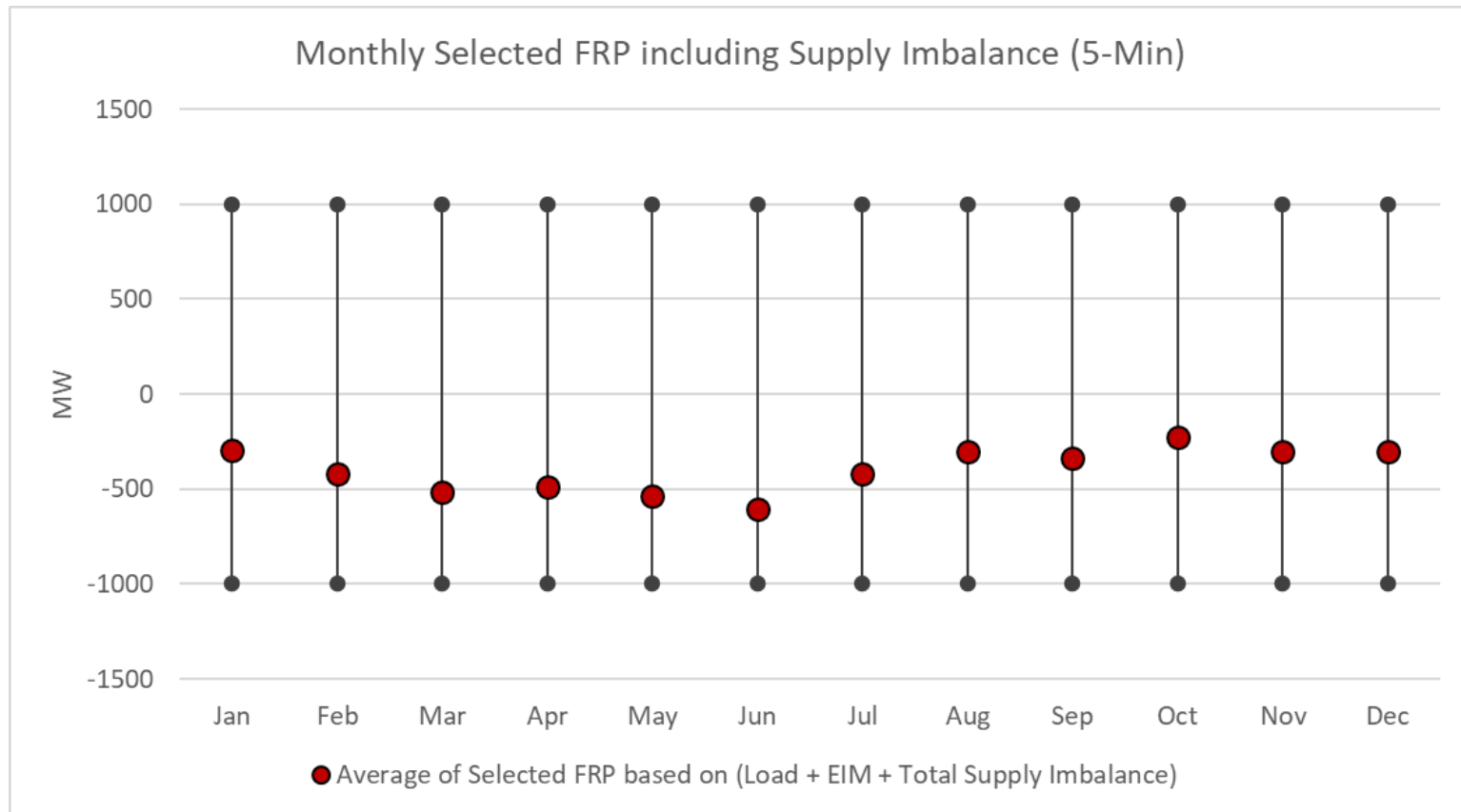
Total observed FMM imbalance that can be met by 15 and 5 minute dispatchable resources – Monthly



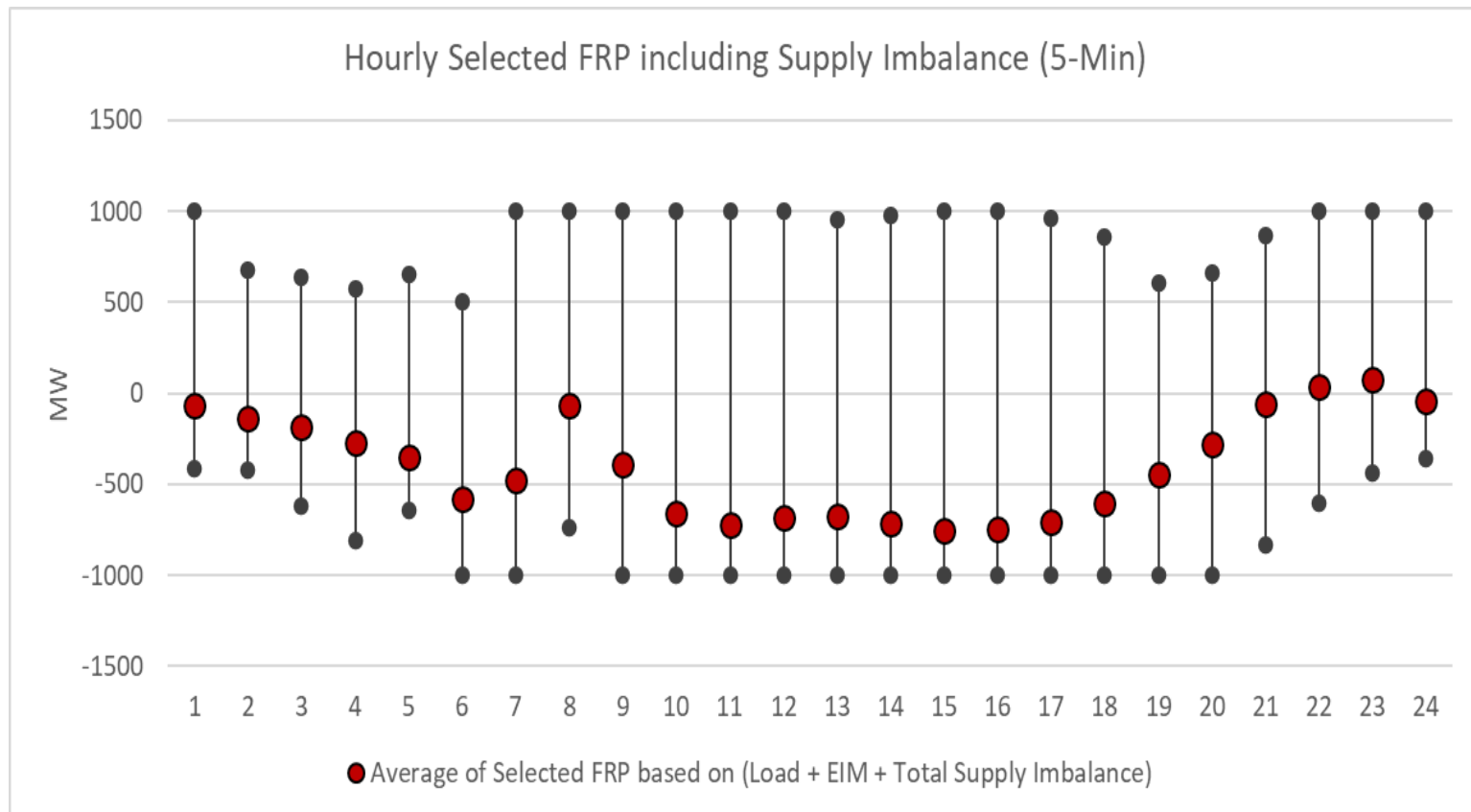
Total observed FMM imbalance that can be met by 15 and 5 minute dispatchable resources – Hourly



Total FRP requirement only met by 5-minute dispatchable resources - Monthly



Total FRP requirement only met by 5-minute dispatchable resources - Hourly



Day-Ahead Market Enhancements

IMBALANCE RESERVE REQUIREMENT OPTIONS

Amber Motley

Manager

Short Term Forecasting

Methodology Option #1 – Near Term Approach

- Utilize a methodology that is similar to what is used for the Flexible Ramping Product (FRP) procurement. Requirement will be determined based on differences between the DAM and RTD.

Methodology Option #2 – Mid Term Approach

- Utilize a statistical regression technique to estimate the variation for individual components of load, wind and solar. After completion of the regression estimates, combine the results into the total imbalance reserve requirement. This methodology will analyze differences between the DAM and RTD.

Methodology Option #3 – Far Term Approach

- Utilize probabilistic forecasting in combination with a statistical regression technique (methodology #2) to estimate the variation for individual components of load, wind and solar. Combine these results to determine the total imbalance reserve requirement.
- Probabilistic forecasting uses numerical weather prediction ensembles; this is a good way to determine weather variability for individual days looking at future forecasted information.

Day-Ahead Market Enhancements

CORRESPONDING EIM CHANGES

Don Tretheway

Sr. Advisor

Market Design Policy

EIM changes need to align with ISO day-ahead market

- EIM base schedules are currently hourly consistent with ISO's current day-ahead scheduling granularity
- With DAM enhancements implementation, base schedules will now be submitted with 15-minute granularity
- 15-minute base schedules results in changes to:
 - Resources sufficiency evaluation
 - Over/under scheduling penalties

Resource sufficiency evaluation ensures EIM entities don't lean on others capacity, flexibility or transmission

- Currently, performed hourly if any test is failed, EIM transfers cannot exceed prior hour's level.
- Propose to consider each 15-minute interval individually
 - Still perform prior to operating hour to identify which intervals will be frozen
 - If a 15-minute interval test is failed, hold transfers at previous 15-minute interval binding result.

Over / under scheduling penalty will align with 15-minute base schedules

- Determine if penalty should apply each 15-minute interval
- Penalty only applies for 15-minute interval not entire hour
- Under extended DAM, this penalty is no longer applicable because EIM participants can't determine how much imbalance is settled in EIM

During SMUD implementation identified need to add regulation up and regulation down energy settlement (1 of 2)

- Currently, an EIM entity use a manual dispatch after the operating hour to identify energy that resulted from following AGC
- Manual dispatch changes the classification of the regulation energy from uninstructed imbalance energy to instructed imbalance
- This is important because uninstructed imbalance energy determines the amount of uplift costs that can be shifted between BAAs.

During SMUD implementation identified need to add regulation up and regulation down energy settlement (2 of 2)

- Add regulation up and regulation down to hourly resource plan
- ISO will then settle regulation energy for the resource
- This eliminates the need for a manual dispatch to have the energy deviations classified as instructed

Day-Ahead Market Enhancements

OPEN ISSUES

Don Tretheway

Sr. Advisor

Market Design Policy

Seeking stakeholder comments. Plan is to address in next paper.

- Deliverability
- Settlement between IR & FRP
- Re-procurement of AS in FMM
- DAM bidding of corrective capacity
- Self Provision of AS
- Consideration of Energy Bid in Awarding IR

Imbalance reserves use sub-regional requirement to improve deliverability

- This issue exists for ancillary services and flexible ramping product today.
 - Block resources from awards to address congestion
- RUC currently does ensure RUC award are transmission feasible
- ISO can modify DAM enhancement formulation assure deliverability for portion of IR that meets demand forecast.
- Need separate initiative to discuss locational IR and AS needed?

Settlement of imbalance reserves and flexible ramping product

- Imbalance reserves have a must offer obligation into real-time to address uncertainty between DAM and FMM
- If scheduled or dispatched in FMM, should the resource be charged the flexible ramping product?
 - Imbalance reserve up deployed buy back FRU
 - Imbalance reserve down deployed buy back FRD
- Are imbalance reserve effectively day-ahead flexible ramping product for uncertainty?

Re-procurement of ancillary services improves efficiency in FMM

- Imbalance reserves improve efficiency by ensuring sufficient energy and ancillary services bids
- Currently do not re-optimize AS in FMM. FMM only procures incremental AS.
- Should change to allow optimization of all products in FMM?
- In FMM, do we need real-time capacity bids for spin and non-spin? Regulation up and down?

DAM bidding for corrective capacity is similar to allowing bidding for imbalance reserves

- Similar costs to have a resource available for economic dispatch via a must offer obligation for energy (corrective capacity and FRP) and AS.
- Need to address market power concerns if bidding allowed for corrective capacity

Eliminate the ancillary services self-provision qualification process

- Currently, pre-process before the DA market optimization
- Maintain scheduling priority, but allow co-optimization with other products

Consideration of Energy Bid in Awarding IR

- Generally, if two resources has the same IR up bid, you would prefer to award the resource with the lower energy bid
 - Ignoring congestion and losses
- Do we need to lock the bids for real-time which reduces flexibility?

Day-Ahead Market Enhancements

EIM CATEGORIZATION & NEXT STEPS

Kristina Osborne

Sr. Stakeholder Engagement Specialist

Stakeholder Affairs

Proposed EIM Governing Body Classification

- The CAISO proposes the EIM Governing Body has a **hybrid** approval role for this initiative
- Stakeholders can include response to the EIM categorization in their comments

Proposed Initiative Schedule

Milestone	Date
<i>Post Issue Paper/Straw Proposal</i>	<i>February 28, 2018</i>
<i>Stakeholder Meeting</i>	<i>March 7, 2018</i>
<i>Stakeholder Written Comments Due</i>	<i>March 21, 2018</i>
Post Revised Straw Proposal	April 11, 2018
Stakeholder Meeting	April 18, 2018
Stakeholder Written Comments Due	May 2, 2018
Post Revised Straw Proposal	May 16, 2018
Stakeholder Meeting	May 23, 2018
Stakeholder Written Comments Due	May 30, 2018
Post Draft Final Proposal	June 19, 2018
Stakeholder Call	June 26, 2018
Stakeholder Written Comments Due	July 11, 2018
EIM Governing Body Meeting	Aug 22, 2018
Board of Governors Meeting	Sep 5-6, 2018



QUESTIONS?

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