Day Ahead Market Enhancements

Issue Paper/Straw Proposal

February 28, 2018

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Issue Paper & Straw Proposal

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1. Purpose

The purpose of this initiative is to improve grid reliability and 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. 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 for the real-time market.

Fifteen-minute scheduling granularity will ensure the day-ahead market commits resources with sufficiency 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). With day-ahead fifteen-minute schedules, the real-time market must dispatch resources to address uncertainty in the day-ahead forecasts that materializes in the real-time market.

The real-time market addresses uncertainty 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 bid-in demand and net load forecast simultaneously.

1.1. Background & References

The purpose of the CAISO's day-ahead market is 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. As the grid has advanced, the resource fleet has changed, and the policies regulating operation of the grid have evolved, the day-ahead market hourly procurement has resulted in a strain on the real-time market.

The security constrained economic dispatch (SCED) is responsible for dispatching resources up or down in real-time to meet changes that have occurred. 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 load. However, intra hour net load changes have increased to a point in which the hourly procurement does not set up the real-time grid up for success. Net load is defined as load less variable energy resources output.

The CAISO has successfully implemented real-time market enhancements to ensure reliability of the bulk electric grid; 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 resources are procured ahead of time to ensure success of the real-time market and reliability of the bulk electric grid.

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

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

In order to work towards the strategic vision, a three-year roadmap is developed based on stakeholder input from the initiative catalog. The Day Ahead Market Enhancements initiative is a core element in the 2018 Policy Initiative Roadmap[1] and assists in the achievement of all three elements in the strategic vision.

Successful implementation of the DAM Enhancements also 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 effective integration of renewable resources across a larger footprint.

2. Issue Paper: Limitations of the Current Day-Ahead Market

The CAISO's current DAM is limited due 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. 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 (if needed) to match the CAISO Forecast of CAISO Demand (CFCD) when the IFM has not cleared adequate forward schedules. However, RUC is unable to de-commit resources that were cleared in the IFM. RUC clears based on the RUC procurement target, which is largely determined by the CFCD. When the CFCD is lower than the IFM, the IFM has committed too much energy and is set up for an over-generation 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.

[1] The 2018 Policy Initiatives Roadmap is located at: http://www.caiso.com/Documents/2018FinalPolicyInitiativesRoadmap.pdf

When the CAISO first designed the DAM, this limitation did not pose a problem. As the CAISO's fleet has evolved over time, the CAISO has experienced increased episodes of over-generation. 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.

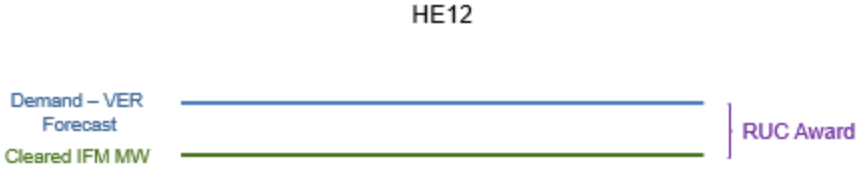
In addition to combining the IFM and RUC processes, the CAISO proposes to introduce the procurement of imbalance reserves in the day-ahead market to ensure upward and downward capacity will be available to resolve imbalance that occurs in real-time. These reserves will address uncertainty between the day-ahead and real-time market and better position the CAISO system to address both under- and over-generation in the real-time. Imbalance reserves will be procured based on the CAISO net load forecast, not based upon the cleared demand from the IFM.

The imbalance reserves proposed in this initiative will address the problem posed when the IFM clears below the CAISO forecast but there is still upward uncertainty that RUC cannot address because it's target is based on the CFCD and not uncertainty. The imbalance reserves will also address the problem created today when the IFM clears above the CAISO forecast RUC, creating the risk of over-generation.

2.1. RUC does not address upward uncertainty

Currently, when the IFM clears physical supply below the CAISO net load, RUC will bring additional capacity online 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 net load forecast.*



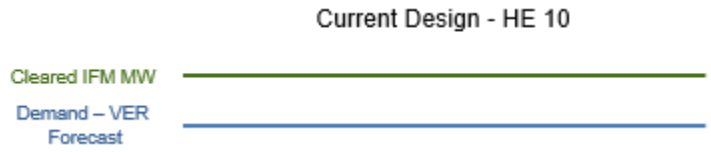
The process of committing additional resources when the IFM clears below the CFCD is known as the RUC net short process. This tool is used to bring additional capacity online in the day-ahead time frame and occurs for hourly blocks. Any imbalance or deviations that occur (load forecast error, VER forecast error, outages, generator deviation, net virtual supply/demand, etc.) must be corrected in the real-time market. RUC can resolve forecast differences between the IFM and CAISO net load forecast, but it does not address upward uncertainty between the IFM and real-time market.

2.2. RUC does not address downward uncertainty or forecast differences

When the IFM clears physical supply above the CFCD, RUC is 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 net load 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 over-generation 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.*

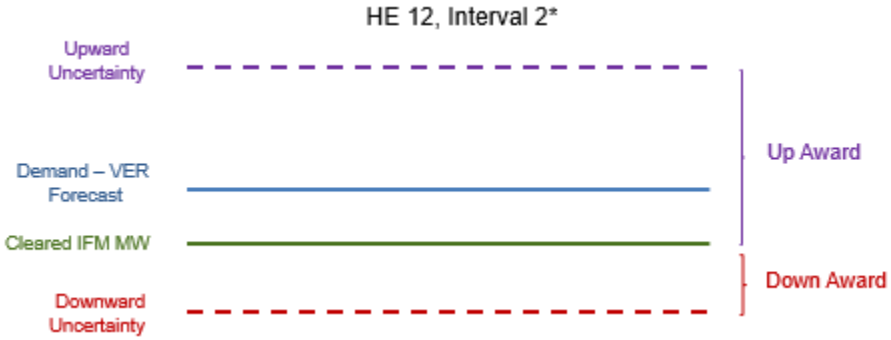


When the IFM clears above the net load forecast, there is the potential for an over-generation situation for the corresponding hour in real-time. Even though it is known in the day-ahead timeframe that the net load forecast is less than what has cleared, the real-time market must resolve the imbalance.

2.3. RUC availability bids replaced with imbalance reserves

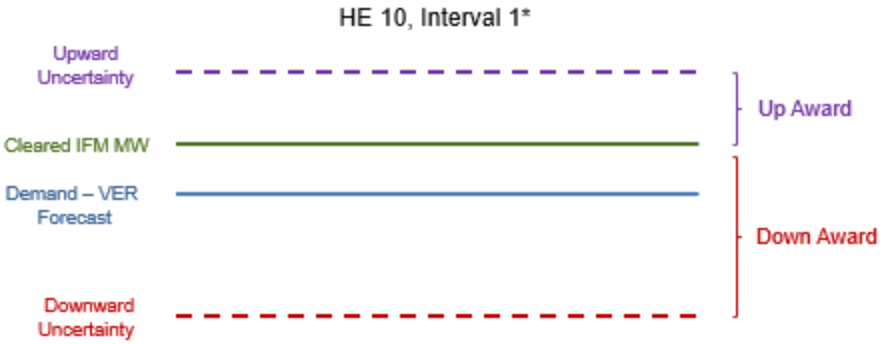
In order to address the uncertainty that occurs between the day-ahead and real-time market, the CAISO proposes to replace RUC availability bids with upward and downward imbalance reserves bids. The introduction of imbalance reserves will ensure sufficient bids are available in real-time to meet uncertainty in the net load forecast that may materialize. This is demonstrated in Figure 3 and Figure 4.

Figure 3: *When the IFM clears below the ISO net load forecast, uncertainty[2] is accounted for with imbalance reserves in the up and down direction.*



In Figure 3, the ISO net load forecast is higher than what has cleared in the IFM for HE12, Interval 2[3]. This results in imbalance reserves that are awarded to account for upward and downward net load forecast 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 net load forecast, net load forecast uncertainty is accounted for with imbalance reserves in the up and down direction.*



In Figure 4, the ISO net load forecast is lower than what has cleared in the IFM for HE10, Interval 1[4]. This results in imbalance reserves that are awarded to account for upward and downward net load forecast uncertainty. The up award covers the upward uncertainty less the portion of the uncertainty already

[2] The term "uncertainty" refers to the potential amount of imbalances that must be met by dispatchable resources in the real-time market.

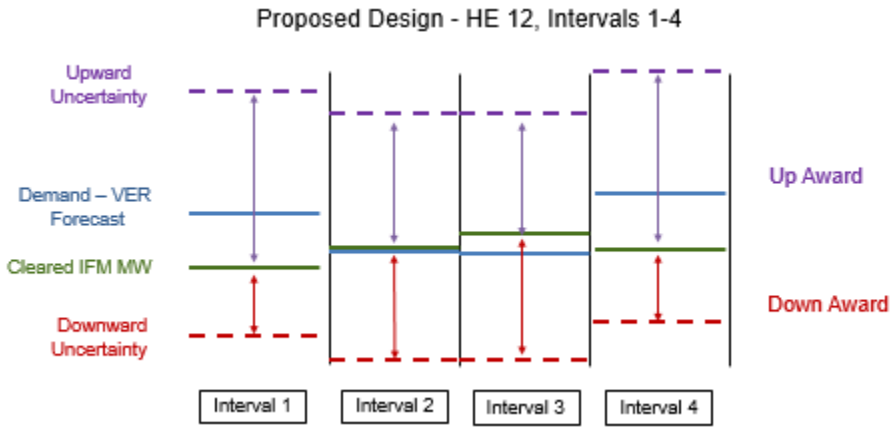
[3] Interval 2 refers to the second 15-minute interval in the operating hour, HE12. This corresponds to 11:15 – 11:30 AM.

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

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 only ISO/IFM 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 as a continuation of Figure 3, now showing four 15-minute intervals.

Figure 5: Net load forecast 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 net load forecast.

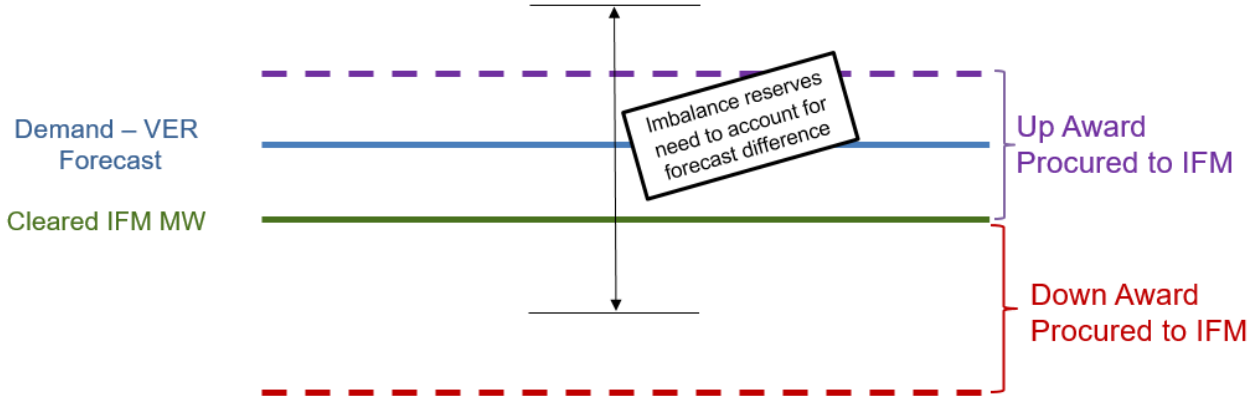


Uncertainty can now be addressed for each fifteen-minute interval with upward and downward imbalance reserves. The day-ahead market secures sufficient resources with a must-offer obligation into the real-time market. This ensures that the real-time market will be able to economically re-dispatch the 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.

2.4. Combining IFM and RUC addresses forecast differences

Combining IFM and RUC is necessary so imbalance reserves can be procured relative to the CAISO net load 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.*

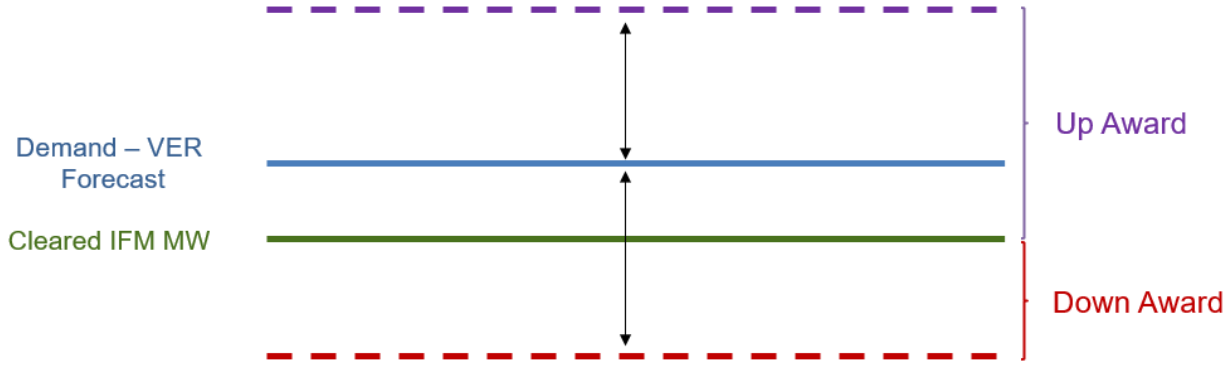


As shown above, the IFM (green line) cleared below CAISO forecast (blue line). When imbalance reserves are procured based on the cleared IFM value (purple line indicates up award, red line indicates down award), the difference CAISO forecasted demand is not taken into account.

In this scenario, there would be too much down awards and not enough up awards to address uncertainty. Imbalance awards should account for forecast difference between the IFM and net load forecast, but ensure that the full uncertainty in both direction can be covered.

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

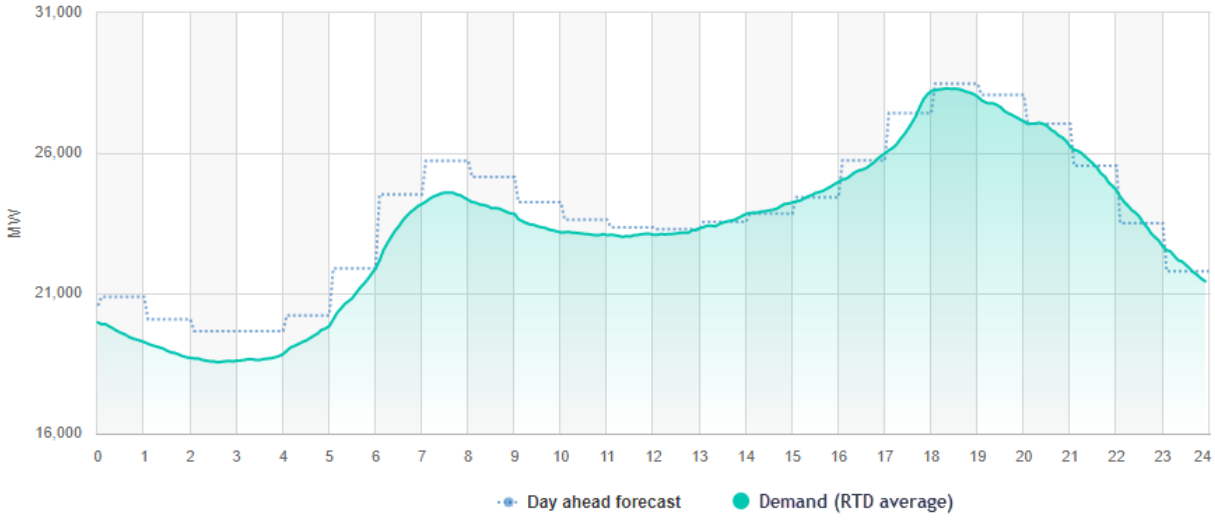
Figure 7: *Imbalance Reserves procured based on IFM cleared value.*



2.5. 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 the CAISO forecast of CAISO demand (CFCD). As shown in Figure 8, the current day ahead market procures in hourly blocks making it challenging to ramp between operating hours, especially during the morning and evening load pull.

Figure 8: *Day Ahead Market 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:

For HE24 (11:00PM – 12:00AM), the DAM correctly procured resources to meet the load at the middle of the operating hour. 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 RTD averages is approximately 500 MW greater than the day ahead forecast. Granularity differences throughout the operating hour can be addressed by moving to fifteen-minute day-ahead scheduling.

Procuring resources 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:

For HE07 (6:00AM – 7:00AM), 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 over-generation 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 mitigated with self-schedule cuts and administrative prices. 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 schedule in the day-ahead time frame.

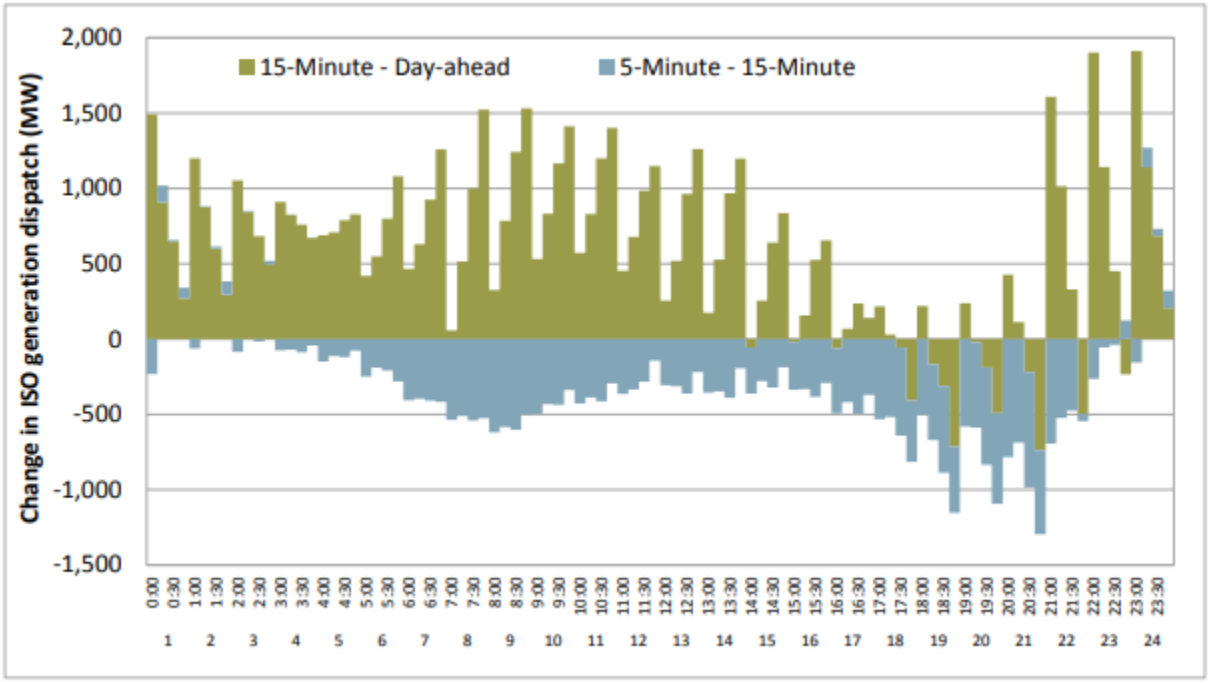
15-minute shaped intertie schedules can more accurately match the actual ramping needs of the CAISO than hourly day-ahead schedules. Dynamically schedule resources can also be used to address uncertainty between IFM and RTM; however, there may be physical limitations on dynamic transfer

capacity that prevent the hydro resources from being scheduled in the real-time market.[5] 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.

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-head 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 Performance[6]

[5] 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.

[6] 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 dispatch an additional 1,500 MW for the first interval of the operating hour. This is because the DA 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 more closely follow the load curve resulting in less strain on the real-time market.

3. Straw Proposal: Day-Ahead Fifteen-Minute Scheduling

The CAISO will move to fifteen-minute scheduling granularity, but bid submission will remain hourly for both the day-ahead and real-time markets. 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 real-time dispatch.

- Scheduling coordinators will still submit hourly bids for energy, ancillary services, imbalance reserves, and convergence bidding. The bid in amount will be the same for the hour; however, the awarded amount can now change for each fifteen-minute interval in the hour.
- Scheduling coordinators will have the option to select block scheduling for resources. The block option will keep the schedule at the same value for the duration of the operating hour or multiple hours. If block scheduling is not selected, the resource schedule may change on a fifteen-minute basis. This applies to internal resources and intertie resources.
- Resources can now be committed intra-hour at the beginning of any fifteen-minute interval.

The CAISO also 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 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 UEL. This will enable the day ahead market to shape the available capacity for each fifteen-minute interval.
    - The IFM will use either the CAISO forecast or the scheduling coordinator submitted UEL as determined by the scheduling coordinator.
    - The real-time market (RTM) will use the CAISO forecast to clear the market, but the scheduling coordinator submitted UEL can be used for settlements as is consistent with the current design.
    - If the scheduling coordinator uses its own forecast in the IFM, this does not preclude the scheduling coordinator for using the ISO forecast in the real-time market.

4. Straw Proposal: Imbalance Reserves Proposal

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. 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 versus administrative or 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. The requirement calculation and data analysis of historical imbalance will be explained in subsequent papers.

The example below is a generic example showing how 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 dispatch 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**

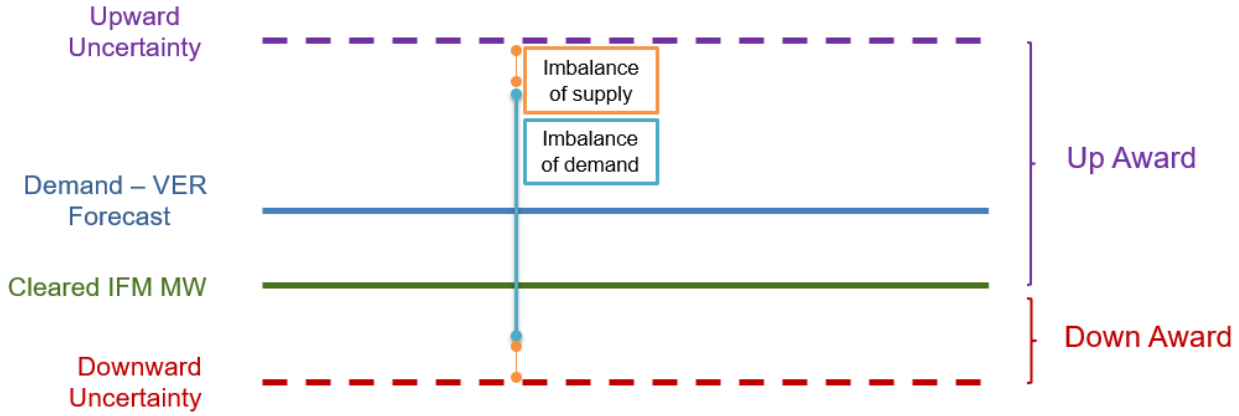
If the upward imbalance reserve requirement was above 105 MW the market is assured that the materialized deviations from day-ahead schedules can be addressed by deploying upward imbalance reserves as energy.

4.1. Drivers

The imbalance reserve requirement is driven by both demand and supply. 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.

Explained visually in Figure 10, the total imbalance is determined by imbalance of demand (teal bar) and the imbalance of supply (orange bar). Imbalance of demand is typically greater than imbalance of supply because of load forecast changes. Imbalance of supply occurs due to generator and intertie deviations (including outages). The procurement of imbalance reserves should ensure imbalance of supply and demand can meet the upward and downward uncertainty.

Figure 10: *Total imbalance is the summation of supply-driven imbalance and demand-driven imbalance.*



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.

Drivers of upward imbalance reserves:

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[7] above their IFM schedule

[7] 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 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.

Drivers of downward imbalance reserves:

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
- 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

Imbalances can be resolved in FMM and RTD:

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 static imports/exports can be economically scheduled to address imbalances that have materializes from the IFM. In RTD, internal generation and dynamic schedules on the interties can be economically dispatched to address additional imbalances that material 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.

Similar to contingency reserves which divides the total requirement between two different quality levels of services (spinning reserves and non-spinning reserves), the CAISO proposes to do the same for both upward and downward imbalance reserves. A portion of the imbalance reserves must be met by 5-minute dispatchable resources because these are the only resources that can resolve imbalance that materializes in RTD. However, not all imbalance must be resolved in RTD, therefore 15-minute dispatchable resource should not be restricted form providing a prudent portion of the imbalance reserves. The CAISO will determine the appropriate split between 15-minute requirement and 5-minute requirement based on the analysis discuss later.

Similar to contingency reserves where the higher quality service (spinning reserves) can also meet the lower quality services (non-spinning reserves) if economic, the imbalance reserves will also the same cascading. Resources that can only be schedule in the FMM will only be eligible to meet the 15-minute

imbalance reserve requirement. Resources that can be dispatched in RTD will be eligible to meet both the 15-minute requirement and the 5-minute requirement.

4.2. Design Features

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

The CAISO proposes the following policies related to procurement of imbalance reserves:

- The total imbalance reserve requirement will be based on potential imbalance needs that occur between the IFM and real-time market. The requirement will be split between fifteen minute and five minutes eligible resources in both the up and downward direction. 5-minute resources can be used to meet the 15-minute requirement.
- The CAISO will have a balancing authority area imbalance reserve requirement and will have the ability to be procured in sub-regional zones, similar to AS procurement.
- The requirements will be posted to OASIS, as is similar to AS.
- The CAISO will procure 100% of the imbalance reserve requirement, as is similar to AS procurement. The procurement will not be based on a demand curve as is done for the flexible ramping product in the real-time market.
- If there are inadequate imbalance reserve bids, a penalty price will be used to allow the market to reach a solution. The penalty price will be set at the real-time flexible reserve product penalty price.[8]
- Resources will be procured in both the up and down direction based on operational characteristics including start up time, ramp rate, PMin/PMax, etc. The CAISO will consider testing and qualification of resources that plan to provide imbalance reserves.
- A resource without an imbalance reserve award can elect not to bid into the real-time market. After the market runs a resource may then be exceptionally dispatched for operational needs. The CAISO will investigate whether existing exceptional dispatch compensation rules need to be changed as a result.

[8] 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.

- In real-time, day ahead imbalance reserve awards can be used for energy, certified ancillary services, flexible ramping product forecasted movement or uncertainty awards, and corrective capacity.

- 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 would like to leverage the existing ramping model which currently takes energy and regulation into consideration. With the new DAM enhancements, the CAISO will consider using ramp rates in the market optimization for all energy schedules and upward products to ensure deliverability in real time.

- Long start unit and medium start unit:
    - Maximum MW Quantity = Dispatchable Ramp Rate x 15-minute
    - If committed in IFM, eligible for up award to maximum quantity
    - If committed in IFM, eligible down award of MIN(IFM energy – PMin, maximum quantity)

- Fast start unit (start up within the shortest real-time unit commitment run which is 4 fifteen minute intervals)
    - Maximum MW Quantity = Ramp Rate x 15-minute
    - Eligible for up award to maximum quantity
    - If scheduled in IFM, eligible down award of MIN(IFM energy – PMin, maximum quantity)

- Since real-time unit commitment is only performed it the 15-minute real-time unit commitment process, start-up to PMin can only be awarded the 15-minute upward imbalance reserve and shut-down from PMin can only be award the 15-minute downward imbalance reserve.

4.3. Bidding

The CAISO proposes the following policies related to bidding for imbalance reserves:

- 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.

- All resources can submit an economic bid to provide imbalance reserves. Unlike RUC availability bids today, resource adequacy resources will not be required to bid $0.00[9]. 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.

4.4. Settlement

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. If the resource is dispatched for energy or 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.

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, undispatchability, or unavailability, in contrast to the rules that apply to ancillary services today currently.

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[9] 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 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.

4.5. Cost Allocation

The cost allocation for imbalance reserves will be consistent with the existing CAISO guiding principles.[10] 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 IFM, the resource is using the imbalance reserves. When this occurs, another resource must be dispatched up or down to accommodate the IFM change. Therefore, the cost of the imbalance reserve should be allocated to the resource causing necessary re-dispatch to keep the system balanced.

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.

Cost Allocation – Imbalance Reserves, Upward Direction

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

- Metered load at the resource level 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 bid will be used as the UEL
- Exports that self-schedule with a lower economic limit (LEL) above their IFM schedule
- Virtual Supply

Cost Allocation – Imbalance Reserves, Downward Direction

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

- Metered load at the resource level that is lower than the IFM schedule

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

- 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 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 and will be performed at the scheduling coordinator (SC) level. It 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 that 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 = Min(Up price, Net negative imbalance reserve deviation)
- Up Tier 2 = Measured demand (metered load and exports)

The allocation for downward imbalance reserves will be:

- Down Tier 1 = Min (Down price, Net positive imbalance reserve deviation)
- Down Tier 2 = Measured demand (metered load and exports)

4.6. Additional Design Considerations

The items listed below are related to the DAM Enhancements initiative but do not directly fall into development of the imbalance reserves. These are current market design features that may need to be modified in order to align with change to 15-minute scheduling and elimination of the sequential RUC process. The CAISO requests stakeholder input on these items, as well as additional items that may need to be addressed.

- With the removal of RUC, bid cost recovery cannot be specifically attributed to RUC.[11] For this reason, RUC should no longer be incorporated in the real-time bid cost recovery (BCR). Instead, the imbalance reserves will be incorporated in the IFM BCR.

- 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.

- Unless RA resources obtain a Day-ahead schedule, a RUC award, an ancillary service, or an imbalance reserve award, the RA resource will no longer have a real-time must offer obligation. This simplifies the RAAIM calculations.[12] RAAIM will now only consider compliance with day-ahead must offer obligations. Interactions between RAAIM and the imbalance reserve no-pay will need to be addressed. RA resources may have additional penalties to ensure economic incentive for deliverability.[13]

- Review what occurs after imbalance reserves are used but additional energy and/or capacity is called up via an exceptional dispatch (ED) or capacity procurement mechanism (CPM). How will this impact existing tools, processes, cost allocation, etc.?

- Congestion revenue rights will now be settled based upon 15-minute IFM schedules versus hourly. The CAISO doesn't at this time believe there are settlement implications by making the change in granularity; however, the congestion revenue rights (CRR) clawback rule will be need to be reviewed due to the change from hourly to fifteen-minute scheduling granularity in the day ahead time frame.

- 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.

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11 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. Imbalance reserves are awarded in the IFM and therefore BCR for imbalance reserves should be incorporated in the IFM BCR.

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

13 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

- Extra-long start resources (resources with a startup time longer than 1100 minutes) will need to be procured in the 72 hour RUC commitment process. The CAISO will continue to maintain hourly granularity and procurement for market timelines longer than the day-ahead market.

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 advisory 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 Straw Proposal	April 11, 2018
Stakeholder Meeting	April 18, 2018
Stakeholder Comments Due	May 2, 2018
Post Revised Straw Proposal (tentative)	*May 16, 2018*
Stakeholder Meeting (tentative)	*May 23, 2018*
Stakeholder Comments Due (tentative)	*May 30, 2018*
Post Draft Final Proposal	June 12, 2018
Stakeholder Call	June 19, 2018
Stakeholder Comments Due	June 26, 2018
EIM Governing Body Meeting (advisory)	July 12, 2018
CAISO Board of Governors Meeting	July 25-26, 2018

The CAISO proposes to present its proposal to the EIM Governing Body and CAISO Board of Governors on July 12, 2018 and July 25-26, 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

These proposed enhancements lay the foundation for a future initiative that would give EIM Entities the option of participating in the day ahead market. For this reason, Management believes it would be appropriate for the EIM Governing Body to have an advisory role on all aspects of this initiative.

Management acknowledges this proposed advisory classification for the entire initiative departs from a strict application of the rules in the Guidance Document and Charter for EIM Governance. Under those rules, Management believes the EIM Governing Body would have no decisional role in any of the three elements, each of which is severable from the remainder of the initiative: imbalance reserves, day-ahead fifteen minute scheduling[14] and combining the residual unit commitment process and the integrated forward market. None of these elements would involve changes to either the rules of the real-time market, or to rules that govern participation in all ISO markets.

Nevertheless, Management believes an advisory classification is appropriate for the full initiative given 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.[15]

Stakeholders are encouraged to submit a response to the EIM categorization in their written comments following the conference call for the Issue Paper/Straw Proposal, particularly if they have concerns or questions.

5.3. Next Steps

The CAISO will discuss the Issue Paper/Straw Proposal during the stakeholder meeting on March 1, 2018. The CAISO requests stakeholders submit written comments in response to the Day Ahead Market Enhancement paper and stakeholder meeting by March 15, 2018.

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[14] The ISO's December 7, 2017, Policy Initiatives Catalog indicated that the EIM Governing Body would have an advisory role in the fifteen minute day-ahead market. At this time, Management contemplated that this element would include changing EIM base schedules to fifteen minute granularity. However, changes to EIM base schedules are no longer expected, and thus the EIM Governing Body would not have an advisory role under the rules.

[15] https://www.caiso.com/Documents/Decision_EIM_GovernanceProposal-AttachA-Proposal-Sep2015.pdf

6. Appendices

6.1. Appendix A: Historical Analysis of Imbalance

The CAISO will perform analysis to inform the development of the imbalance reserves. The analysis will seek to quantify the benefits of moving from hourly scheduling to 15-miute scheduling, the additional benefits that can be achieved because net load forecast do not follow hourly linearity, the potential total requirement for upward and downward imbalances reserves, and lastly the split between the 15-minute requirement and the 5-minute requirement.

The analysis 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 includes of the 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 in comparison to the RTD. Description of these calculations will be provided in the next paper. The data will be used to show historically how much imbalance occurs between day-ahead and real-time; furthermore the data will allow for an understanding of how efficiently the imbalance can be resolved when moving from hourly to fifteen-minute granularity in the day-ahead timeframe.

The CAISO will complete additional analysis to evaluate how far off the 15-minute linearization is from actual imbalance. This will be determined by subtracting the 15-minute VER schedules (DA) from the 15-minute day ahead load. The resulting value will be compared to the linearized hourly schedules.

6.2. Appendix B: Imbalance Reserve Requirement

The CASIO proposes to calculate the imbalance reserve procurement requirement using historical imbalance data and completing regression testing to develop a forward-looking requirement based on varying levels of load/solar/wind/etc. Additional information will be provided in the next policy paper.

6.3. Appendix C: Mathematic Formulations

The mathematic formulations for the day ahead market enhancements will be included in the next policy paper.