



Day Ahead Market Enhancements

Revised Straw Proposal

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1. Purpose

The purpose of this initiative is to improve grid reliability and the efficiency of the California ISO's (CAISO) day ahead market. The day-ahead market enhancements will better position the system to accommodate net load variability that occurs in real-time. The CAISO proposes enhancements to change the day-ahead market from hourly to fifteen-minute granularity, combine the integrated forward market (IFM) and residual unit commitment (RUC) processes, and procure imbalance reserves that will have a must offer obligation to submit economic bids to the real-time market.

Fifteen-minute scheduling granularity will ensure the day-ahead market commits resources with sufficient ramping capability by modeling ramping that more closely aligns with real-time conditions. Currently the real-time market must dispatch resources to manage granularity differences between the day-ahead market and the real-time dispatch (RTD). Moving to day-ahead fifteen-minute scheduling granularity will reduce the granularity differences.

The real-time market must manage the uncertainty that occurs between the day-ahead and real-time markets by dispatching resources economically based on supply bids and load forecasts. To ensure sufficient real-time supply bids, the CAISO is adding new day-ahead imbalance reserves to compensate resources that would have a must offer obligation to bid into the real-time market.

Finally, combining the IFM and RUC increases efficiency and allows the CAISO market systems to optimize supply against bid-in demand and net load forecast simultaneously.

1.1. Changes from Issue Paper/Straw Proposal

The CAISO appreciates the written stakeholder comments that were received in response to the DAM Enhancements Issue Paper/Straw Proposal. Responses to the comments are included throughout this paper. The CAISO emphasizes the importance of stakeholder engagement in this initiative to identify all impacts as the proposal is developed. The key changes made in this revised straw proposal are:

- In the prior proposal, there was discussion that there would be distinct 15-minute and 5-minute imbalance reserve products for both upward and downward directions. In this proposal, the ISO proposes to have a single product for each direction. The 5-minute need can be addressed by distributing portions of the imbalance reserve requirement to sub-regions. Thus the regional requirement will be set at the total need to address FMM imbalance and the FMM flexible ramping product uncertainty requirement. The FMM flexible ramping uncertainty requirement will then be distributed to the various sub-regions where only 5-minute dispatchable resources will be eligible to meet the sub-regional requirement.
- Provided additional information in the attached draft technical paper explaining the formulations for the new day-ahead market.

- Provided data analysis of historical imbalance.
- Proposed methodologies to determine the imbalance reserve requirement.
- Provided a settlement and cost allocation worksheet.

1.2. Background & References

The purpose of the CAISO's day-ahead market is to provide price certainty and to schedule resources in advance to ensure operational reliability of the bulk electric grid in real-time. Historically, day-ahead procurement of resources in hourly blocks was adequate and the real-time market could manage deviations that occurred. Grid infrastructure has advanced, the resource fleet has changed, and the policies regulating operation of the grid have evolved (i.e. FERC mandated fifteen-minute scheduling in real-time energy markets). As a result, hourly scheduling granularity is no longer the most efficient way to schedule resources.

The ISO market's security constrained economic dispatch (SCED) is responsible for to dispatch resources up or down based on system constraints. The intent of the day-ahead market is to set the real-time market up to have sufficient energy and capacity online and available to economically balance supply with load. However, intra-hour net load changes have increased to a point in which the day-ahead market's hourly schedules do not align with the real-time load curve; this puts a strain on the real-time market to make up for granularity differences and uncertainty.¹

The CAISO has successfully implemented several real-time market enhancements to ensure reliability of the bulk electric grid and enhance economic efficiency; however, there have been limited improvements to the day-ahead market. Therefore, the purpose of this initiative is to improve the day-ahead market to ensure that sufficient resources are committed and adequate available capacity is procured ahead of time to ensure the success of the real-time market and high reliability of the bulk electric grid.

The Day Ahead Market Enhancements (DAME) initiative is a core element in the CAISO's strategic vision. The CAISO has a three-fold strategic vision, which is broken down into the following strategies:

- 1) Lead the transition to a low carbon grid
- 2) Reliably manage the grid during energy industry transformation
- 3) Expand collaboration to unlock regional benefits

¹ Net load is defined as load less variable energy resources output.

In order to work towards the strategic vision, the ISO develops a three-year roadmap based on stakeholder input. The Day Ahead Market Enhancements initiative is a core element in the ISO's three-year roadmap and assists in the achievement of all three elements in the strategic vision.²

Additionally, successful implementation of the DAM Enhancements will enable the CAISO to extend this functionality to Energy Imbalance Market (EIM) entities. Extension of the CAISO's DAM (with fifteen-minute scheduling granularity) will allow for more efficient unit commitment of resources and more effective integration of renewable resources across a larger footprint.

2. Limitations of the Current Day-Ahead Market

2.1. Addressing Uncertainty and Forecast Differences

The CAISO's current DAM is limited in its ability to account for net load uncertainty, specifically potential excess supply, because of its sequential runs of the integrated forward market (IFM) and the residual unit commitment (RUC). When the IFM runs based on bid-in demand, the resulting energy procurement may be less than the anticipated CAISO demand forecast. RUC will then procure incremental capacity to ensure additional resources are available in real-time to cover the shortfall. Resources that receive a RUC award have a must offer obligation to submit economic bids into the real-time market.

Based on current market design, RUC will commit additional resources to match the CAISO Forecast of CAISO Demand (CFCD) when the IFM has not scheduled enough supply.³ However, RUC is unable to de-commit resources that were scheduled in the IFM. RUC clears based on the RUC procurement target, which is largely determined by the ISO's demand forecast. When the ISO's demand forecast is lower than the IFM, the IFM has committed too much energy and is set up for an excess supply situation in real-time. In this way, the current IFM and RUC processes do not work together to determine the most efficient day-ahead schedules based on anticipated real-time conditions.

When the CAISO first designed the DAM, this limitation did not pose a problem. As the CAISO's fleet has evolved to include more variable energy resources, the CAISO has increasingly experienced excess supply in real time because of variable energy resources' do not always bid into the day-ahead market. Therefore, the issue of IFM clearing above the CAISO forecast has become a larger problem than it was in the past. The CAISO needs a tool to increase or decrease capacity based on the CAISO forecast.

In addition to combining the IFM and RUC processes, the CAISO proposes to procure imbalance reserves in the day-ahead market to ensure upward and downward capacity will be available to resolve

² The 2018 Policy Initiatives Roadmap is located at:
<http://www.aiso.com/Documents/2018FinalPolicyInitiativesRoadmap.pdf>

³ The term "CAISO Forecast of CAISO Demand" (CFCD) is used in CAISO tariff. This term is synonymous with "ISO's demand forecast" which is used in this paper.

imbalance that occurs in real-time. This new market product will address uncertainty between the day-ahead and real-time market and better position the CAISO system to address both under- and excess supply in real-time. Imbalance reserves will be procured based on the VER adjusted demand forecast, not based on the cleared demand in the IFM.

Definitions of forecast terms:

Net Load: Load (forecasted or actual) minus wind and solar output.

CAISO Forecast of CAISO Demand (CFCD): The ISO forecasts demand using the Automated Load Forecast System (ALFS), which considers the weather, historical trends, current load trends, and other measures. The CFCD is the anticipated load forecast as calculated by the CAISO using ALFS.

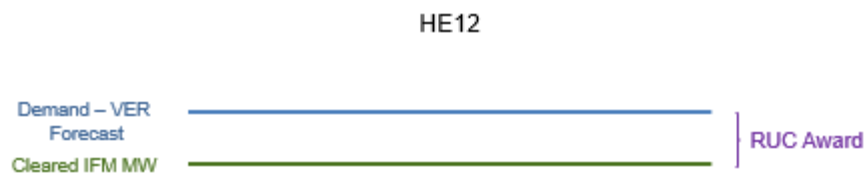
VER Adjusted Demand Forecast: The VER adjusted demand forecast is the CFCD minus the VER delta. The VER delta is the difference between the CAISOs VER forecast and cleared VERs.⁴ This essentially accounts for VERs that are not scheduled in the DAM but are anticipated to generate in the RTM.

Reliability Forecast: The reliability forecast is the VER adjusted demand forecast minus convergence bids. Convergence bids must be matched by physical energy in the real-time market. Therefore, convergence bids that clear the IFM must be replaced by physical resources in the real-time market by dispatching resources with real-time economic bids.

RUC does not address upward uncertainty:

Currently, when the IFM clears physical supply below the VER adjusted demand forecast, RUC will commit additional capacity as necessary to meet the anticipated demand. This addresses the forecast difference that has occurred, as shown in Figure 1.

Figure 1: Procurement of additional capacity is needed to address the forecast difference between IFM and the VER adjusted demand forecast.



⁴ “VER adjusted demand forecast” is being used to replace the term “ISO net load forecast” which was used in the previous version of this paper. ISO net load forecast can be interpreted to have different meanings. For simplicity and to ensure clarity, the term VER adjusted demand will be used in the DAM Enhancements initiative.

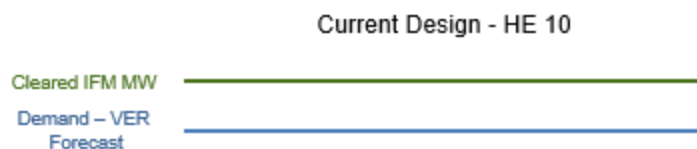
If it is anticipated that the online capacity will not be adequate to meet forecasted demand, the CAISO can elect to use the “RUC net short” process. This process commits additional resources in the day-ahead market and can be necessary when the IFM clears physical resources, i.e. excluding virtual supply, below the demand forecast. Although RUC capacity and RUC net short commitment is helpful when IFM clears below the forecast, it is unable to de-commit resources when the IFM clears above the forecast. In summary, RUC can resolve forecast differences between the IFM VER adjusted demand forecast, but it does not address upward uncertainty between the IFM and real-time market.

RUC does not address downward uncertainty or forecast differences:

When the IFM clears physical supply above the VER adjusted demand forecast, RUC does not de-commit units when they have already been committed by the IFM. Therefore, the real-time market is largely responsible for resolving the imbalance even though it is known in the day-ahead time frame. As shown in Figure 2, there is no decremental capacity award or de-commitment of resources when the VER adjusted demand forecast clears below the IFM.

The current Intermittent Resource Adjustment process accounts for under-scheduled VERs that are anticipated to over-generate in real-time. However, because RUC is unable to de-commit units to match the CFCD, the real-time market is left to resolve the potential excess supply situation. Currently, RUC does not address downward forecast differences (IFM clearing above the CFCD) or uncertainty between the IFM and the real-time market.

Figure 2: RUC is unable to de-commit units when the IFM clears higher than the CFCD. There is no downward RUC award available.

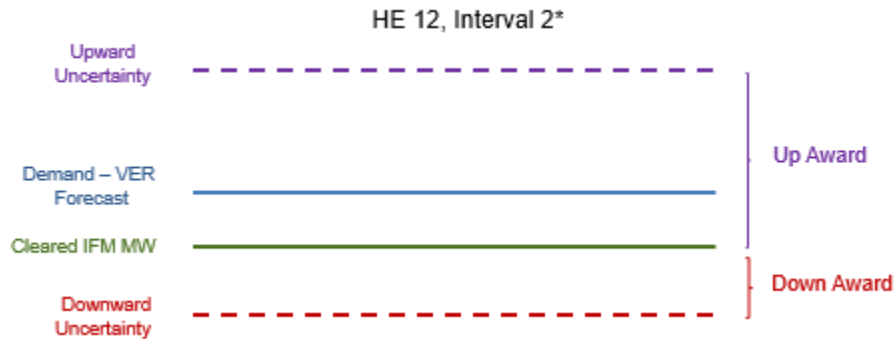


When the IFM clears above the VER adjusted demand forecast, there is the potential for an excess supply situation for the corresponding hour in real-time. Even though it is known in the day-ahead timeframe that the VER adjusted demand forecast is less than what has cleared, the real-time market must resolve the imbalance.

RUC availability bids replaced with imbalance reserves:

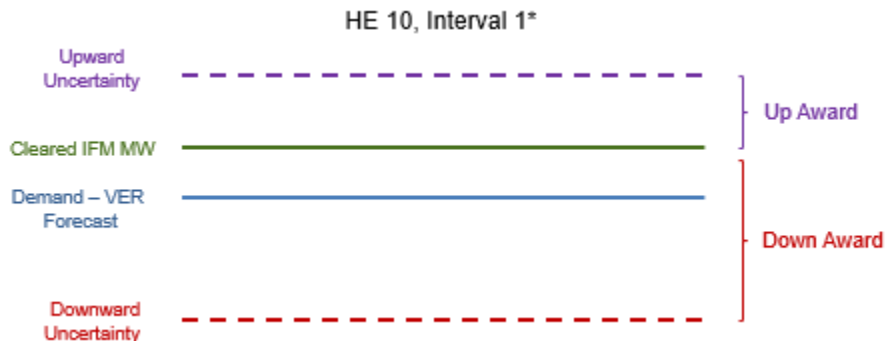
The CAISO proposes to replace RUC by introducing upward and downward imbalance reserve to address the uncertainty that materializes between the day-ahead and real-time market. The introduction of imbalance reserves will ensure sufficient economic bids are available to meet real-time system conditions. This is demonstrated in Figure 3 and Figure 4.

Figure 3: When the IFM clears below the VER adjusted demand forecast, uncertainty is accounted for with imbalance reserves in the up and down direction.⁵



In Figure 3, the VER adjusted demand forecast is higher than what has cleared in the IFM for HE12, Interval 2.⁶ This results in imbalance reserves that are awarded to account for upward and downward net load uncertainty. The up award covers both the day-ahead forecast differences and upward uncertainty. The down award covers the downward uncertainty less the portion of the uncertainty already met by the IFM schedules.

Figure 4: When the IFM clears above the VER adjusted demand forecast, net load uncertainty is accounted for with imbalance reserves in the up and down direction.



In Figure 4, the VER adjusted demand forecast is lower than what has cleared in the IFM for HE10, Interval 1.⁷ This results in imbalance reserves that are awarded to account for upward and downward

⁵ The term “uncertainty” refers to the potential amount of imbalance that must be met by dispatchable resources in the real-time market.

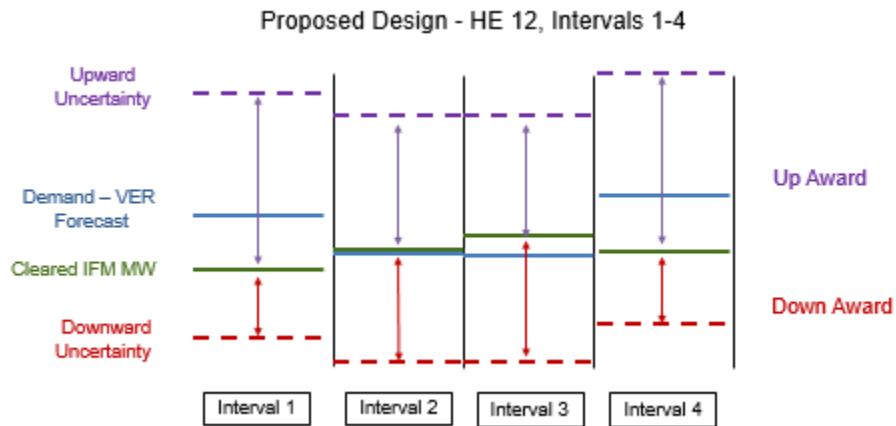
⁶ Interval 2 refers to the second 15-minute interval in the operating hour, HE12. This corresponds to 11:15 – 11:30 AM.

⁷ Interval 1 refers to the first 15-minute interval in the operating hour, HE10. This corresponds to 9:00 – 9:15 AM.

net load uncertainty. The up award covers the upward uncertainty less the portion of the uncertainty already met by the IFM schedules. The down award covers the downward forecast differences and the downward uncertainty.

Upward and downward imbalance reserves will be awarded on a fifteen-minute basis and are used to cover forecast differences and uncertainty. Upward and downward imbalance reserves create an envelope around the IFM schedules. The envelope of imbalance reserves ensure sufficient economic bids are available to address uncertainty that materializes. The real-time market can then resolve the imbalance between day-ahead and real-time. This is illustrated in Figure 5.

Figure 5: Net load uncertainty is accounted for with imbalance reserves in the up and down direction for each fifteen-minute interval. Uncertainty is addressed when the IFM clears above or below the VER adjusted demand forecast.



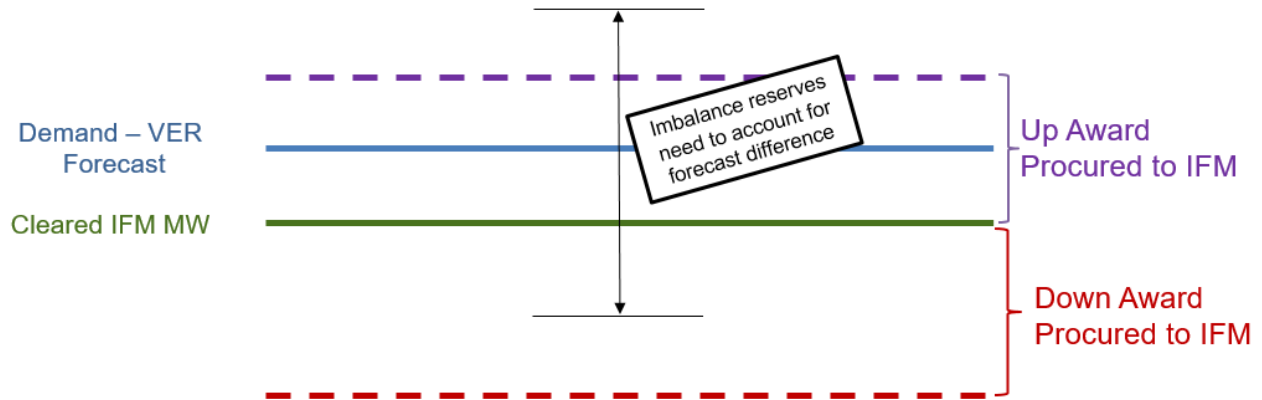
Uncertainty can now be addressed for each fifteen-minute interval with upward and downward imbalance reserves. The day-ahead market secures sufficient resources with a must-offer obligation into the real-time market. This ensures that the real-time market will be able to economically re-dispatch the system to meet imbalances that materialize. Since imbalances are relative to the IFM schedule, the imbalance reserves cannot be implemented through a sequential IFM and RUC process. The imbalance reserves and bid in demand/supply must be co-optimized in a single market optimization.

Co-optimized day-ahead market addresses forecast differences:

The co-optimized day-ahead market (removal of the sequential IFM and RUC runs) is necessary to allow imbalance reserves to be procured relative to the VER adjusted demand forecast. Currently, the IFM runs ahead of the RUC. If the IFM and RUC were not combined, imbalance reserves would be procured

based on the cleared IFM value. This could result in operational deficiencies in real-time as demonstrated in Figure 6.

Figure 6: Imbalance Reserves procured based on IFM cleared value.

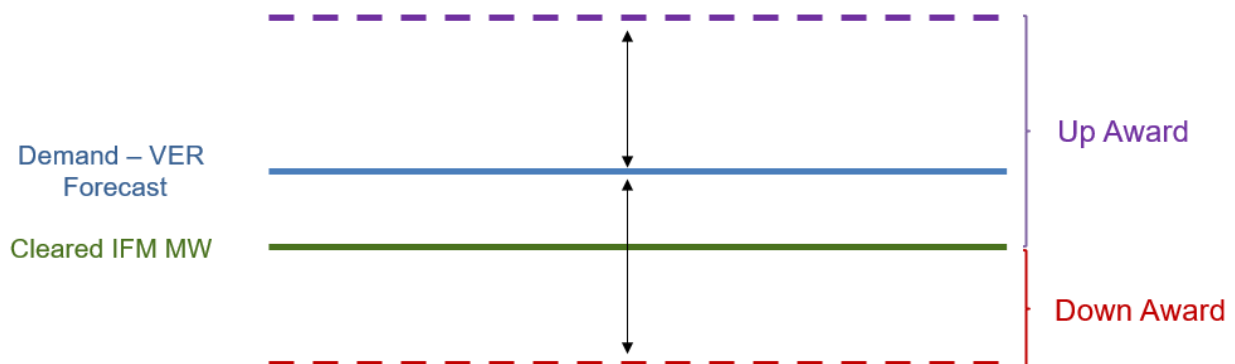


As shown above, the IFM (green line) cleared below CAISO forecast (blue line). When imbalance reserves are procured based on the cleared IFM value (purple line indicates up award, red line indicates down award), the difference between the VER-adjusted CAISO demand forecast and the cleared demand in IFM is not taken into account.

In this scenario, there would be too many down awards and not enough up awards to address uncertainty. Imbalance awards should account for forecast difference between the IFM and VER adjusted demand forecast, while ensuring that the full uncertainty in both direction can be covered.

By combining IFM and RUC, the CAISO can procure imbalance reserves to ensure adequate upward and downward imbalance reserves based on bid in demand instead of the cleared demand in IFM as shown in Figure 7.

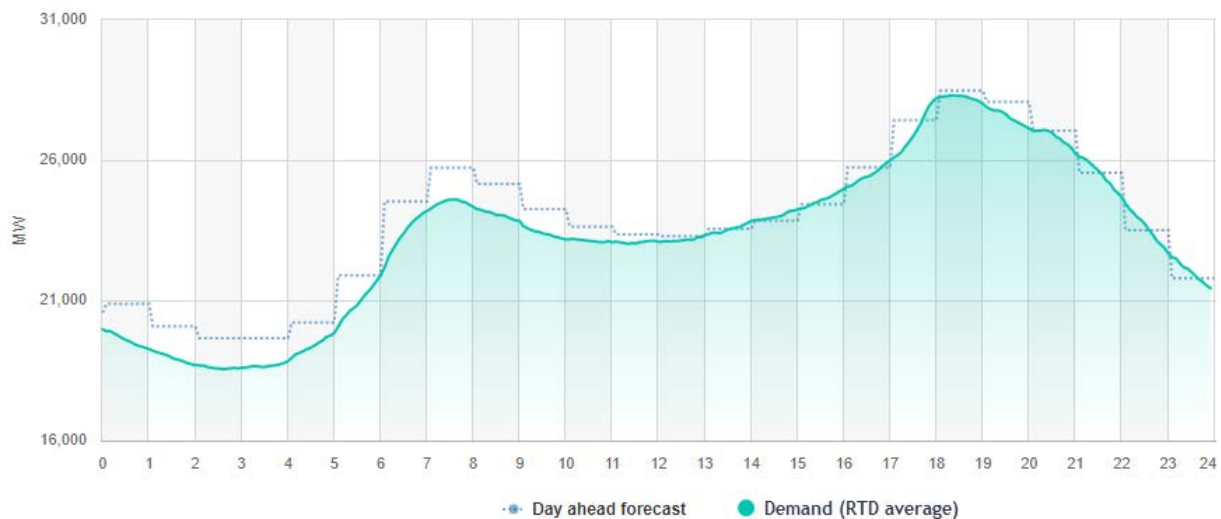
Figure 7: Imbalance Reserves procured based on IFM cleared value.



2.2. Shortcomings of Day-Ahead Hourly Scheduling

The CAISO proposes to move from hourly scheduling to fifteen-minute scheduling in the day-ahead market. This will allow resources to be scheduled in intervals that more closely follow the load curve as predicted by the CAISO forecast of CAISO demand (CFCD). As shown in Figure 8 and explained below, the current day-ahead market procures in hourly blocks making it challenging to ramp between operating hours, especially when load increase in the morning and evening.

Figure 8: Day Ahead Market hourly procurement in comparison to real-time demand curve.
California CAISO Trade Date February 5, 2018.



When resources are scheduled in hourly blocks in the day ahead market, the real-time market must dispatch resources to make up for uncertainty as well as granularity differences that occur within the hour.

Granularity differences:

As displayed in Table 1, the DAM correctly procured resources to meet the load at the middle of the operating hour for HE24. However, the real-time market must address granularity differences that occur throughout the operating hour. For example, at the beginning of the operating hour, the real-time demand is approximately 650 MW greater than the day ahead forecast. Granularity differences throughout the operating hour can be addressed by moving to fifteen-minute day-ahead scheduling.

Scheduling supply and demand in fifteen-minute intervals, as shown in Table 1 below, will allow the day ahead market to more closely follow the net load and be prepared for real-time conditions.

Table 1: Hourly Day Ahead Market procurement and approximated Fifteen-Minute Day Ahead Market procurement in comparison to real-time demand curve.

Interval	DA Hourly Interval Procurement	DA Fifteen-Minute Interval Procurement*	Real-time Demand
1 (23:00 – 23:15)	21,500 MW	22,000 MW	22,150 MW
2 (23:15 – 23:30)	21,500 MW	21,750 MW	22,000 MW
3 (23:30 – 23:45)	21,500 MW	21,500 MW	21,600 MW
4 (23:45 – 24:00)	21,500 MW	21,000 MW	21,200 MW

California CAISO Trade Date February 5, 2018.

By providing fifteen-minute granularity in the day-ahead market, energy scheduling more closely matches the real-time demand throughout the operating hour. Since the CFCD can calculate load in fifteen minute increments, it is appropriate to procure energy to match the estimated load for each fifteen-minute interval.

Uncertainty:

Uncertainty can be seen in Figure 8 from HE00 – HE12. Specifically, refer to HE07 (6:00AM – 7:00AM) in which the DAM procured too much energy in comparison to load for the majority of the operating hour. The real-time market will need to de-commit resources or reduce generation to avoid an excess supply situation. Additionally, if there are insufficient real-time economic decremental bids, the market will not be able to clear. If this occurs, the imbalance between the day-ahead and real-time market must be addressed with self-schedule cuts, under administrative prices, and possibly manual operator action. Uncertainty between the day-ahead and real-time market can be addressed with the procurement of imbalance reserves.

Pacific Northwest Hydro:

The large amount of hydroelectric generation in the Pacific Northwest can be economically bid into the CAISO markets to help address large ramps between intervals. Currently, the flexibility of the Northwest hydro fleet is underutilized partially because it has limited participation in the real-time market. This is because the 15-minute market allows for notification of schedule changes 22.5 minutes prior to flow. 15-minute static interties participating in the real-time market can be used to address uncertainty between the IFM and RTM, but far more ramping capability is available if these imports are scheduled in the day-ahead time frame.

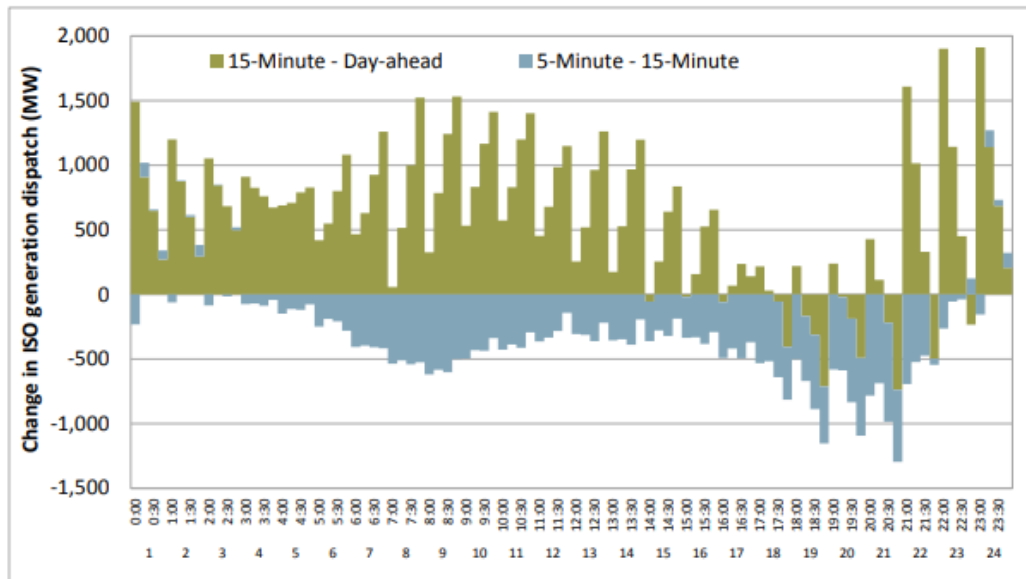
15-minute shaped intertie schedules can more accurately match the actual ramping needs of the CAISO than hourly day-ahead schedules. Dynamically scheduled resources can also be used to address uncertainty between IFM and RTM; however, there may be physical limitations on dynamic transfer

capacity that prevent the hydro resources from being scheduled dynamically in the real-time market.⁸ Thus, the ability to shape even the most flexible of intertie schedules in the day-ahead timeframe increases the flexibility that is available to the CAISO because the 15-minute schedules to additional operations limitations that may limit schedule changes. By moving to fifteen-minute granularity in the IFM, the hydro fleet can be better utilized to meet the forecasted steep ramps in the CAISO and receive imbalance reserve awards to address uncertainty that may materialize. It is important to note that although intertie energy schedules can be shaped with a 15-minute granularity, the transmission profile remains hourly.

Impact on Internal Generation:

The impact of day-ahead hourly scheduling on internal generators was published by the Department of Market Monitoring (DMM). Figure 9 displays the average incremental change for internal generators between the day-ahead and real-time market. The green bars represent the change between the day-ahead and fifteen-minute market. The blue bar represents the change between the 15-minute market and the 5-minute market.

Figure 9: Imbalance generation dispatch volume, CAISO 2017 Q3.



Source: DMM Q3 2017 Report on Market Issue and Performance⁹

⁸ A small portion of hydro from the Northwest is scheduled through dynamic transfers and can be dispatched in 5-minute intervals. Additionally, some resources are scheduled in the 15-minute market through static imports and exports. However, the majority of the hydro fleet is scheduled in the day-ahead market.

⁹ The DMM Q3 2017 Report on Market Issues and Performance can be referenced at: <http://www.caiso.com/Documents/2017ThirdQuarterReport-MarketIssuesandPerformance-December2017.pdf>

This data shows the real-time fifteen-minute market is largely responsible for dispatching generators to compensate for under- or over-procurement from the hourly day ahead market. For example, HE22 (the end of the evening load pull) on average requires the FMM to dispatch an additional 1,500 MW for the first interval of the operating hour. This is because the day-ahead market procures energy for the hour based on an average load value for the hour. However, load changes dramatically during the ramps, and hourly procurement does not set the real-time market up for success. Moving to fifteen-minute scheduling granularity in the day ahead market will allow resources to be scheduled to follow the load curve more closely; this will result in less strain on the real-time market.

3. Day-Ahead Market Enhancements Proposal

3.1. Fifteen Minute Scheduling Granularity

The CAISO will move to fifteen-minute scheduling granularity, but bid submission will remain hourly for both the day-ahead and real-time markets. At this time the CAISO does not see sufficient benefit to justify a major overhaul of its bidding infrastructure. In the day-ahead timeframe, the bids submitted for an operating hour will be used for all four 15-minute intervals. This is similar to the current real-time market where the same hourly bids are used for both the fifteen-minute market and the real-time dispatch.

- Scheduling coordinators will still submit hourly bids for energy, ancillary services, imbalance reserves (price only), and convergence bidding. The bid in amount will be the same for the hour; however, the awarded amount can now be different for each fifteen-minute interval in the hour.
- Self-schedules bid a single MW quantity with a price taker bid price. Therefore, self-schedules will be awarded a flat schedule for the hour.¹⁰ Since internal resources can be scheduled on a 15-minute basis, there is no need to allow block hourly energy bids for internal resources. Block hourly bidding is only applicable for intertie bids and RDRR selecting the hourly scheduling option. This is consistent with the bidding of self-schedules in the current market structure.
- Scheduling coordinators will have the option to select block hour scheduling for imports and exports. The block hourly scheduling option will keep the schedule at the same MW value for the duration of the hour or for multiple contiguous hours. If the block hourly scheduling option is not selected, the intertie schedule may change on a fifteen-minute basis.
- Resources can now be committed intra-hour at the beginning of any fifteen-minute interval.

¹⁰ Load and VERs may provide a 15-minute forecast acting as an upper economic limit and therefore may have a schedule change during the hour even if the bid is submitted as a self-schedule.

Bidding based upon a forecast

The CAISO proposes to allow bid-in load and variable energy resources to shape their economic bids based upon the relative forecast. The CAISO implemented this functionality for variable energy resources in the real-time market as part of the FERC Order No. 764 market design changes. The similar principle will be allowed for bid-in demand in the day-ahead market. Demand will continue to not submit economic bids in the real-time market.

- Scheduling coordinators for load will provide a fifteen-minute forecast that would act as a fifteen-minute upper economic limit (UEL) for their hourly bids. This will enable the day ahead market to shape bid-in demand for each 15-minute interval.
- Scheduling coordinators for variable energy resources (VERs) will have the option to submit a fifteen-minute forecast that would act as a fifteen-minute UEL. This will enable the day ahead market to shape the available capacity for each fifteen-minute interval.

Load aggregation point pricing in the real-time market

Currently the ISO calculates a real-time hourly load aggregation point price based upon the weighted average of the FMM and RTD prices based upon the load forecast used to clear the relevant market interval in the operating hour. With the move to 15-minute day-ahead schedules, the ISO proposes to calculate a 15-minute load aggregation point price based upon the weighted average of the FMM and the three relevant RTD prices based upon the load forecast used to clear the market intervals in that 15-minute period.

3.2. Introduction of Imbalance Reserves

The new day-ahead imbalance reserves will ensure the day-ahead market schedules resources such that if uncertainty materializes in the real-time market there are sufficient resources available for the real-time market to clear for FMM imbalances and the FMM flexible ramping product requirement. Resources awarded imbalance reserves will have a must-offer obligation into the real-time market which ensures the real-time market can resolve uncertainty economically instead of administratively or with out-of-market actions.

Imbalance reserves will ensure sufficient real-time economic bids are available to resolve deviations that occur between the IFM and real-time market. Imbalance occurs due to changes in both supply and demand from the day-ahead to the real-time market. The imbalance reserve requirement is the total amount of imbalance reserves needed to address those changes. This proposal explains the drivers, design features, bidding, settlement, and cost allocation for the proposed imbalance reserves. Imbalance reserves are different from and do not overlap with contingency reserves; the latter are reserved capacity that is released under contingency and not to meet demand deviations or uncertainty.

The example below is a generic example showing how an imbalance may occur between IFM and real-time. Assume load has increased 100 MW from the day-ahead value, a generator has self-scheduled 40 MW above its forward schedule, a VER is unable to meet its day-ahead forecast by 15 MW, an import didn't tag 20 MW, and an export self-scheduled an additional 10 MW above its forward scheduled. The combination of these events result in upward imbalance of 105 MW, as shown in Table 2.

Table 2: Total imbalance is the difference between IFM and real-time for both supply and demand. The imbalance reserve requirement should ensure enough imbalance reserves are available to address imbalance that occurs.

Reason for Deviation	Difference between IFM and real-time
Bid in demand is lower than actual load increase	+ 100 MW
Generator self-schedule increase from IFM	- 40 MW
VER unable to meet day-ahead forecast by 15 MW	+15 MW
Import under tags 20 MW	+ 20 MW
Export self-schedule increase from IFM	+ 10 MW
TOTAL IMBALANCE	105 MW

If the upward imbalance reserve requirement was above 105 MW the market is assured that the materialized deviations from day-ahead schedules can be addressed by deploying upward imbalance reserves as energy through their bids.

Imbalance reserves provide necessary real-time market energy bids

The imbalance reserve results in a must offer obligations in the real-time market. The real-time energy bids can be converted into energy or flexible ramping product awards. Imbalance reserves are deployed in the real-time market when either a load or supply resource's schedule changes from IFM and must be resolved by dispatching other resources through the real time market and to meet the flexible ramping product uncertainty requirement.

When load changes from what was cleared in the IFM (imbalance of demand), there is no option if the load change should be met or not; load changes between IFM and real-time must be balanced with supply. In order to the address this imbalance, the real-time market dispatches resources with economic bids off their IFM schedules.

Likewise, if a generator is unable to meet its IFM schedule (imbalance of supply), the real-time market will dispatch resources that have economically bid above their IFM schedules to resolve the imbalance. In this scenario, it is the generator that has caused the imbalance and imbalance reserves are deployed as energy to balance the change in supply. However, when a generator is dispatched below its IFM schedule as a result of economic bid, while this results in an imbalance settlement, it doesn't require the real-time market to dispatch other resources in order to honor the schedule change. The real-time

market has the ability to determine whether or not the schedule change is consistent with system conditions.

Users of upward imbalance reserves for FMM imbalance energy:

Upward imbalance reserves are converted to energy when the real-time market must accommodate an inflexible schedule change. Resources that have been awarded upward imbalance reserve will have provided economic bids which allow the real-time market to schedule/dispatch the resource above its IFM schedule. Assuming no other changes from the IFM, the following require upward imbalance reserves to be used:

- Load that is higher than IFM schedule
- Virtual supply
- Conventional generators that are unable to meet their IFM schedule
- Variable energy resources that are unable to meet their IFM schedule
- Imports that that don't tag their IFM schedule
- Exports that self-schedule above their IFM schedule¹¹

Users of downward imbalance reserves for FMM imbalance energy:

Downward imbalance reserves are converted to energy when the real-time market must accommodate an inflexible schedule change. Resources that have been awarded downward imbalance reserves will have provided economic bids which allow the real-time market to schedule/dispatch the resource below its IFM schedule. Assuming no other changes from the IFM, the following require downward imbalance reserves to be used:

- Load that is lower than IFM schedule
- Virtual demand
- Conventional generators that self-schedule above their IFM schedule

¹¹ If the export submitted an economic bid rather than submitting a self-schedule this would not cause imbalance reserves to be deployed to address uncertainty. This is because the real-time market can evaluate both export bid and supply bids to determine if it is economic to increase the export schedule. If the market determines it is not economic based upon current system conditions, the export will not clear the real-time market.

- Variable energy resources that self-schedule above their IFM schedule
- Imports that self-schedule above their IFM schedule
- Exports that don't tag their IFM schedule

Flexible ramping product requirement in FMM¹²

In the real-time market the flexible ramping product ensures that there is sufficient ramping capability to address uncertainty that may materialize in the real-time dispatch. In the FMM, the flexible ramping product requirement ensures that sufficient ramping capability is available to resolve differences between the cleared FMM schedule and each of the relevant 5-minute real-time dispatch intervals. All resources that have submitted a real-time economic bid are eligible for being awarded the flexible ramping product. Thus, the imbalance reserve requirement must ensure there are sufficient real-time economic bids to meet FMM schedules and the FMM flexible ramping product requirement.

3.3. Imbalance Reserves Design Features

This proposal has focused primarily on discussing the issues with the current RUC process and the need to replace that process with imbalance reserves. The following design elements are proposed by the CAISO. The CAISO looks forward to stakeholder comments on these and other potential design features that need to be finalized through this stakeholder initiative.

General Design Features

- Imbalance reserves will be awarded in both the up and down direction based on operational characteristics including start up time, ramp rate, PMin/PMax, etc.
 - Online unit:
 - Maximum MW Quantity = Dynamic Ramp Rate over 15-minutes from energy schedule
 - Eligible for up award to min(Pmax, maximum quantity)
 - Eligible for down award of min(IFM energy – Pmin, maximum quantity), but Pmin can be included if the resource can shut down
 - Offline short-start unit (start-up time less than 15 minutes):

¹² Additional information on the flexible ramping product is available at <http://www.caiso.com/informed/Pages/StakeholderProcesses/CompletedClosedStakeholderInitiatives/FlexibleRampingProduct.aspx>

- Maximum MW Quantity = LOL + Dynamic Ramp Rate over (15 minutes – SUT) from LOL
 - Eligible for up award to min(Pmax, maximum quantity)
 - Not eligible for down award
- Imbalance reserves must be procured to ensure ramp deliverability in the RTM. Ramp rate must be prioritized over procurement of upward services to ensure an energy schedule change is not greater than its ramp capability. The CAISO plans to leverage the existing shared ramping model which currently takes energy and ancillary services awards into consideration. With the new DAM enhancements, the CAISO will consider using dynamic ramp rates in the market optimization for all energy schedules and ancillary services to ensure deliverability in real time.
 - A resource without an imbalance reserve award can elect not to bid into the real-time market. A resource that does not elect to bid into the real-time market may be exceptionally dispatched for operational needs.
 - In real-time, imbalance reserves can be used for energy, awarded ancillary services, flexible ramping product forecasted movement or uncertainty awards, and corrective capacity.
 - If there are no real-time market bids, allow 15-minute self-scheduled generation in the RTM to match the 15-minute DAM schedule.

Imbalance reserve bidding

- All generators, imports and exports can submit bids to provide upward and downward imbalance reserves which will replace the current residual unit commitment (RUC) availability bids. Only a bid price will be submitted because the total quantity that a resource can be awarded will be determined based upon its energy bid range and its ramp capability over the 15-minute interval. The default bid price for imbalance reserves will be \$0.00/MWh. If a resource doesn't submit energy bid, the resource cannot be awarded imbalance reserves.
- Unlike RUC availability bids today, resource adequacy resources will not be required to bid \$0.00.¹³

¹³ In the current EIM, a key design principle is that participation is voluntary and therefore there is no must offer obligation in the EIM. When the day-ahead market is extended to EIM entities, it would be inappropriate to require CAISO RA resources to bid in for imbalance reserves at a price of \$0.00 while other EIM entities would not have a similar requirement given the voluntary nature. Similar to the flexible ramping product in the real-time market, imbalance reserves will be able to be met by resources in the EIM footprint not solely those located in a given balancing authority area. Allowing RA resources to economically bid the imbalance reserve product will allow the scheduling coordinator to express the price

- Resources that are awarded imbalance reserves will be paid the marginal clearing price.
- All resources that are awarded imbalance reserves in the day-ahead market must submit economic bids for energy and ancillary services covering the MW quantity of the imbalance reserve award.
- There will be no self-provision of imbalance reserves, this is in contrast to what we have currently for ancillary services.
- The grid management charge for imbalance reserves will be the same as currently used for ancillary services. The upward and downward imbalance reserves will be subject to the bid segment fee because this is a biddable product (\$0.005 per bid segment). Awards of the upward and downward imbalance reserves will be charged the market services rate (currently \$0.1056 per MWh).

Procurement of imbalance reserves

The CAISO will seek to procure 100% of the imbalance reserve requirement, as is similar to AS procurement. CAISO operators will have the ability to review the imbalance reserve procurement target prior to the day-ahead market run. The process for adjusting the imbalance reserve requirement will be documents in an operating procedure.

In the highly unlikely event that there are inadequate imbalance reserve bids, the requirement will be relaxed at a penalty price so that imbalance reserves have lower priority than ancillary services.¹⁴ The penalty price ensures priority of products; for example, ancillary services (regulation, spinning and non-spinning reserves) will always be awarded at a higher priority than imbalance reserves. The CAISO is considering two approaches for the imbalance reserve penalty price:

1. The penalty price will be set at the real-time flexible reserve product penalty price.¹⁵
2. The penalty price will be tiered based on the deficient amount of imbalance reserve bids. If the market recognizes a small shortage of imbalance reserve bids (~25 MW), a lower penalty price

at which it is willing to provide this reserve to either the CAISO or another EIM balancing authority area and be compensated at the marginal clearing price of the imbalance reserves.

¹⁴ The FRACMOO initiative is establishing resource adequacy requirements that ensure sufficient resources have been procured by LSEs to meet their allocable share of the highest potential imbalance reserve requirement for each month. These flexible RA resources have a must offer obligation to submit economic energy bids into the day-ahead market. Thus, the potential for scarcity in the day-ahead market is extremely low and may not justify the added complexity of tiered penalty prices or a demand curve.

¹⁵ The flexible ramping produce penalty price is set lower than all ancillary services and corrective capacity. As a result, the market optimization will forgo meeting the imbalance reserve requirement if resources are needed to meet ancillary services or corrective capacity requirements.

will be used. However, if the market recognizes a significant shortage of imbalance reserve bids (~200 MW) a larger penalty price will be used.

The CAISO requests stakeholder feedback to determine, if needed, which tiered penalty price approach or a demand curve similar to the flexible ramping product should be used for the procurement of imbalance reserves.

Regional and sub-regional requirements for imbalance reserves

The real-time market contains two processes to resolve imbalances from IFM: (1) the 15-minute market (FMM) and (2) the 5-minute real-time dispatch (RTD). In the FMM, internal generation and 15-minute static imports/exports can be economically scheduled to address imbalances that have materialized from the IFM. In RTD, internal generation and dynamic schedules on the interties can be economically dispatched to address additional imbalances that materialize after the FMM. RTD provides the operational instructions that resources follow in order to balance supply and demand in the real-time market. Any difference between the 5-minute dispatch and actual conditions within that interval are addressed by resources awarded regulation up and regulation down.

The CAISO proposes to have a single 15-minute product for upward and downward imbalance reserves. A regional requirement will be set to procure imbalance reserve in each direction from internal resources and interties. The sum of all sub-regional requirements will be used to procure imbalance reserve from 5-minute dispatchable resources because only internal resources and dynamic schedules can meet this requirement.

Resources that can only be scheduled in the FMM will only be eligible to meet the regional imbalance reserve requirement. Resources that can be dispatched in RTD will be eligible to meet both the regional requirement and the sub-regional requirement.

These requirements will be posted on OASIS.

Performance Evaluation of Imbalance Reserve Resources:

In the Issue Paper/Straw Proposal, the ISO discussed whether it was necessary to have a process to certify that resources are eligible to provide imbalance reserves similar to what is performed for ancillary services.¹⁶ The ISO has determined that it is not necessary to have a certification process. Similar to the flexible ramping product in the real-time market, the ramp rate associated with providing energy will determine the eligible quantity of imbalance reserves that can be awarded.

However, a performance evaluation, in addition to the no-pay provision, may be needed to ensure resources that are awarded imbalance reserves will meet the real-time market must offer obligation.

¹⁶ The CAISO is not proposing changes for AS must offer rules or AS no pay provisions.

The ISO will not generate real-time energy bids in the event that a scheduling coordinator fails to submit energy bids to cover a resource's imbalance reserve awards.

The CAISO discusses two approaches below: (1) a minimum performance threshold and disqualification from providing the service in the future and (2) modify the no-pay rules to further penalize non-performance. The CAISO seeks stakeholder comments on the need for a performance evaluation and the approach mechanism to ensure the must offer obligation is met.

Disqualification Approach

If the resource does not have sufficient economic bids to cover its imbalance reserve award, the shortfall will count against the monthly performance threshold required to continue to be awarded imbalance reserves in future months. For example, assume a resource was awarded 100 MW of upward imbalance reserves for a single 15-minute interval. In the real-time market, the resource has only 80 MW of economic bids above its day-ahead schedule. The resource has not met its must offer obligation by 20 MW. Since the resource was awarded for a single 15-minute interval, this is a 5 MWh shortfall.

This approach would establish a minimum monthly performance threshold that must be met in order for a resource to continue to be awarded imbalance reserves.¹⁷ Assume the minimum performance threshold is set at 95% of awarded imbalance reserves. The minimum performance threshold will be calculated for both upward and downward imbalance reserves separately and a resource will be disqualified only for the direction it has not met the minimum performance threshold. If a resource fails to meet the minimum performance threshold it will be disqualified from being awarded imbalance reserves as follows:

1. Fails month M1, then cannot be awarded imbalance reserves in M3
2. Fails month M2, then cannot be awarded imbalance reserves in M4
3. In a rolling 12-month fails three months, then cannot be awarded imbalance reserves for the upcoming quarter
4. After the quarterly period, the performance threshold resets for the rolling 12 month window.

Any disqualification process should align with resource adequacy program to allow a scheduling coordinator to know prior to the monthly showing if a resource will be eligible to provide imbalance reserves. Currently, monthly resource adequacy showings are made 45 days prior to the operating month. In order to align, a resource's performance will be calculated using the monthly data prior to the resource showing. For example, if a resource fails the performance threshold in June it will be ineligible to be awarded imbalance reserves in August. This will provide market participants the opportunity to adjust their monthly resource adequacy showings if needed because one of their resources has been disqualified from providing imbalance reserves.

¹⁷ An example of the monthly calculation is included the attachment titled *APPENDIX D Imbalance Reserves Settlement Worksheet*.

Penalty

If the resource does not have sufficient economic bids to cover its imbalance reserve award, the shortfall will result in no-pay provisions which claw back the payments made to the resource in the day-ahead market. An alternative option in lieu of the disqualification process is to determine a settlement mechanism to incentivize appropriate bidding behavior for the imbalance reserve must offer obligation into the RTM. Rather than only clawing back the day-ahead award, the no pay rules could require the clawback to be two times the day-ahead. However, the penalty approach does allow the scheduling coordinator to make an economic decision whether or not to meet its must offer obligation for a given 15-minute interval.

Bid Cost Recovery

Due to the elimination of RUC, bid cost recovery (BCR) cannot be specifically attributed to RUC.¹⁸ Historically, even though RUC was a part of the day-ahead market, RUC was attributed to the real-time market BCR. Bid cost and revenue recovery will now be solely attributed to BCR for the day-ahead market or the real-time market.

Imbalance reserves are awarded in the day-ahead time frame but may result in the commitment of energy in the real-time market. However, because imbalance reserves are a day-ahead market product, it is appropriate that imbalance reserve bid cost and revenues be allocated in the DAM BCR.

Additionally, the CAISO proposes to modify the rules related to the exceptional dispatch of resources. Excess revenue from the ED will be used to offset commitment costs in the RTM.

Convergence bids will no longer be allocated BCR; however, awarded convergence bids will be allocated a portion of the imbalance reserve costs.

Hour Ahead Scheduling Process Reversal Rule

The hour ahead scheduling process (HASP) reversal rule (aka "HASP clawback") rule will still apply. The pricing rules associated with the HASP reversal rule are intended to address implicit virtual bidding and will not be addressed with the cost allocation associated with imbalance reserves. HASP clawback will move from an hourly IFM to FMM comparison to a 15min DAM to FMM comparison. This will allow the clawback rule to compare fifteen-minute forward schedules to fifteen-minute schedules in the real-time market.

¹⁸ The RIMPR initiative introduced changes that separated the day-ahead and real-time BCR. RUC, however was included in the real-time BCR. Because this initiative proposes the removal of RUC, only the IFM and RTM BCR will exist.

Congestion Revenue Rights

The rules associated with the CRR clawback are dependent on the on-going Congestion Revenue Rights Auction Efficiency Initiative. Assuming the CRR auction remains in hourly granularity, the CAISO does not anticipate changes to the CRR clawback rules.

Congestion revenue rights will now be settled based upon 15-minute IFM schedules as opposed to hourly. The CAISO doesn't at this time believe there are settlement implications by making the change in granularity.

Resource Adequacy Availability Incentive Mechanism changes

Resources Adequacy (RA) resources have additional penalties to provide economic incentives for availability of RA capacity.¹⁹ The Resource Adequacy Availability Incentive Mechanism (RAAIM) determines whether or not a resource provided bids to meet an RA obligation. Flexible RA capacity, this means providing an economic bid for this capacity. However, as noted in imbalance reserve bidding section above, unless RA resources obtain a day-ahead schedule, an ancillary service, or an imbalance reserve award, the RA resource will no longer have a real-time must offer obligation. This means that a resources will have met all of its RA must offer obligations through participation in the day-ahead market. This allows the ISO to simplify the RAAIM calculations.²⁰ RAAIM will now only consider compliance with day-ahead must offer obligations. The only additional consideration the ISO may need will depend on the final determination between penalties and disqualification of resources attempting to provide imbalance reserves. Specifically, if the ISO determines it is necessary to disqualify resources from providing imbalance reserves, then the ISO would set any disqualified flexible RA capacity as zero percent available for all days it is disqualified and has not offered replacement capacity for the flexible RA capacity.

Inter-SC Trades:

Inter-SC Trades are a settlement mechanism that market participants can use to trade MWh quantities settled through the CAISO markets, although the trades do not affect the market optimization or

¹⁹ The policy information and stakeholder comments on the modification of resource adequacy availability incentive mechanism (RAAIM) can be found at:
<http://www.caiso.com/informed/Pages/StakeholderProcesses/ResourceAdequacyAvailabilityIncentiveMechanism.aspx>

²⁰ The CAISO will need to review various resource types and bidding requirements to determine what modifications are needed.

resource scheduling. Three forms of Inter-SC Trades are processed through the CAISO's settlements: Inter-SC Trades of Energy, Inter-SC Trades of Ancillary Services, and Inter-SC Trades of IFM Load Uplift Obligation.

Inter-SC Trades of Energy may be either Inter-SC Trades at Aggregated PNodes or Physical Trades. Except for conversion to the 15-minute scheduling intervals as necessary to match FMM's intervals, which will facilitate the markets' response during rapid ramping periods, the day-ahead market enhancements discussed in this revised straw proposal do not require changes to the existing provisions of the CAISO tariff. Both the day-ahead and RTM Inter-SC Trades of Energy are currently settled on an hourly basis. In RTM, Inter-SC Trades of Energy are settled at the simple average of the four applicable FMM LMPs. Physical Trades of Energy are subject to adjustments based on the awarded schedules of underlying physical resources, through submittal screening, pre-market validation, and post-market confirmation processes that are detailed in tariff section 28.1.6. These processes seek to limit Physical Trades of Energy, on average, to less than or equal to the generation that is scheduled or dispatched at the same location of the trade. All MWh quantities of Physical Trades that are confirmed through the post-market confirmation are settled at the LMP of the relevant PNode, while all MWh quantities of Physical Trades that are reduced during the post market confirmation are settled at the relevant generation trading hub price. The day-ahead process will match the treatment of 15-minute intervals that is used in RTM, and enhancements to the RTM processes will be considered in a future stakeholder process.

The CAISO does not propose to allow inter-SC trading of imbalance reserves.

Virtual bidding

Virtual bids will be submitted hourly but can receive different schedules for each 15-minute interval in the DAM. Virtual bids will no longer be allocated bid cost recovery (BCR); they will be allocated the imbalance reserve costs.

Intertie Deviations

The cost allocation proposal will result in charges for undelivered interties for a portion of the operating hour. However, based on current market design, there is no penalty or cost allocation when the intertie schedules deviates from its award for the first two intervals of the operating hour. This can create operational challenges and that are not necessary addressed by imbalance reserves. Operational concerns related to intertie deviations will be addressed in the Intertie Deviation Settlement initiative.²¹

²¹ The Intertie Deviation Settlement initiative is scheduled to begin in May 2018.

3.4. Settlement of Imbalance Reserves

Resources that receive an imbalance reserve award will be paid at the day-ahead imbalance reserve marginal price. Imbalance reserve bids will be guaranteed through the resource's day-ahead bid cost recovery (BCR) calculations, which will also include any revenues earned through imbalance reserves awards.

If a resource meets its real-time must offer obligation and is not dispatched or scheduled, the resources will keep the day-ahead payment for imbalance reserve awards. If the resource is dispatched for energy or awarded another service in real-time, the resource will also receive payments for energy and other services.

If a resource is unable to submit an economic bid in real-time and does not meet its must offer obligation, there will be no pay provisions. For example, if a resource is awarded 10 MW of imbalance reserves but only submits economics bids that cover bids 8 MW into the real time market, the resource will be charged for 2 MW that was not available at the same imbalance reserve price that was used in the DAM settlement.

If a resource is awarded imbalance reserve in the day-ahead market and does not follow the 15-minute or 5-minute dispatch (also known as deviation), the resource will be charged for the costs associated with the uncertainty movement allocation of the resulting flexible reserve product (FRP). There will be no rescission of payments for imbalance reserve award related to the deliverability, undispachability, or unavailability, in contrast to the rules that apply to ancillary services today currently.

3.5. Cost Allocation for Imbalance Reserves

The cost allocation for imbalance reserves will be consistent with the existing CAISO guiding principles.²² The intention is to allocate costs to resources that create need for the imbalance reserves. As discussed above, if the real-time market must accommodate a schedule change from the DAM, the resource is using the imbalance reserves. When this occurs, another resource must be dispatched up or down to accommodate the schedule change from the DAM. Therefore, the cost of the imbalance reserve should be allocated to the resource causing the necessary re-dispatch to keep the system balanced. Any no-pay charges applied reduce the total cost that need to be allocated.

An explanation of the cost allocation for imbalance reserves in the upward and downward direction is summarized below. In general, costs will be allocated to resources with schedules less than or greater than their IFM schedules (up or down imbalance reserves) unless the resource schedule change is the result of an economic dispatch.

²² The CAISO's guiding principles on cost allocation can be found: <http://www.caiso.com/Documents/DraftFinalProposal-CostAllocationGuidingPrinciples.pdf>

Calculation of Upward Billing Determinant

Cost will be allocated to scheduling coordinators that create inflexibility and require the dispatch of upward imbalance reserves. This will apply to:

- Metered load that is higher than the IFM schedule
- Generating resources, VERs, NGR and PDR/DDR that have real-time schedules less than their IFM schedule (unless economically dispatched down). This will trigger when the minimum of the upper economic limit or the upper operating limit is less than the IFM schedule.
 $Min(UEL, UOL) < IFM$
 - For VERs, the forecast will be used as the UEL
 - For import resources, the top of the energy bid will be used as the UEL
- Exports that self-schedule with a lower economic limit (LEL) above their IFM schedule
- Virtual Supply

Calculation of Downward Billing Determinant

Cost will be allocated to scheduling that create inflexibility and require the dispatch of downward imbalance reserves. This will apply to:

- Metered load that is lower than the IFM schedule
- Generating resources, VERs, NGR and PDR/DDR that have real-time schedules greater than their IFM schedule (unless economically dispatched up). This will trigger when the maximum of the lower economic limit or the lower operating limit is greater than the IFM schedule.
 $Max(LEL, LOL) > IFM$
 - For VERs, the forecast will be used as the LEL
 - For export resources, the bottom of the energy bid will be used as the LEL
- Exports that self-schedule below their IFM schedule or are unable to tag to their IFM schedule
- Imports that self-schedule above their IFM schedule
- Virtual Demand

Two Tier Cost Allocation

The cost allocation will be performed by 15-minute intervals. The costs of meeting both the regional requirement and sub-regional requirements will be summed into a single allocation. The allocation will be performed at the scheduling coordinator (SC) level and will allow for netting of load, generation, VERs, imports, exports, and virtuals. This is appropriate because it recognizes that the total amount of imbalance reserves needed to be dispatched is based upon the total inflexibility of the SC portfolio. For example, assume a SC's load was 100MW higher than its IFM schedule and the SC self-scheduled a

100MW import, the real-time market does not need to dispatch other resources to accommodate the IFM schedule changes.

The allocation for upward imbalance reserves will be:

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

The allocation for downward imbalance reserves will be:

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

The ISO has posted a settlement spreadsheet that provides an illustrative model for the cost allocation. This can be found in the attached Appendix D.

3.6. Additional Design Considerations

The items listed below are additional design considerations related to the DAM Enhancements initiative. The CAISO requests stakeholder input on these items, as well as additional items that may need to be addressed.

Deliverability of Imbalance Reserves

The current proposal does not explicitly insure deliverability of imbalance reserves, but rather utilizes sub-regional requirements to distribute a portion of the regional requirement across the CAISO balancing authority area. This insures that all of the imbalance reserves are not procured in one area, for example, all the imbalance reserves procured from resources in the north. Similar to ancillary services, the sub-regional approach provides sufficient confidence that the reserves can be dispatched at a later time. At the April 5 Market Surveillance Committee, there was discussion if the imbalance reserve design needed to ensure deliverability since the flexible ramping product has seen instances where the uncertainty awards were procured behind constraints. The ISO seeks stakeholder comments if the imbalance reserve design should address deliverability or if deliverability should be addressed for all products? If the latter, should deliverability be added to this initiative or prioritized through the annual roadmap process?

Settlement Interaction between Imbalance Reserves and Flexible Ramping Product

At the April 5 Market Surveillance Committee, there was discussion that if a resource with an imbalance reserve award is dispatched for energy, ancillary services, or corrective capacity should the resource buy back at the flexible ramping product price. The CAISO has not modified its proposal at this time. The current proposal considers imbalance reserve as similar to RUC availability bids. These awards have a real-time must offer obligation and once that is met the resource has provided the service for which it was procured. If imbalance reserves are considered similar flexible ramping product to address uncertainty, then this may argue for settling deviations when deployed for other market products at the flexible ramping product price. The CAISO seeks stakeholder comments to help decide the appropriate approach in the next version of the proposal.

Re-procurement of ancillary services in FMM

Currently, the CAISO only procures incremental ancillary services in the FMM. The CAISO believes market efficiency could be improved the ancillary service awards were re-optimized in FMM. This would allow the economic buy back of day-ahead ancillary services if this capacity had a higher value as energy or other product. If AS is re-procured between the DAM and the RTM, re-procurement can only occur in the 15-minute market, not the 5-minute market. In real-time market, the CAISO does not believe there are additional marginal costs beyond the opportunity cost of not being scheduled for energy. Thus, the need for economic bids for all ancillary services may not be needed. The CAISO requests stakeholder feedback to determine if ancillary services should be re-procured between the DAM and the RTM

Self-Provision of Ancillary Services

The CAISO will continue to support ancillary service self-provision (ASSP), but will eliminate the existing ASSP qualification process that takes place before the market and will instead co-optimize ASSP with the energy, bid-in ancillary services, and the imbalance reserves (FRP in RTM) using penalty prices for ASSP in the security constrained unit commitment (SCUC) scheduling run to provide the necessary scheduling priority. This change will result in a more efficient market solution and will eliminate an antiquated feature that has increasing ongoing maintenance costs.

Day-Ahead Bidding of Corrective Capacity

As part of the contingency modeling enhancement initiative, the CAISO committed to evaluate allowing bidding of corrective capacity in the day ahead market. The concern with allowing bidding for corrective capacity is the potential to exercise market power because these are local requirements. However, it was acknowledged that there may be costs to make this capacity available to the real-time market. These costs are similar to the costs of providing imbalance reserves, but the key difference is that imbalance reserves can be met by all resources while corrective capacity can only be met by

effective localized resources. For imbalance reserves, there is not system market power in the CAISO. However, for localized corrective capacity there is a market power concern. To address market power concerns for corrective capacity bidding, one approach could be to require the same bid price to be submitted for both corrective capacity and imbalance reserves.

4. Corresponding Energy Imbalance Market changes

The energy imbalance market extends the ISO's real-time market to other balancing authority areas in the West. Prior to the start of the EIM, the EIM entity approves hourly base schedules. Hourly base schedules are the reference point from which imbalance energy is calculated and settled through the EIM. The use of hourly base schedules was originally chosen to align with the ISO's reference point for imbalance energy which was hourly day-ahead schedules. Since the ISO is proposing to move to 15-minute granularity for the day-ahead market, the ISO proposes to also change the EIM base schedule granularity from hourly to 15-minute. The change to 15-minute base schedules will also require modifications to other elements of the EIM design as discussed below.

Resource sufficiency evaluation

Currently, on an hourly basis, the ISO performs a series of tests to determine if a BAA is not leaning on the EIM for capacity, flexibility or transmission. If the BAA passes the resource sufficiency evaluation, it will have access to other BAA resources to meet its load and materialized uncertainty. If the BAA fails the resource sufficiency evaluation for the next Trading Hour, the EIM transfer limits will be set such that incremental transfers cannot occur in that Trading Hour in the direction of the failure. Thus the BAA must rely solely on its resources to meet imbalances and uncertainty within its balancing authority area. Specifically, if the BAA fails the upward test for the next Trading Hour, then EIM transfer imports into that BAA are limited during that Trading Hour to the previous hour final FMM transfer or that Trading Hour's base transfer, whichever greater; if the BAA fails the downward test for the next Trading Hour, then EIM transfer exports out of that BAA are limited during that Trading Hour to the previous hour final FMM transfer or that Trading Hour's base transfer, whichever greater.

When the ISO implements the day-ahead market enhancements, the ISO will similarly test each BAA for sufficiency in each 15-minute interval and when a BAA fails the flexible ramping sufficiency test, the EIM transfer for that BAA will be similarly limited for the corresponding 15-minute intervals. Consequently, the real-time test will be modified such that if the flexible ramping sufficiency test fails for a 15-minute interval in a Trading Hour, the EIM Transfer for that BAA will only be limited for that 15-minute interval in FMM and RTD.

Over and under scheduling charges²³

The intent of the over and under scheduling charges is to ensure that EIM entity balancing authority areas have sufficient supply to meet its imbalance energy independently. Currently, if the EIM entity uses the ISO load forecast and the hourly base scheduled load is within 1% of the ISO load forecast, the EIM balancing authority area is exempt from charges. If the EIM entity uses its own load forecast or has hourly base schedule load that differs from the ISO load forecast by more than 1%, the EIM entity is subject to the over and under scheduling charges for that operating hour. If load imbalance exceeds 5% (but at least 2MWh) for the operating hour the EIM entity is subject to the first tier charges. If the load imbalance exceeds 10% for the operating hour the EIM entity is subject to the second tier charges. If load imbalance for the operating hour does not reach 5%, then there are not over or under scheduling charges.

The ISO proposes to modify the determination of whether an EIM entity's load imbalance reaches the penalty thresholds from an hourly evaluation to 15-minute evaluation. The 15-minute base schedule load forecast will be compared to the 15-minute actual load. Since the evaluation is now being performed on a 15-minute basis the minimum load imbalance level will be changed from 2MWh to 0.5MWh. The ISO is not proposing any changes to the percentage thresholds or LMP multipliers of the charge.

Settlement of Regulation Energy

During the SMUD implementation into the EIM, the need to automate the calculation and settlement of energy resulting from resources that provide regulation up and down was identified. Since there are other elements of the day-ahead enhancements that will require EIM governing body approval, the ISO has included this item in this initiative.

Energy resulting from providing regulation is currently settled at the 5-minute real-time dispatch price. The same price is used if the energy is classified as instructed imbalance energy or uninstructed imbalance energy. However, uninstructed imbalance energy is used to determine the amount uplift costs that should be shifted between EIM balancing authority areas. Currently, EIM entity scheduling coordinators can inform the ISO through a manual dispatch after the market interval has concluded the amount of energy that a resource has provided in response to the balancing authority areas regulation signal. This allows the ISO to then classify the deviations from dispatch as instructed imbalance energy which does not result in uplift costs being shifted between EIM balancing authority areas.

The CAISO proposes that the hourly resource plan for resources to be expanded to include a MW quantity for both regulation up and regulation down. This will allow the scheduling coordinator to specify the MW quantity that is being used for automated generation control (AGC). This regulation

²³ See section 3.3.6 of the EIM Draft Final Proposal for additional details on the over and under scheduling charges. The draft final proposal is available at:
<https://www.westerneim.com/Documents/EnergyImbalanceMarket-DraftFinalProposal092313.pdf>

capacity will be protected in the market optimization. Incremental energy dispatches will respect the regulation up capacity. Decremental energy dispatches will ensure that there is sufficient energy dispatched above the resource's PMIN to support regulation down capacity.

The ISO will use this information to automatically calculate regulation energy which is classified as instructed imbalance energy.²⁴ This eliminates the need for the EIM entity scheduling coordinator to inform the ISO through a manual dispatch to ensure the deviations are classified as instructed imbalance energy.

5. Stakeholder Engagement and EIM Governing Body Role

Stakeholder input is critical for developing market design policy. The schedule proposed below allows opportunity to for stakeholder involvement and feedback. This initiative will require briefing to EIM Governing Body to support its hybrid role and approval from the CAISO Board of Governors.

5.1. Schedule

Table 3 lists the proposed schedule for the Day Ahead Market Enhancements stakeholder process.

Table 3: Schedule for Imbalance Conformance Enhancements Stakeholder Process

Item	Date
Post Issue Paper	February 28, 2018
Stakeholder Meeting	March 7, 2018
Stakeholder Comments Due	March 21, 2017
Post Revised Straw Proposal	April 11, 2018
Stakeholder Meeting	April 18, 2018
Stakeholder Comments Due	May 2, 2018
Post Second Revised Straw Proposal	May 16, 2018
Stakeholder Meeting	May 23, 2018
Stakeholder Comments Due	May 30, 2018

²⁴ Additional information on the calculation of regulation energy is included the BPM-CG PC Real Time Energy Quantity available at:
<https://bpmcm.caiso.com/Pages/SnBBPMDetails.aspx?BPM=Settlements%20and%20Billing>

Post Draft Final Proposal	June 19, 2018
Stakeholder Meeting	June 26, 2018
Stakeholder Comments Due	July 11, 2018
EIM Governing Body Meeting (hybrid non-EIM specific)	August 22, 2018
CAISO Board of Governors Meeting	September 5-6, 2018

The CAISO proposes to present its proposal to the EIM Governing Body and CAISO Board of Governors on August 22, 2018 and September 5-6, 2018 respectively. The CAISO is committed to providing ample opportunity for stakeholder input into its market design, policy development, and implementation activities. Stakeholders should submit written comments to InitiativeComments@caiso.com.

5.2. EIM Governing Body Role

The Issue Paper/Straw Proposal published February 28, 2018, indicated this initiative would fall entirely within the EIM Governing Body’s advisory authority. After additional policy development, the CAISO now believes the appropriate classification is hybrid non-EIM specific.

While the majority of the DAM Enhancements proposal continues to involve changes to the ISO’s Day Ahead Market, which management is proposing to classify as advisory, CAISO staff now recognizes that the proposal will also include a change to an EIM-specific rule of the real-time market.²⁵ The change to fifteen-minute scheduling granularity in the day-ahead market will require fifteen-minute scheduling granularity for EIM base schedules. This will ensure alignment between the CAISO and the EIM.

This change to the granularity of EIM base schedules is not severable from the remainder of the initiative, because the CAISO would not want to proceed with the remainder of the initiative if this element were not approved as well. Otherwise, there would not be alignment between the EIM and the rest of the ISO market.

For that reason, the CAISO proposes to classify this initiative as hybrid-non EIM specific. As explained in the EIM classification guideline, a hybrid non-EIM specific initiative is appropriate “when the driver for

²⁵ The February 28, 2018 Issue Paper/Straw Proposal acknowledged that proposed changes to rules of the day-ahead market would not involve a decisional role for the EIM Governing Body. It nevertheless proposed an advisory classification for the full initiative due the unique foundational nature of this initiative and the intentions of the Transitional Committee, which expected that EIM Governance would have a role in “decisions ... that would ... [a]llow options to expand the functionality of the market to provide additional services” *Final Proposal*, August 19, 2015, p. 14.

the initiative is **not** EIM and the policy initiative is a hybrid in that it has **both** a component that would fall within the EIM governing body's primary authority and a component that would fall within its advisory authority."²⁶

Stakeholders are encouraged to submit a response to the EIM classification in their written comments following the stakeholder meeting for the Revised Straw Proposal, particularly if they have concerns or questions.

5.3. Next Steps

The CAISO will discuss the Revised Straw Proposal during the stakeholder meeting on April 18, 2018. The CAISO requests stakeholders submit written comments in response to the Day Ahead Market Enhancement paper and stakeholder meeting by May 2, 2018.

²⁶ https://www.caiso.com/Documents/Decision_EIM_GovernanceProposal-AttachA-Proposal-Sep2015.pdf

6. Appendices

6.1. Appendix A: Data Analysis of Historical Imbalance and Forecast Accuracy

The CAISO has performed analysis to inform the development of the imbalance reserves. The analysis seeks to quantify the benefits of moving from hourly scheduling to 15-minute scheduling, the additional benefits that can be achieved because net load does not follow hourly linearity, and the potential requirement for upward and downward imbalance reserves.

The data will also be used to inform the FRACMOO2 stakeholder initiative. The underlying data to develop both the forward procurement requirement and the hourly IFM requirement are similar. The FRACMOO2 requirement will ensure that the resource adequacy showings can meet the peak monthly flexibility needs, including of the LSE's contribution to peak imbalance reserves need. The hourly requirement for the IFM will ensure that sufficient imbalance reserves are procured through the IFM to meet that given hours net load uncertainty.

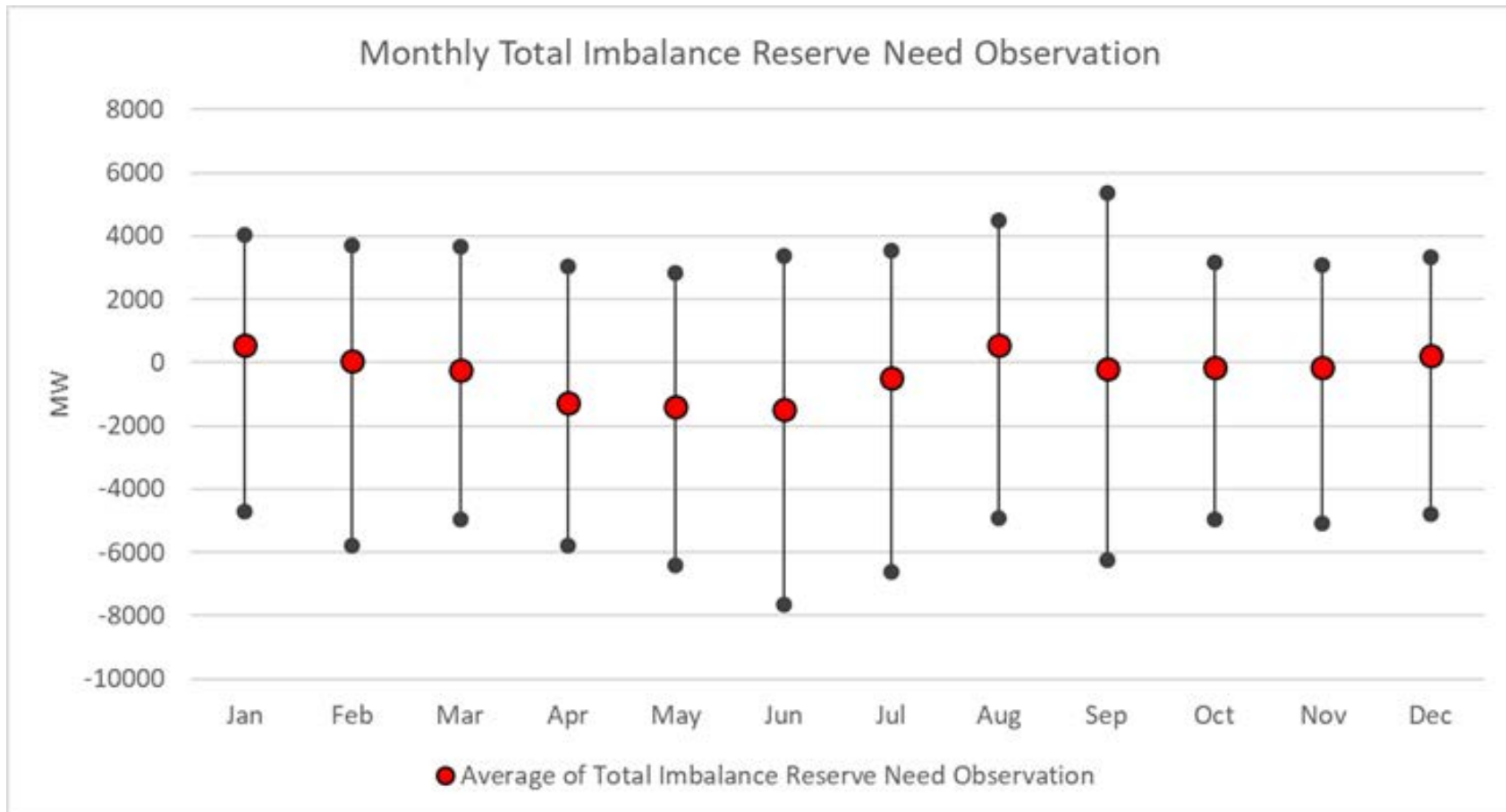
Total imbalance is calculated by summing the demand-driven and supply-driven imbalance between the DAM and the FMM.²⁷ This calculation starts with the reliability forecast as shown below. The reliability forecast is the VER adjusted demand forecast minus convergence bids. The following steps are then completed to calculate the imbalance between the DAM and FMM. The terms used in this analysis are defined in [Section 2.1](#).

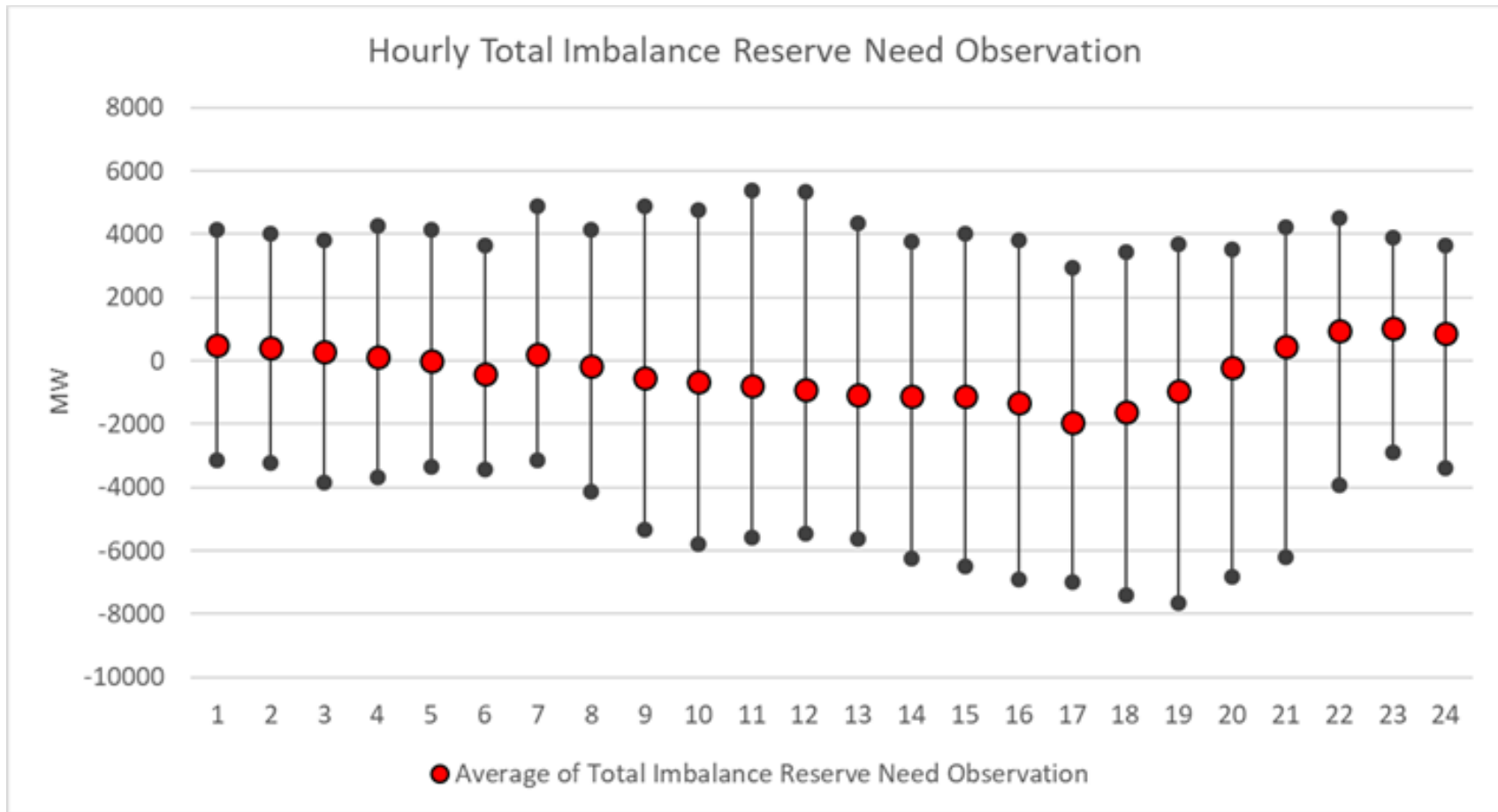
Data to Determine ISO Reliability Forecast		
	HE8	HE9
IFM	20,000	22,000
RUC Delta	+ 1,000	+ 1,000
Net Virtuals	-500 (supply)	-500 (supply)
VER Forecast Delta	-800	-800
ISO Reliability Forecast	19,700	21,700

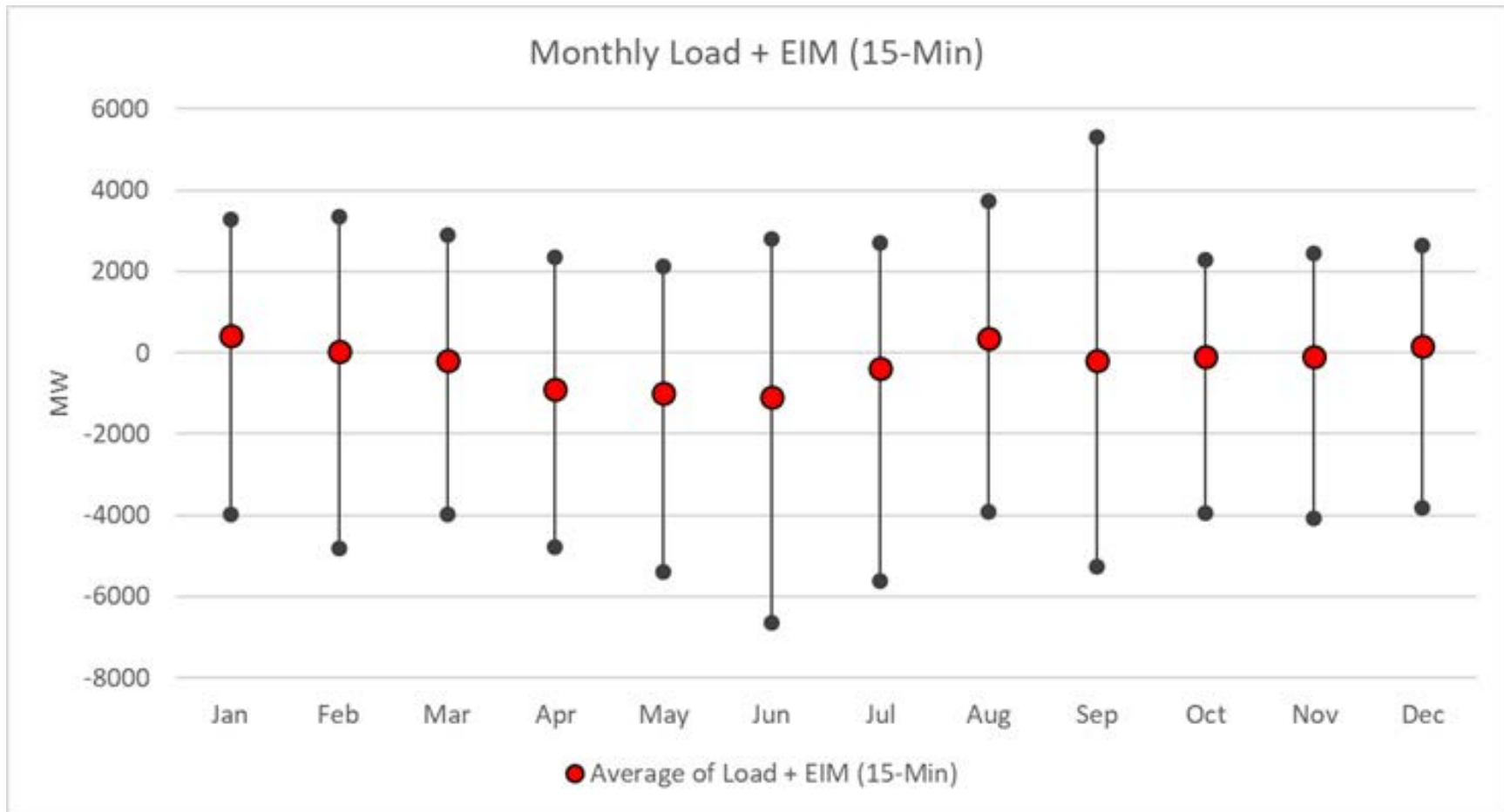
1. Linearize the ISO reliability forecast to convert hourly schedules to 15-minute granularity.
2. Subtract the FMM load forecast from the ISO reliability forecast to determine the total imbalance of load.
3. Compare generator and intertie changes between the DAM and FMM that require another resource to accommodate the schedule change. This results in the total imbalance of supply.
4. Total imbalance is the summation of the load and supply driven imbalance.

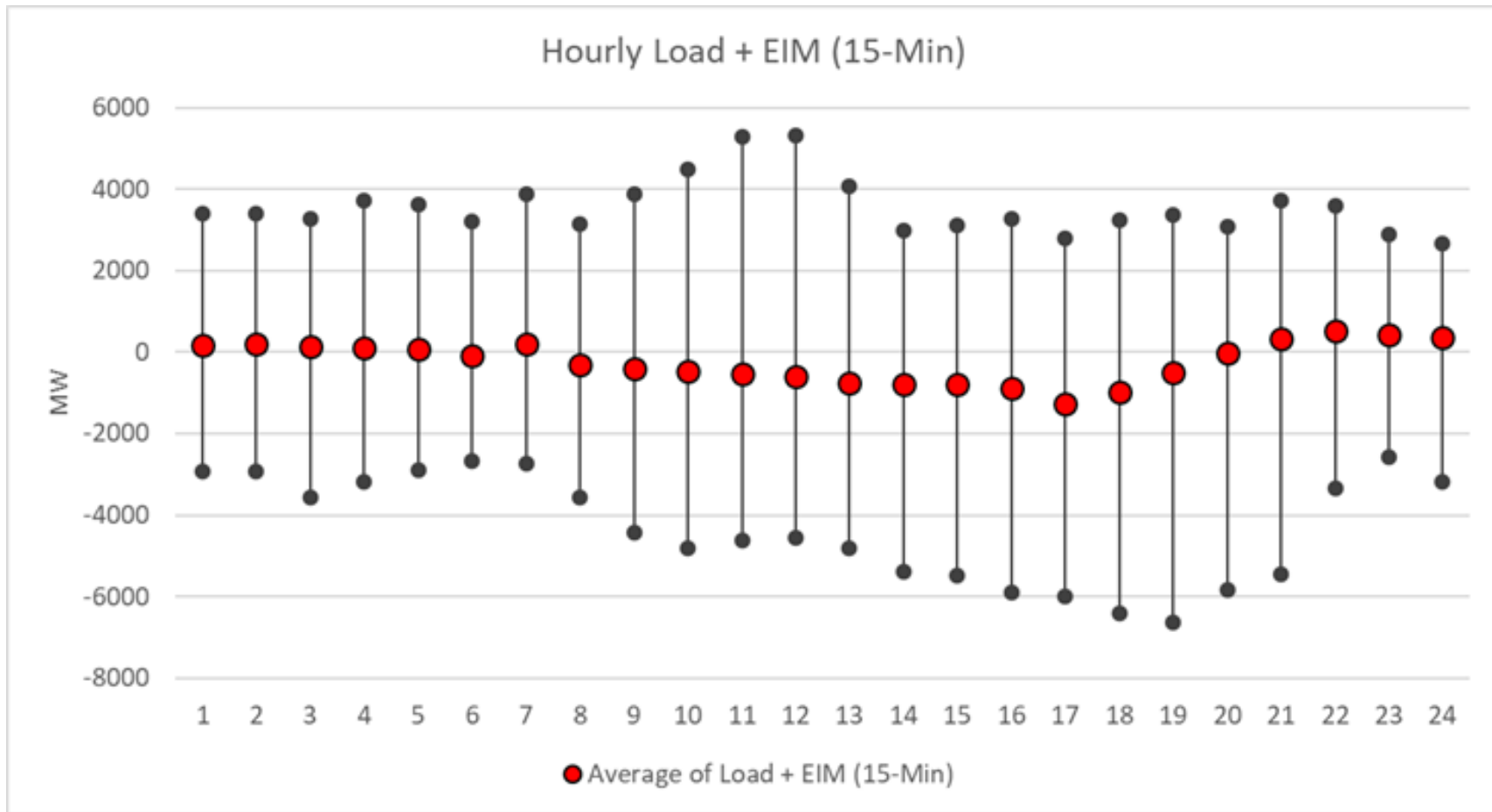
²⁷ VERs are intentionally excluded in the supply-drive imbalance calculation because they are included in the demand-driven imbalance calculation.

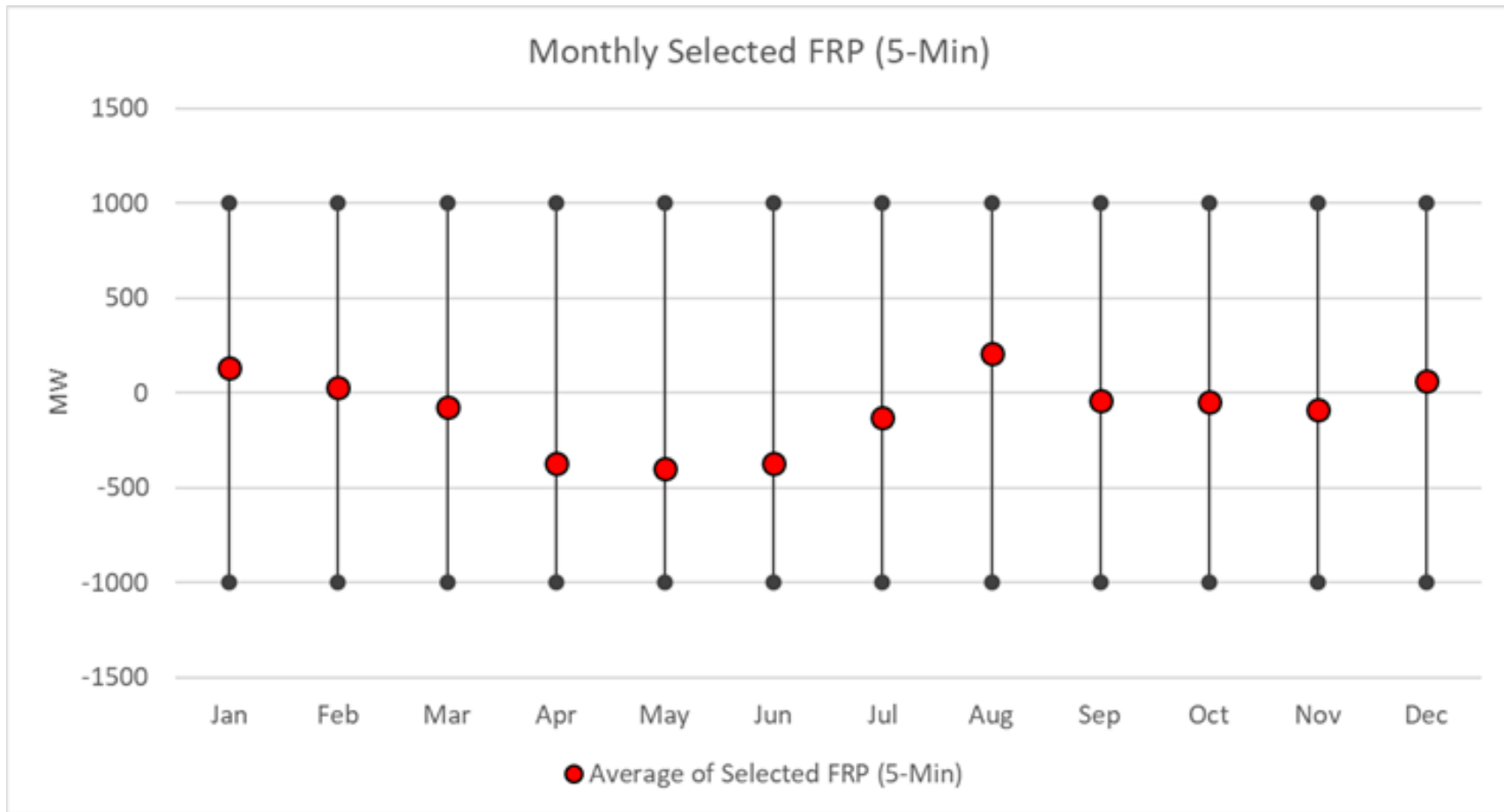
The data below summarizes the historical imbalance in MW that occurs between day-ahead and real-time. The data presented in this appendix will be discussed in more detail at the Stakeholder Meeting on April 18, 2018.

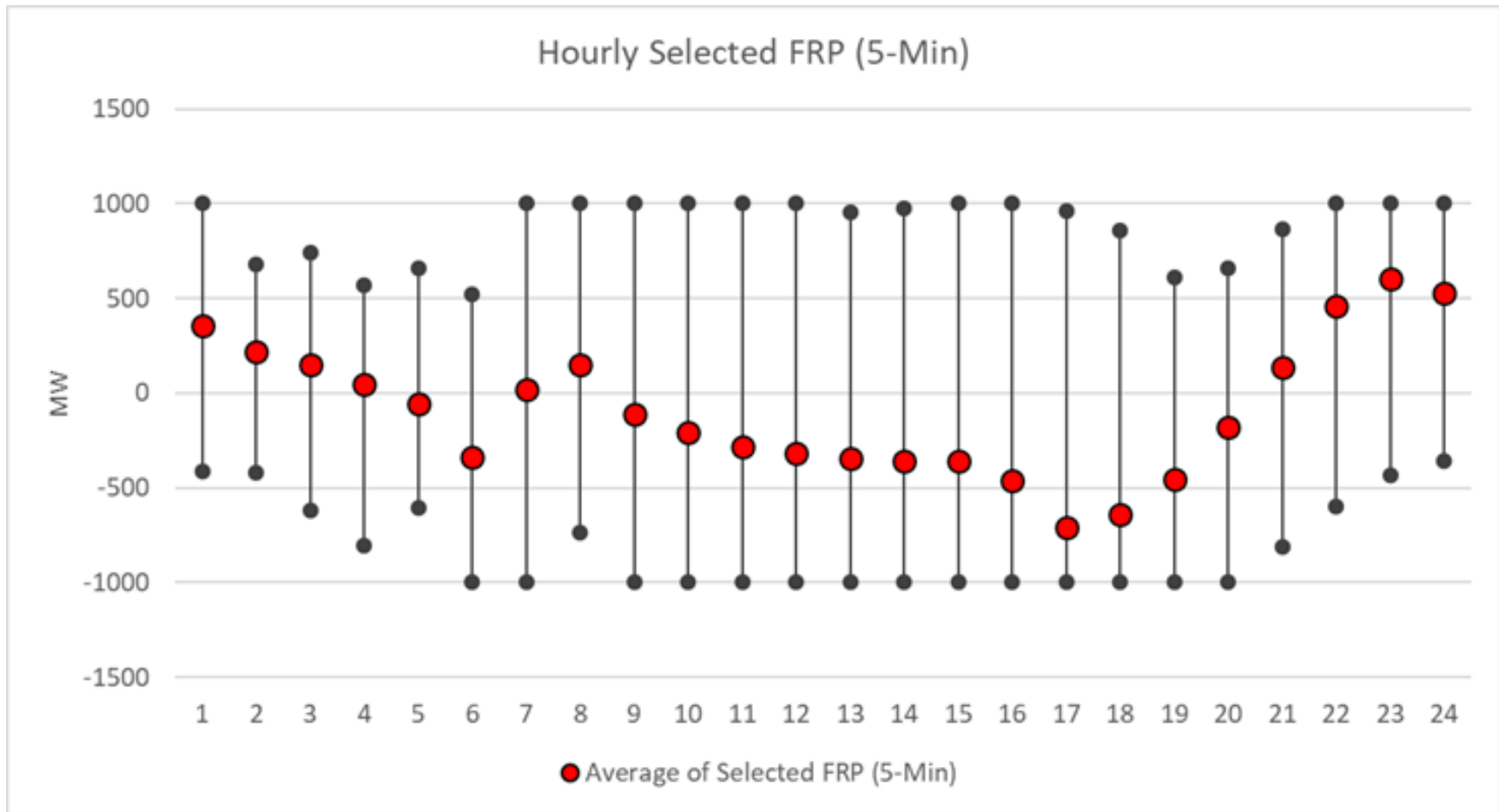




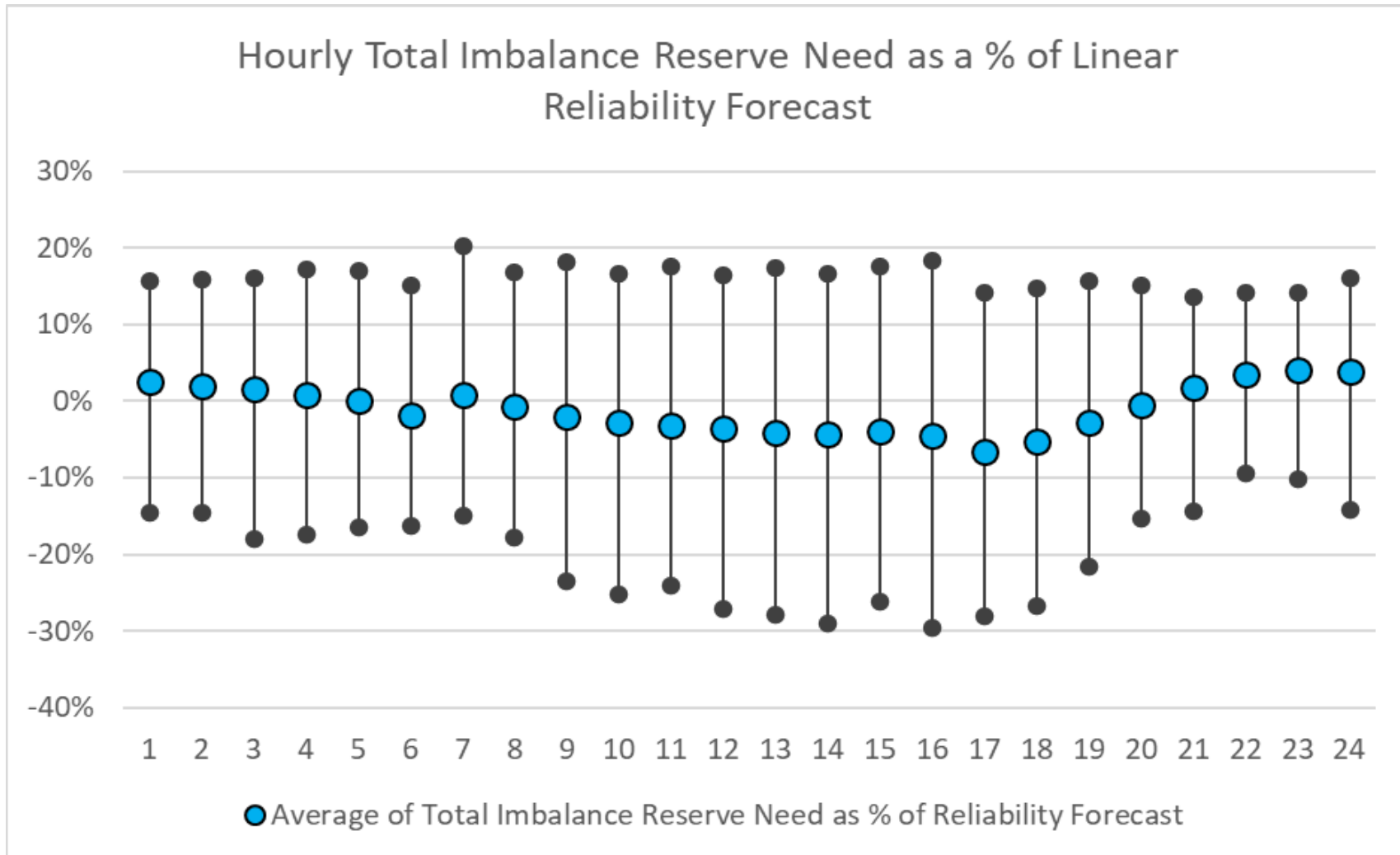


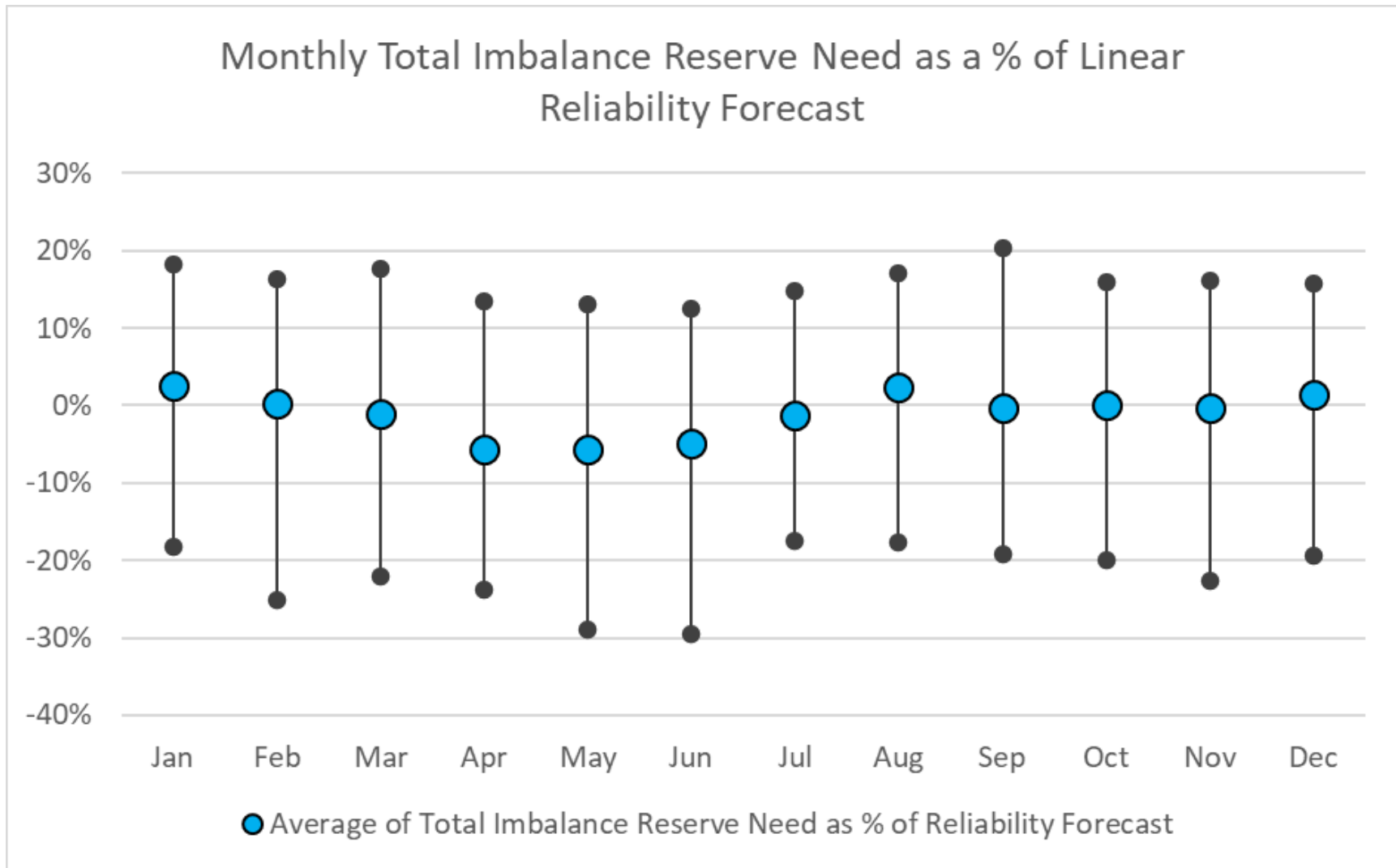






The data below summarizes the historical imbalance needs as a percentage of the reliability forecast that has been linearized to a 15-minute basis.





Load, wind and solar forecast accuracy:

The ISO publishes forecast accuracy information in each Market Performance and Planning Forum.²⁸ This bimonthly forum engages stakeholders in review of market performance issues and in high level dialogue on release planning, implementation and new market enhancements. The ISO provides the following information on day-ahead forecast accuracy.

*Day-ahead load forecast accuracy. Mean Absolute Percent Error (MAPE) by month.
Source: Market Performance and Planning Forum. February 20, 2018 – Slide #71.*



²⁸ The Market Performance Planning Forum webpage is available at <http://www.caiso.com/Pages/documentsbygroup.aspx?GroupID=587B83F7-5396-404E-AB51-D8B469BF1390>

Day-ahead wind forecast accuracy. Mean Average Errors (MAE) by month.
 Source: Market Performance and Planning Forum. February 20, 2018 – Slide #73.



**In 2015-2016, Economic dispatches are not added back in to the generation data.
 **The 2017 generation data used for accuracy calculation contains the economically dispatched MW.

Day-ahead solar forecast accuracy. Mean Average Errors (MAE) by month.
 Source: Market Performance and Planning Forum. February 20, 2018 – Slide #74.



**In 2015-2016, Economic dispatches are not added back in to the generation data.
 **The 2017 generation data used for accuracy calculation contains the economically dispatched MW.

6.2. Appendix B: Imbalance Reserve Requirement

The CAISO proposes to calculate the imbalance reserve requirement using a combination of historical data, regression testing, and new weather prediction technologies. These elements will enable the CAISO to develop a forward-looking imbalance reserve requirement based on varying levels of load/solar/wind/etc.

Currently, the CAISO is considering three methodologies to determine the imbalance reserve requirement. The three methodologies are briefly described below and are listed in order of complexity. The terms Near-, Mid- and Long-term approach refer to the ease with which the CAISO could implement the methodology. For example, the near-term approach could be implemented easily leveraging existing functionality. The long-term approach, however, relies on new technology from external vendors and will be more challenging to implement.

The CAISO requests stakeholder feedback to determine which approach, or combination of approaches, is most favorable. Subsequent policy papers will contain additional details, examples, and data for the proposed methodologies.

Methodology #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. Additional information describing the FRP methodology can be found in the Flexible Ramping Product draft final proposal, Section 4.3.1.²⁹

Methodology #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.

²⁹ Reference section 4.3.1 for a description of the flexible ramping product procurement methodology:
<http://www.aiso.com/Documents/Addendum-DraftFinalTechnicalAppendix-FlexibleRampingProduct.pdf>

Methodology #3 – Long 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. Though there is some availability of probabilistic forecasting coming from the weather vendors and research community, further development of probabilistic forecasting for the energy industry are ongoing to assist with addressing inherent biases that have been seen in Numerical Weather Prediction models. Additionally, integration of the new technology into the CAISO systems would involve more complexities in comparison to the other two methodologies.

A description of the probabilistic forecasting technology is attached in the document titled *APPENDIX B Probabilistic Forecasting Technical Publication*. This document was written by Ollinaho, et al., and published in the Quarterly Journal of the Royal Meteorological Society. This article is provided for educational purposes and context.

6.3. Appendix C: Day-Ahead Market Mathematic Formulations

The mathematic formulation for the day ahead market enhancements is attached in the document titled *APPENDIX C Day-Ahead Market Enhancements: Draft Technical Description*.

6.4. Appendix D: Settlement, Cost Allocation and Disqualification Worksheet

The CAISO has developed a worksheet to aid as an educational tool for stakeholders; it contains separate tabs detailing the settlement, no pay calculations, and disqualification of imbalance reserves. This worksheet serves for educational and illustrative purposes only. It is attached as an excel sheet titled *APPENDIX D Imbalance Reserves Settlement Worksheet*.