



California ISO

**Day-Ahead Market Enhancements
Phase 1:
Fifteen-Minute Granularity**

Third Revised Straw Proposal

February 28, 2019

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Day-Ahead Market Enhancements Phase 1

Third 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 CAISO proposes to enhance the day-ahead market by replacing the current hourly granularity with fifteen-minute granularity. Introducing fifteen-minute granularity will better position the system to accommodate net load ramps that occur in real-time. Currently the real-time market must dispatch resources to manage granularity differences between the day-ahead market (with hourly granularity) and the real-time dispatch (RTD) (with five-minute granularity). Fifteen-minute scheduling granularity in the day-ahead market will allow the day-ahead market to commit resources with sufficient ramping capability that more closely aligns with anticipated real-time conditions.

1.1. Background & References

The purpose of the CAISO's day-ahead market is to provide price certainty while scheduling resources 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 materialized in real-time. 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 CAISO market's security constrained economic dispatch (SCED) is responsible for dispatching resources up or down based on system constraints. The SCED for the day-ahead market is currently hourly and the SCED for the real-time market is every fifteen-minutes (Fifteen Minute Market) and five-minutes (Real Time Dispatch). The day-ahead market commits sufficient energy and capacity in advance of the fifteen-minute and real-time markets to economically balance supply with load. However, intra-hour net load changes have increased to a degree that the day-ahead market's hourly schedules do not align with the real-time load curve; this results in a need for the real-time market to make up for granularity differences and uncertainty.¹

The CAISO has successfully implemented several real-time market enhancements to support bulk electric system reliability and improve 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 reliability of the bulk electric grid.

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

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

To implement this strategic vision, the CAISO develops a three-year roadmap based on stakeholder input. The Day-Ahead Market Enhancements initiative assists in achieving all three elements in the strategic vision.²

Additionally, successful implementation of the Day-Ahead Market Enhancements will enable the CAISO to extend this functionality to Energy Imbalance Market (EIM) entities. Extension of the CAISO's day-ahead market (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.

1.2. Changes from Second Revised Straw Proposal

The CAISO appreciates the written stakeholder comments responding to the Day-Ahead Market Enhancements Second Revised Straw Proposal, as well as comments received after the September 4th stakeholder call. In response to this input, CAISO is phasing both the policy development and the implementation of the Day-Ahead Market Enhancements initiative.

The first phase of the DAME initiative proposes changing day-ahead scheduling granularity from hourly to fifteen minutes. Policy changes pertaining to day-ahead market fifteen-minute scheduling granularity are discussed in this paper. Unless otherwise noted, the CAISO intends to implement the Day-Ahead Market Enhancements Phase 1 in fall 2020.

The second phase of the DAME initiative will explore enhancements to the integrated forward market (IFM) and residual unit commitment (RUC) processes, including the introduction of a new day-ahead flexible ramping product to address uncertainty. The CAISO plans to update the technical appendix describing integrated IFM/RUC and day-ahead flexible ramping product with publication of the issue paper/straw proposal DAME Phase 2.

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

The CAISO has made the following changes since the *DAME Phase 1, Second Revised Straw Proposal* was published on August 27, 2018:

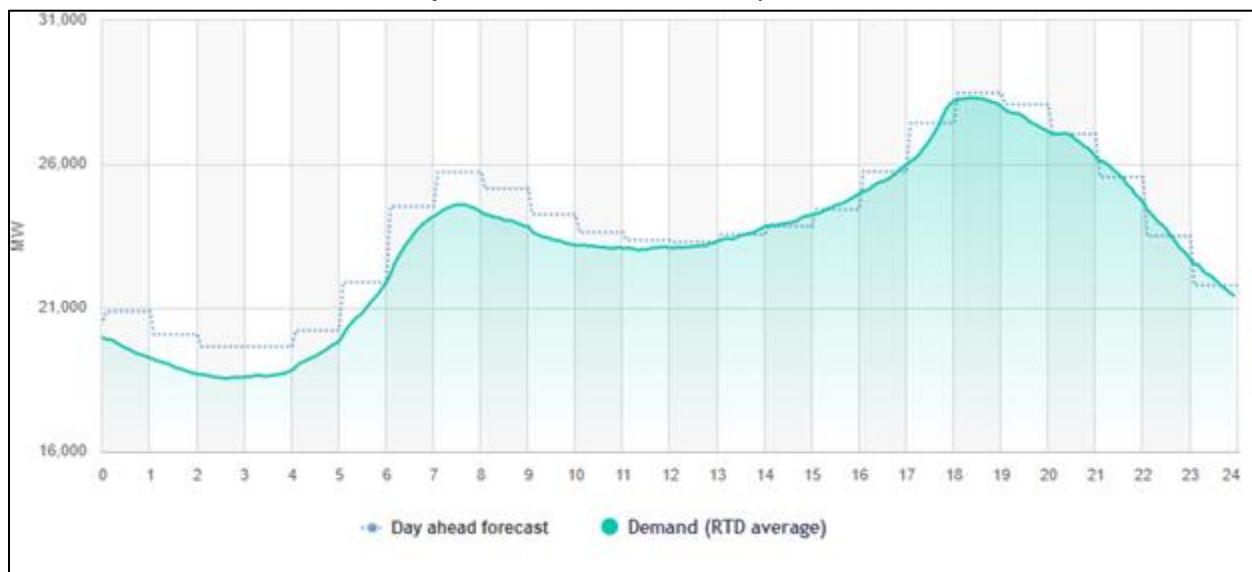
- Provided additional information on the design features of fifteen-minute scheduling granularity, including:
 - Unit Commitment Decisions
 - Fifteen-Minute Residual Unit Commitment
 - Intertie Bidding and Scheduling Options
 - Load Meter Submission
 - Non-Generator Resources Providing Ancillary Services
 - Demand Response

2. Fifteen-Minute Granularity Design Features

2.1. Fifteen-Minute Scheduling

The CAISO proposes to move from hourly 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 projected by the CAISO forecast of CAISO demand (CFCD). As shown in **Figure 1** and further explained below, the current day-ahead market procures energy in hourly blocks. It can be challenging, and occasionally infeasible (See **Figure 2**), for the real-time market to ramp between operating hours because of the day-ahead block energy schedules, especially when load increases in the morning and evening.

Figure 1: Day-Ahead Market hourly procurement in comparison to real-time demand curve.
California ISO Trade Date February 5, 2018.



When the day-ahead market schedules resources in hourly blocks, the real-time market must dispatch resources granularity differences that occur within the hour in addition to uncertainty that materializes between the day-ahead and real-time markets. Granularity differences are changes between intervals (i.e. hourly interval to hourly interval, or fifteen-minute interval to fifteen-minute interval). Uncertainty differences are changes that materialize between market runs (i.e. IFM to FMM).

In **Figure 1** *uncertainty* exists between HE01 and HE13, while *granularity* differences exist between HE14 and HE24.

Note: The CAISO plans to address uncertainty that materializes between the day-ahead and real-time market by introducing a new day-ahead flexible ramping product. This product is being discussed in detail in the Day-Ahead Market Enhancements: Phase 2 initiative.

Granularity differences

Table 1 presents the data from **Figure 2**: Hourly schedules do not portion the fleet to respond to short transitions between fifteen-minute interval net load ramps and may result in inadequate ramping capacity, in which the day-ahead market correctly procures resources to meet the load for 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.

Table 1: Hourly Day-Ahead Market procurement and approximated Fifteen-Minute Day-Ahead Market procurement in comparison to real-time demand curve. California ISO Trade Date February 5, 2018.

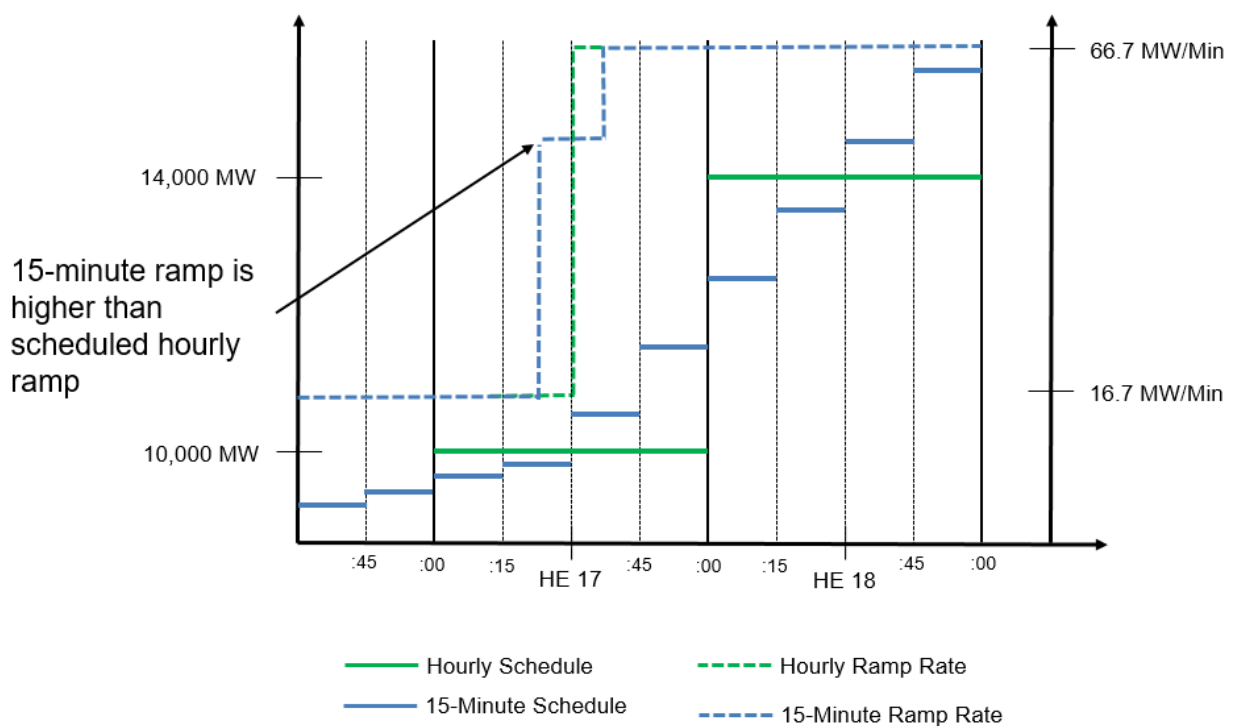
Interval	DA Hourly Interval Procurement	DA Fifteen-Minute Interval Procurement*	Real-time Demand
1 (23:00 – 23:15)	21,500 MW	22,000 MW	22,150 MW
2 (23:15 – 23:30)	21,500 MW	21,750 MW	22,000 MW
3 (23:30 – 23:45)	21,500 MW	21,500 MW	21,600 MW
4 (23:45 – 24:00)	21,500 MW	21,000 MW	21,200 MW

Table 1 shows that fifteen-minute day-ahead schedules allow the day-ahead market to more closely follow the net load and better prepare the system for real-time conditions. The CAISO can schedule the day-ahead market in fifteen-minute intervals to narrow the difference between the day-ahead schedules and real-time demand, making the markets more efficient.

Impact on Ramp Rates

When granularity differences are not uniform across the hour (e.g. minor ramp changes for the first two intervals and steep ramp changes for the second two intervals), the ramp capacity procured by the hourly day-ahead market may result in an infeasible fifteen-minute ramp capable solution. This is demonstrated in **Figure 2**: Hourly schedules do not position the fleet to respond to short transitions between fifteen-minute interval net load ramps and may result in inadequate ramping capacity., which shows actual data for hourly vs. fifteen-minute schedules (left axis) and hourly vs. fifteen-minute ramp rate (right axis).

Figure 2: Hourly schedules do not position the fleet to respond to short transitions between fifteen-minute interval net load ramps and may result in inadequate ramping capacity.



The data displayed in **Figure 2** shows minor fifteen-minute schedule changes between the first two intervals of HE17 and more significant fifteen-minute schedule changes between the last two intervals of the same hour. The hourly ramp rate is procured for mid-point to mid-point of consecutive hours. Therefore, in this scenario, the hourly ramp rate is less than the actual fifteen-minute ramp rate that is needed between the second and third interval of HE17. This causes considerable operational challenges and may result in out-of-market actions.

Fifteen-minute scheduling granularity – as opposed to hourly scheduling granularity – will allow the CAISO to ensure ramp rates are feasible between all intervals.

Impact on Pacific Northwest Hydro

The CAISO markets underutilize large amounts of hydroelectric generation from the Pacific Northwest because, although these resources can provide significant flexibility between and within hours, they largely operate on day-ahead schedules alone. In the day-ahead timeframe the Pacific Northwest hydroelectric fleet has the opportunity to set and adjust water schedules to plan to meet day-ahead energy schedules with significant flexibility, however it does not have the same water scheduling flexibility in real-time. While the hydroelectric fleet is fully capable of meeting even dramatic changes in output between each day-ahead interval, it does not have the same level of flexibility in real-time.

Any new or existing bidding options to provide flexibility in the real-time market would not resolve the Pacific Northwest hydroelectric generation fleet's underlying limitation in providing flexibility the real-time market. When scheduling import energy in real-time, the CAISO is limited to using hourly static import bids, fifteen-minute static import bids, and dynamic resource bids to address scheduling granularity differences. The Pacific Northwest generation fleet is limited in its ability to offer hourly static output, fifteen-minute static output, or dynamic resource output in real-time due largely to water scheduling that must occur the day before.³

The ability to shape the most flexible of intertie schedules in the day-ahead timeframe increases the overall flexibility available to the CAISO. By moving to fifteen-minute granularity in the integrated forward market, the CAISO can better utilize available hydro resources to meet the forecasted steep ramps in the CAISO and help address granularity differences that occur throughout the operating hour.

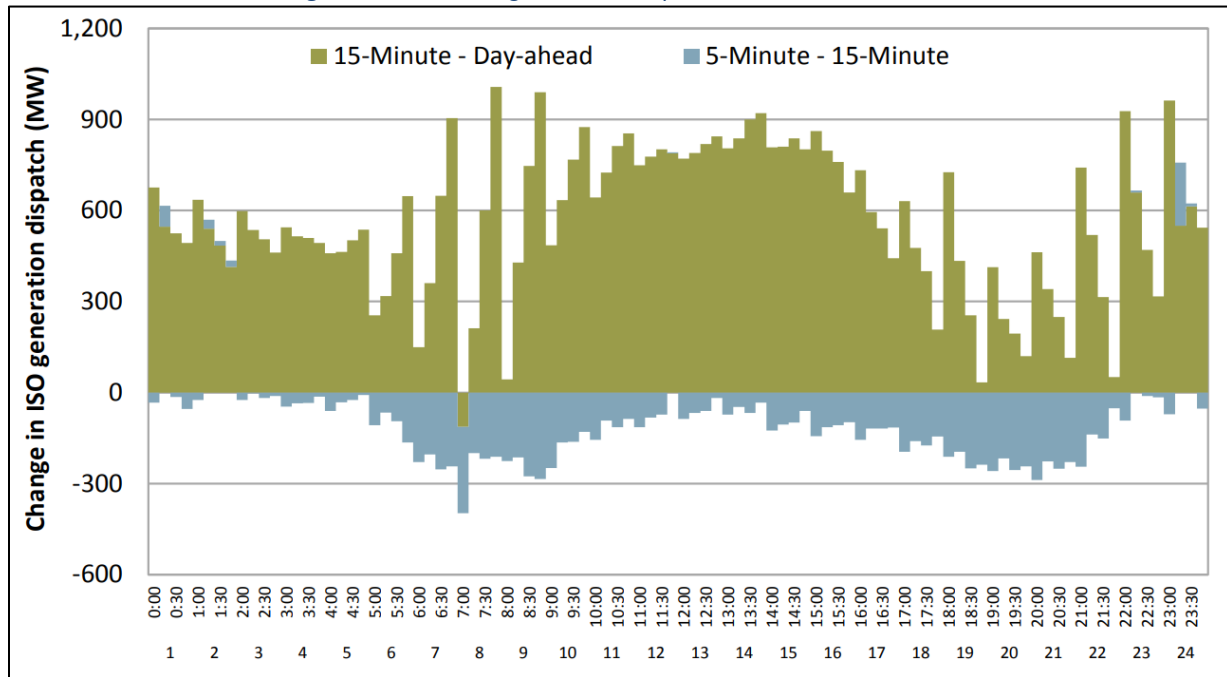
Impact on Internal Resources

Scheduling supply on a fifteen-minute basis in the day-ahead market -- including Pacific Northwest hydroelectric generation -- will free up significant intra-hour ramping capability for ISO internal resources. The ISO internal resources will then have more flexibility to be used to meet uncertainty that materializes between the day-ahead and real-time markets as opposed to being needed to address granularity differences between intervals.

The CAISO's Department of Market Monitoring (DMM) has analyzed the impact of day-ahead hourly scheduling on internal resources. **Figure 3** provides that analysis and displays the average incremental change for internal resources between the day-ahead and real-time market. The green bars represent the change between the day-ahead and fifteen-minute market. The blue bars represents the change between the fifteen-minute market and the five-minute market.

³ 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 fifteen-minute market through static imports and exports. However, the majority of the hydro fleet is scheduled in the day-ahead market.

Figure 3: Imbalance generation dispatch volume, CAISO 2018.



Source: Annual Report on Market Issues and Performance⁴

This data shows the real-time fifteen-minute market is largely responsible for dispatching generators to compensate for under-procurement or over-procurement from the hourly day-ahead market. For example, HE22 (the end of the evening load pull) on average requires the fifteen-minute market 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 day-ahead scheduling results in large amounts of imbalance generation that must be procured in the real-time market. 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 and free up internal generators to have more flexibility to respond to uncertainty that materializes.

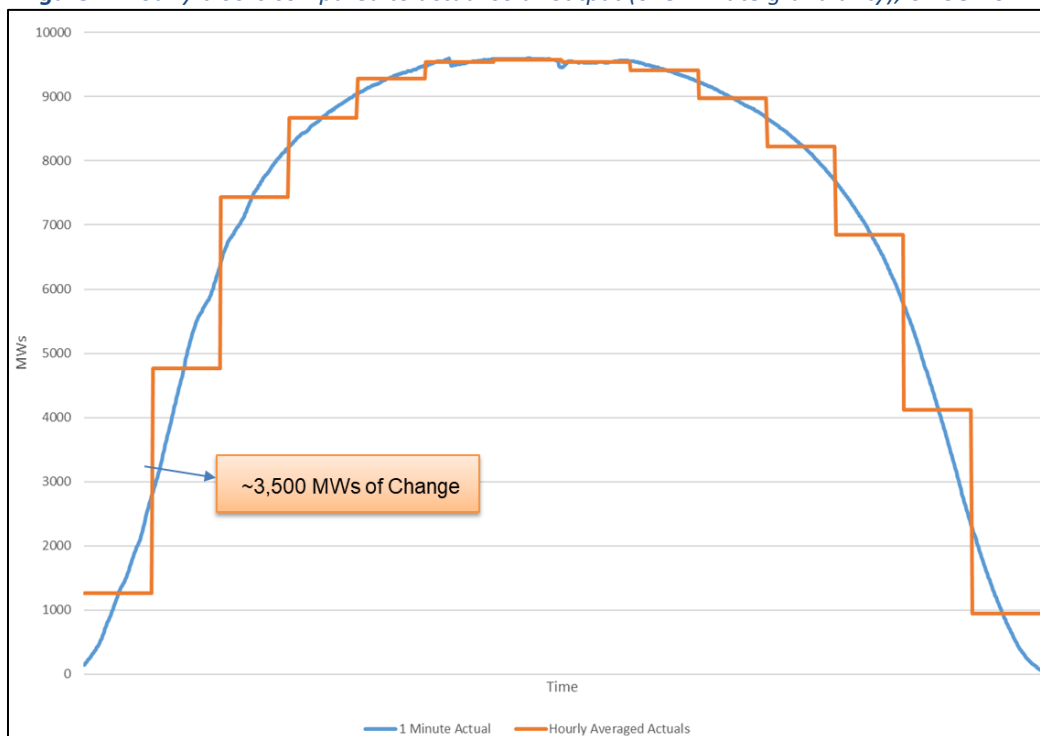
⁴ The DMM 2017 Annual Report on Market Issues and Performance can be referenced at: <http://www.caiso.com/Documents/2017AnnualReportonMarketIssuesandPerformance.pdf>.

Impact on Renewable Resources

Moving to fifteen-minute granularity in the day-ahead market will allow the CAISO to better reflect renewable schedules. This change eliminates the need for traditional generators (*i.e.*, steam plants or multi-stage generators) to be largely responsible for addressing the granularity differences that occur across the hour.

Data presented in **Figure 4** was compiled by the ISO's forecasting team and presents solar data scheduled in hourly blocks compared to actual solar output (one-minute granularity). During the morning ramp, solar output increases quickly and dramatically. During the evening ramp, solar output decreases in a similar fashion. As shown in the data, there is approximately 3500 MW of solar output that may increase (or decrease) from one hour to the next. The CAISO current schedules solar (and all other supply) at a single value for the entire hour. During the morning, this results in the day-ahead market scheduling a ~1750 MW surplus at the beginning of the hour, the perfect amount at the midpoint of the hour, and a ~1750 MW shortage at the end of the hour.

Figure 4: Hourly blocks compared to actual solar output (one-minute granularity), CAISO 2017.



This data further demonstrates that day-ahead market hourly block procurement does not adequately match the changes of the solar ramp-up during the morning, as well as the ramp-down during the evening. Moving to fifteen-minute scheduling in the day-ahead market will allow the ISO to better shape renewable schedules over the morning and evening peaks.

2.2. Fifteen-Minute Bidding

Day-Ahead Market

The CAISO proposes to introduce fifteen-minute bidding granularity in both the day-ahead and real-time markets. This change from hourly to fifteen-minute bidding will align with the proposed fifteen-minute scheduling granularity.

In the DAME Phase 1 second revised straw proposal, the CAISO proposed to move the bid submission timeline from the current deadline of 10:00 AM up to 9:00 AM. This additional hour is needed for the CAISO's market to solve considering the number of intervals has quadrupled (currently 24 hourly intervals, proposed 96 fifteen-minute intervals). In response to stakeholder feedback and in order to capture real-time gas trades (which are used to update reference level adjustments), the CASO has shifted the bid submission deadline by 30 minutes.

The CAISO now proposes a 9:30 AM bid submission deadline for the day-ahead market. By 9:30 AM on the day prior to the trade date, scheduling coordinators will submit 96 bid curves into the day-ahead market. A scheduling coordinator can elect to maintain the same bid curve for all four intervals of the hour. Fifteen-minute bidding will be allowed for all resources participating in the day-ahead market: bid-in load, generation, virtual supply and virtual demand.

Scheduling coordinators requested fifteen-minute bidding granularity during the stakeholder process because it will enable suppliers to reflect fuel costs, particularly for natural gas that may change during an hour. Additionally, fifteen-minute bidding granularity eliminates the need to allow scheduling coordinators to shape load and intertie hourly bids using a forecast submitted to the CAISO. Since the fifteen-minute bids submitted can reflect changes in the upper economic limit of the bid curve, additional forecast information is not needed.

Because the bid submission deadline has shifted by 30 minutes in comparison to the previous proposal, the CAISO also needs to shift the market publication time by 30 minutes. The CAISO proposes publishing results for the day-ahead market at approximately 1:30 PM (13:30), instead of the current posting time of 1:00 PM (13:00).

Real-Time Market

The CAISO proposes to also move from hourly to fifteen-minute bidding in the real-time market. The bid submission deadline will remain 75 minutes prior to the operating hour. Scheduling coordinators will submit 4 bid curves for the upcoming hour. The same fifteen-minute bid curve that is used for the FMM will be used in the corresponding three real-time dispatch intervals. Variable energy resources will continue to have the upper portion of the bid curve adjusted based upon the rolling 5-minute forecast.

2.3. Unit Commitment

Ideally, the CAISO would allow the day-ahead market to commit resources at the start of every fifteen-minute interval. However, achieving this goal would quadruple the number of binary variables used in the day-ahead market unit commitment process. The CAISO's technology team has explained that this is not feasible given the day-ahead market time horizon of 96 fifteen-minute intervals and is a primary reason why the CAISO needs an additional hour for the day-ahead market to solve.

The CAISO technology department has identified alternate unit commitment options. These options are presented below from the most ideal, to the least. It is important to clarify that these options impact the unit commitment process for resources, but do not impact the ability for resources to be scheduled on a fifteen-minute basis as described in the previous sections. The CAISO plans to complete the technology feasibility assessment by March 2019 to solidify the implementation solution.

- ~~1. Full fifteen minute unit commitment~~
- ~~2. Fifteen minute unit commitment for resources with a start up time less than one hour.
Hourly commitment for resources with a start up time greater than one hour.~~
3. Hourly unit commitment for all resources, including MSG transitions.

The CAISO has already determined that option #1 and option #2 are not feasible and is currently pursuing option #3. Option #3 will allow for the commitment of all resources and the transition of multi-stage generators (MSGs) at the beginning of every operating hour.

2.4. Fifteen-Minute Residual Unit Commitment (RUC)

The residual unit commitment (RUC) process runs after the integrated forward market (IFM). The residual unit commitment process clears additional capacity to meet the CAISO's demand forecast. Currently, the residual unit commitment uses an hourly demand forecast. To accommodate fifteen-minute day-ahead scheduling, the CAISO proposes to forecast demand in fifteen-minute increments and use this forecast in the residual unit commitment process.

The residual unit commitment process will continue to run after the integrated forward market, and will move from hourly granularity to fifteen-minute granularity. The RUC process will ensure physical supply can meet the CAISO fifteen-minute load forecast.

Another purpose of the residual unit commitment is to make adjustments for under-scheduled variable energy resources (variable energy resources that are not scheduled into the day-ahead market by the scheduling coordinator). Because the CAISO anticipates the variable energy resources will generate in real-time, an adjustment must be made to ensure the residual unit commitment so it does not over-commit other supply resources. Accordingly, this adjustment process will use a fifteen-minute forecast of variable energy resource output.

For resource adequacy resources, the RUC availability bids will remain at \$0.00/MWh and will be submitted by the scheduling coordinators for each fifteen-minute interval. The CAISO will keep the \$0.00/MWh bid for resource adequacy resources until the implementation of the extended day-ahead market (EDAM), at which time resource adequacy will be able to bid at a non-zero price.

The CAISO clarifies that hourly block imports and hourly block demand resources are eligible to receive residual unit commitment awards. For example, assume the difference between the reliability demand forecast and the cleared physical supply from the integrated forward market is as follows: 10:00-10:15 = 100 MW, 10:15-10:30 = 150 MW, 10:30 – 10:45 = 200 MW, and 10:45 – 11:00 = 250MW. While the shortfall differs for each 15-minute interval, hourly block interties and hourly block demand response could address 100 MW of the shortfall over the operating hour.

2.5. Intertie Bidding and Scheduling Options

Similar to internal resources, imports and exports will be able to bid and schedule with fifteen-minute granularity. Imports and exports will select either a fifteen-minute or hourly block scheduling option through their energy bid. This applies to both system resources defined in the Master File and non-resource specific system resources utilizing transaction IDs. The import/export resource cannot change the scheduling option between the day-ahead and real-time market. The CAISO will develop business rules (likely in the SIBR – Scheduling Infrastructure and Business Rules – application) to validate that the scheduling option is maintained from day-ahead into the real-time market.

The CAISO proposes to continue allowing hourly block bidding of imports and exports. The hourly block bidding option ensures the import or export has the same schedule for all fifteen-minute intervals in the operating hour. Hourly block imports and exports can be re-optimized in the real-time market by the hour ahead-scheduling process. The hour ahead scheduling process will result in an hourly real-time schedule for hourly block resources; however, the prices at which imbalances from the resource's day-ahead schedule will be settled will be determined in the fifteen-minute market. The CAISO is not proposing any change to the real-time settlement of hourly block schedules.

Imports or exports seeking hourly schedules in the day-ahead market and participation in the fifteen-minute market should register as a fifteen-minute resource and submit the same self-schedule into the day-ahead market for all fifteen-minute intervals in the operating hour. For intertie resources that can be scheduled in fifteen-minute granularity in the day-ahead market, but cannot be re-optimized in the fifteen-minute market, the scheduling coordinator will have the option to self-schedule the day-ahead awards into the real-time market.

The CAISO is proposing to eliminate the option for single schedule changes within an hour (also known as “once change”) in the real-time market, as scheduling coordinators rarely use this bidding option today. Removing this option will simplify day-ahead fifteen-minute scheduling implementation, since the CAISO will not need to develop this bidding option for the day-ahead market.

2.6. Inter-Scheduling Coordinator Trades

Inter-scheduling coordinator (SC) trades are a mechanism that scheduling coordinators use to trade energy, ancillary services, and uplift obligation financial settlements. Inter-SC trades do not affect the market optimization or resource scheduling. The CAISO proposes to change inter-SC trades from an hourly trade to a fifteen-minute interval trade.

Inter-SC trades of energy may be aggregated at price nodes (PNodes) or submitted as “physical trades” of energy. Inter-SC trades of energy in both the day-ahead and real-time markets are currently settled on an hourly-basis. In the real-time market, inter-SC trades of energy are settled at the simple average of the four applicable fifteen-minute intervals at the locational marginal prices. 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 28.1.6.⁵ 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 energy quantities (in MWh) of physical trades are confirmed through the post-market confirmation and settled at the locational marginal price of the relevant PNode, while all energy quantities of physical trades that are reduced during the post-market confirmation, are settled at the relevant generation trading hub price.

Currently, trades are submitted for a single hourly inter-SC trade, no later than 45 minutes before the hour. This proposal will allow energy and ancillary service obligation trades to occur on a fifteen-minute interval basis. Real-time inter-SC trades will be submitted 45 minutes prior to each interval in the fifteen-minute market. The grid management charge (GMC) for inter-SC trades is currently \$1.00 per trade. The CAISO proposes to divide this rate into four intervals, resulting in a GMC rate of \$0.25 per trade.

Allowing fifteen-minute inter-SC trades will address concerns of variable energy resource owners that if the forecast used in FMM within the hour is lower than the submitted hourly inter-SC trade quantity, then the financial trade settles at the trading hub but the physical trades are settled at the resource’s locational marginal price. Fifteen-minute inter-SC trades will enable scheduling coordinators of variable energy resources to establish an inter-SC trade quantity using a fifteen-minute forecast closer to the actual flow in a given fifteen-minute interval.

2.7. Load Meter Submission

Under current market rules, actual load can be submitted by scheduling coordinators in either fifteen-minute or hourly granularity, depending on the underlying granularity of the meters. If a load scheduling coordinator’s meters measures with fifteen-minute granularity, data can be submitted with fifteen-

⁵ Tariff section 28.1.6: http://www.aiso.com/Documents/Section28_InterSCTrades_May1_2014.pdf.

minute granularity. If a load scheduling coordinator's meters measure with hourly granularity, the data can be submitted with hourly granularity. If some of the load scheduling coordinator's meters measure in fifteen-minute granularity and others are hourly, the scheduling coordinator must submit all of the meter data in hourly granularity. Examples are provided in **Table 2** below:

Table 2: Scheduling Coordinator Meter Granularity and Data Submission

	Load Scheduling Coordinator 1	Load Scheduling Coordinator 2	Load Scheduling Coordinator 3
Meter Granularity	15-Minute	Hourly	Mixed
Submitted Data	15-Minute	Hourly	Hourly

When load serving entity scheduling coordinators elect to submit hourly load, the CAISO will shape hourly submissions into fifteen-minute granularity using a linear ramp from mid-point to mid-point between hourly meter values. Scheduling coordinators will specify in the Master File if they elect to use the shaping methodology for hourly meters. This will allow the CAISO to distinguish between load meter data that is based on actual 15-minute meter data and load meter data that has been shaped from hourly meter data. Table 3 below provides an example of this approach.

Table 3: Shaped Hourly Load Meter

	HE 10				HE 11				HE 12			
Hourly Meter (MWh)	1000				1200				1400			
	HE 10				HE 11				HE 12			
	Int 1	Int 2	Int 3	Int 4	Int 1	Int 2	Int 3	Int 4	Int 1	Int 2	Int 3	Int 4
15-Minute Shaped (MW)	-	-	1025	1075	1125	1175	1225	1275	1325	1375	-	-
15-Minute Shaped (MWh)	-	-	256	269	281	294	306	319	331	344	-	-

2.8. Ancillary Services

Currently, ancillary services are procured hourly in the day-ahead market and are procured every fifteen-minutes in the real-time market. This initiative proposes that the CAISO will procure ancillary services in fifteen-minute granularity in both the day-ahead and real-time markets.⁶

The CAISO also proposes shifting ancillary services procurement, settlement, obligation, and cost allocation from the existing hourly granularity to fifteen-minute granularity in the day-ahead market.

⁶ The CAISO is not proposing to allow for the re-optimization of ancillary services in the real-time market as a part of the DAME 1 initiative. This concept will be discussed as a part of the DAME Phase 2 initiative.

Appendix K of the CAISO tariff requires spinning and non-spinning reserves to sustain output for thirty minutes, which applies even if a resource is not scheduled to provide spinning or non-spinning reserves in subsequent fifteen-minute intervals.⁷ The changes described below align with this tariff requirement.

Ancillary Services on Interties

The CAISO proposes that ancillary services on the interties only be procured in the day-ahead and real-time markets from resources that can also be scheduled with fifteen-minute granularity. Therefore, only fifteen-minute dispatchable and dynamic/pseudo type intertie resources are eligible to provide ancillary services on the interties. In order to accommodate the delivery of energy, if the awarded ancillary services resource is called upon, the CAISO proposes to automatically update the e-tag energy profile to match the award if it is dispatched for energy during a contingency event.

Hourly block intertie resources will no longer be eligible to provide ancillary services because hourly block scheduling would require contingency dispatches to be held for the remainder of the hour, even if the additional supply is no longer needed to address the contingency event.

Non-Generator Resources Providing Ancillary Services

Currently, the CAISO requires day-ahead regulation up and regulation down awards for non-generator resources to be supported by a state of charge equal to the hourly duration of the award. Since regulation up can cascade to spinning reserves, the ISO will require that the resource have a state of charge sufficient to support 30 minutes of dispatch. The CAISO proposes to implement a resource constraint in the real-time market to ensure the state of charge supports ancillary service awards. Since regulation down cannot cascade to other ancillary services, the state of charge will be required to support fifteen minutes of charging to be awarded regulation down, which is equal to the duration of the fifteen-minute award.

Single Dynamic Ramp Rate

The CAISO proposes that ancillary services and energy will be awarded using a single dynamic operational ramp rate (as provided in the Master File), limited by certified ancillary services capacity. The regulation ramp rate used in the automated generator control (AGC) can be lower than the dynamic ramp rate. If a contingency event occurs, spinning and non-spinning reserves, as well as regulation

⁷ Appendix K of the CAISO Tariff:
http://www.caiso.com/Documents/AppendixK_AncillaryServiceRequirementsProtocol_ASRP_asof_Nov1_2017.pdf.

resources will be dispatched using a dynamic ramp rate. Deviations will only occur as a result of a contingency. Plant operators would be unable to override the ramp rate in the EMS system. If the operational ramp rate has changed, an outage management system (OMS)⁸ card must be submitted to allow recognition of the new ramp rate by the market. This will ensure deliverability based on what is awarded in the market.

Self-Provision of Ancillary Services

The CAISO will continue to support self-provision of ancillary services, but will eliminate the existing ancillary services self-provision qualification process that occurs before the market run. Instead, self-provision of ancillary services will be co-optimized with the energy, bid-in ancillary services, and the flexible ramping products, using penalty prices for ancillary service self-provision. This approach will provide the necessary scheduling priority and result in a more efficient market solution and will eliminate an antiquated feature that has increasing the CAISO ongoing maintenance costs. Necessary modifications for this enhancement will be conducted through changes to the CAISO's internal processes and will not directly impact scheduling coordinators.

2.9. Market Power Mitigation

Market power mitigation will be evaluated on a fifteen-minute interval basis in the new day-ahead market. This will align mitigation with the new fifteen-minute scheduling in the day-ahead market. The local market power mitigation enhancements (LMPME) initiative⁹ further explores options for improving local market power mitigation in the real-time market, such as the consideration of no longer mitigating for the balance of the hour.

⁸ Information on the CAISO's outage management system is posted here:
<http://www.aiso.com/market/Pages/OutageManagement/Default.aspx>.

⁹ Information related to the Local Market Power Mitigation Enhancements initiative is posted here:
<http://www.aiso.com/informed/Pages/StakeholderProcesses/LocalMarketPowerMitigationEnhancements2018.aspx>.

2.10. Ramping Energy Calculation Modifications

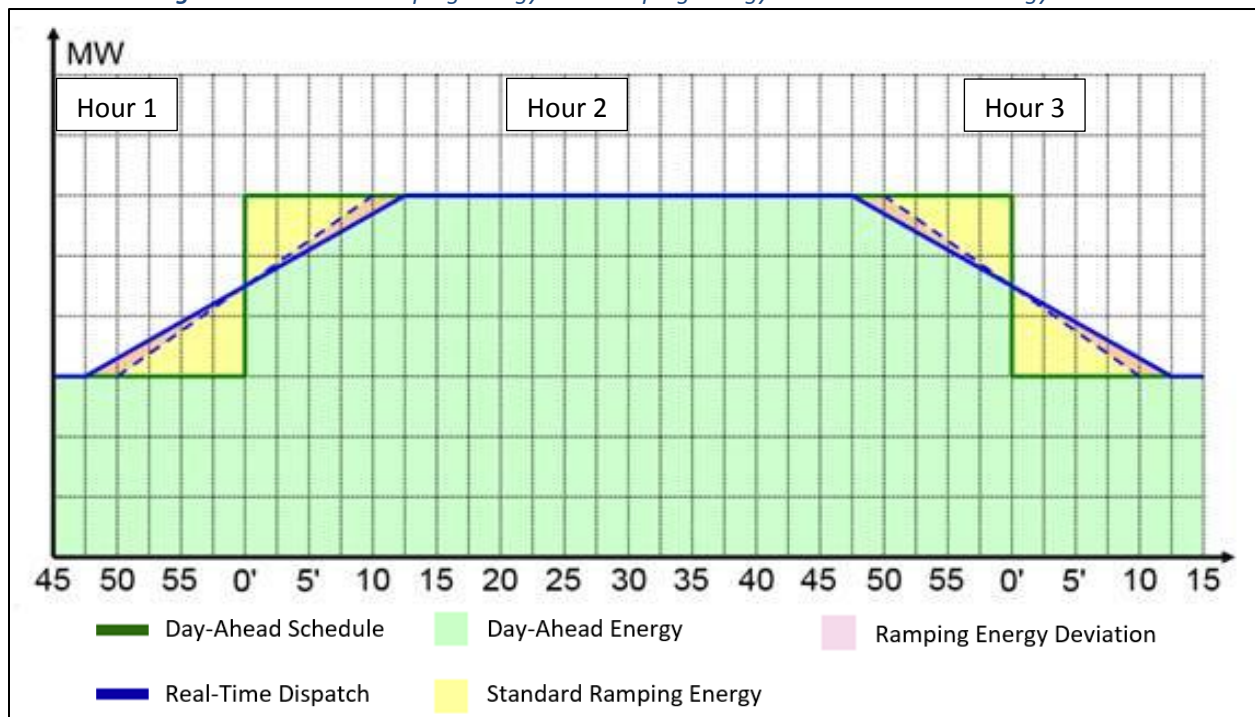
Expected energy calculation changes are required as a byproduct of changing to fifteen-minute day-ahead schedules. For the most part, these will be settlement formula revisions to account for the change in scheduling granularity. However there will be more significant changes required to both the standard ramping energy and ramping energy deviation energy classifications the CAISO uses in settlements.

The primary objective of the standard ramping energy classification is to insulate scheduling coordinators from real-time market charges if they do not participate in the real-time market, but instead follow their day-ahead market schedule. The CAISO prescribes schedule change ramps that, if followed, will avoid exposure to imbalance energy charges in the real-time market. Standard ramping energy represents the energy produced or consumed by this “standard” symmetrical ramp of a resource over 20 minutes between two hourly day-ahead schedules. Standard ramping energy is not settled.

Ramping energy deviation represents energy produced or consumed if a resource is not able to follow this standard ramp. Standard ramping energy and ramping energy deviation are currently calculated for all resources whose day-ahead energy schedule has changed between two consecutive hours.

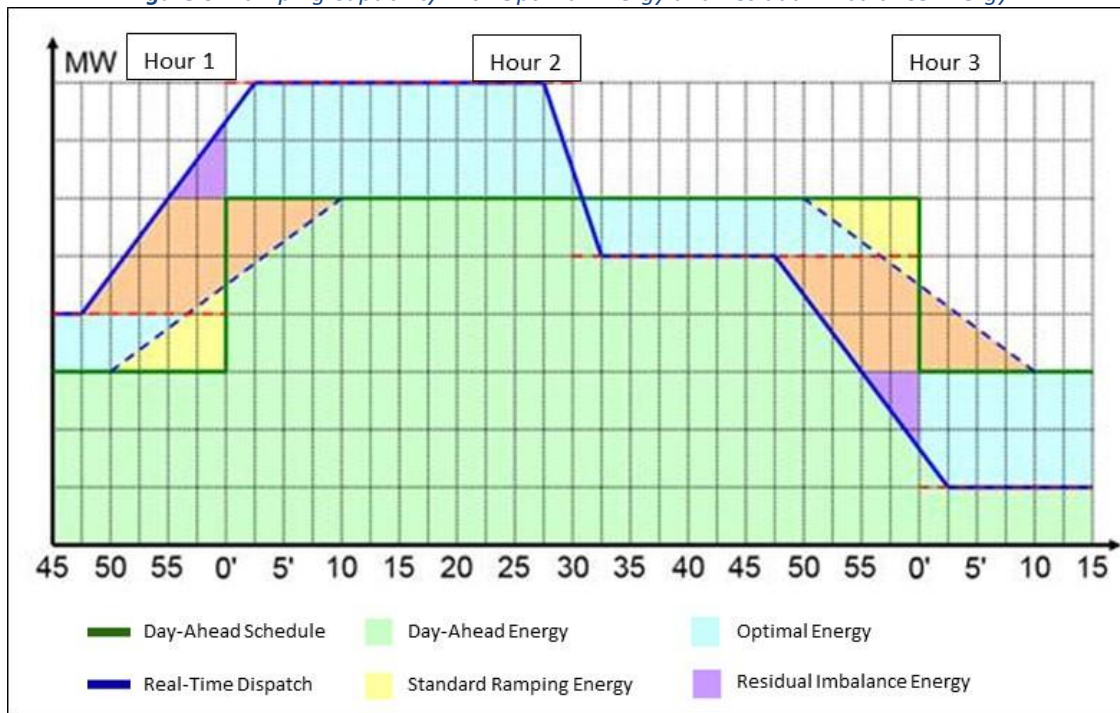
Figure 5 below shows graphically the existing calculation of standard ramping energy and ramping energy deviation for a resource that does not have energy bids and is self-scheduling in order to be dispatched between the day-ahead schedules over a portion of a three-hour period. In this example the resource’s ramping capability allows for a change in schedule over a 25-minute period. Accordingly, the symmetrical ramp between the day-ahead schedule starts at minute 47.5 in the previous hour and ends at minute 12.5 in the following hour. Standard ramping energy is represented by the yellow triangular areas consisting of energy produced or consumed by a dispatch between hourly day-ahead schedules using a 20 minute ramp between minute 50 in Hour 2 and minute 10 in Hour 3. Ramping energy deviation is represented by the pink cross sections consisting of the deviation energy produced or consumed by a dispatch between hourly day-ahead schedules at a slower (25 minute) ramp than the standard ramp.

Figure 5: Standard Ramping Energy and Ramping Energy Deviation with No Energy Bids



Standard ramping energy and ramping energy deviation are both currently calculated for resources that are dispatched optimally with energy bids, as shown in **Figure 6** below. Specifically, the resource represented is economically dispatched to various operating points, based on its real-time market energy bid, with consideration for the resource’s ramping capability. In addition to the day-ahead energy, standard ramping energy and ramping energy deviation elements shown in the previous example, optimal energy (shown in light blue), and residual imbalance energy (shown in purple) would be expected for a resource that is participating in the real-time market. The dashed red line shows the economic point of operation if the resource was not ramp limited.

Figure 6: Ramping Capability with Optimal Energy and Residual Imbalance Energy



For resources that do not participate in the real-time market, the CAISO proposes to retain standard ramping energy and ramping energy deviation. For resources participating in the real-time market, standard ramping energy and ramping energy deviation will not be calculated. Instead energy that was previously calculated as standard ramping energy and ramping energy deviation would be classified under other existing energy types (such as optimal energy and residual imbalance energy) and will be settled and eligible for bid cost recovery. This treatment is appropriate, since these participating resources should be compensated appropriately for energy produced or consumed for instructed deviations from their day-ahead schedules.

For resources that are not participating in the real-time market, the CAISO proposes that standard ramping energy will continue to be based on a 20 minute ramp for cross-hour schedule changes (15-minute schedules between hours) from -10' to +10'. However, for intra-hour schedule changes (15-minute schedules within the hour) the ramp shall be 10 minutes, from -5' to +5'. The 10 minute ramping period is used to match the standard 10-minute ramp for intra-hour intertie schedule changes, thus reducing the potential need for flexible ramping capacity. Ramping energy deviations will continue to be calculated for dispatch operating point deviations from standard ramping energy, due to resource's ramp rate limitations. **Figure 7** illustrates how standard ramping energy and the ramping energy deviation would be calculated for a resource with intra-hour schedule changes with a ramp rate limitation, preventing a 10 minute ramp between the third and fourth interval of Hour 2.

The current approach of excluding Residual Imbalance Energy in bid cost recovery will remain unchanged. However, the CAISO proposes to use the locational marginal price the resource is ramping into regardless of the reference interval bid.

Figure 7: Standard Ramping Capability and Ramping Energy Deviation for Intra-Hour Schedule Changes

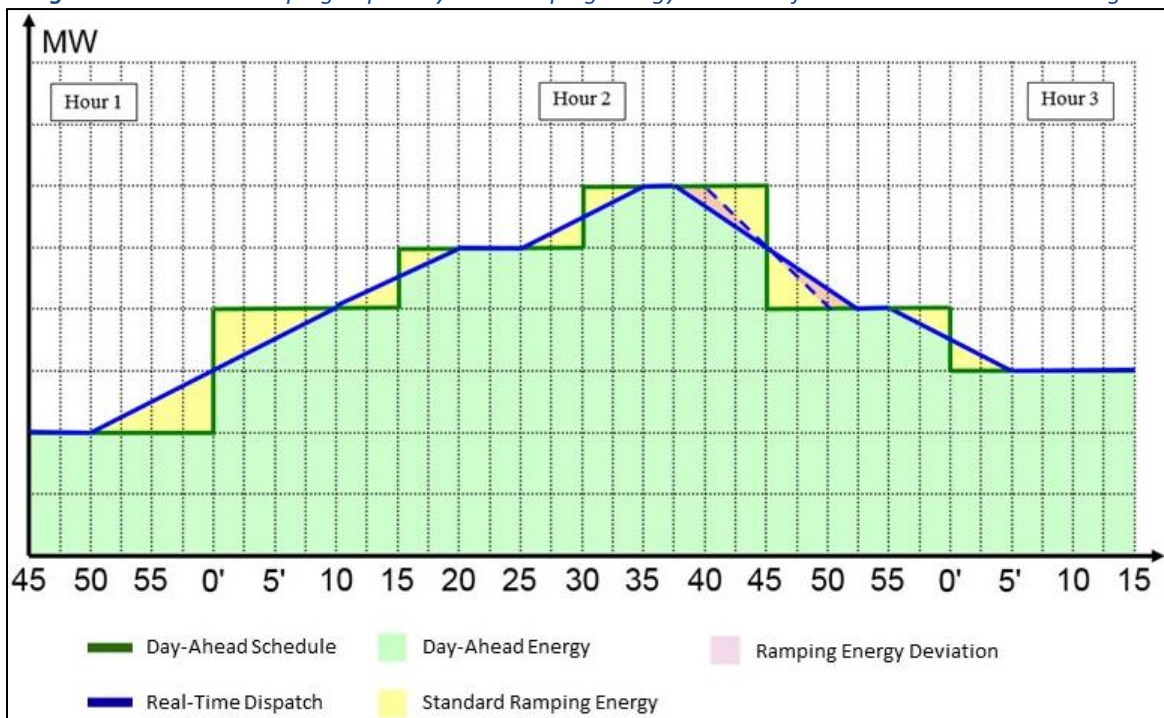
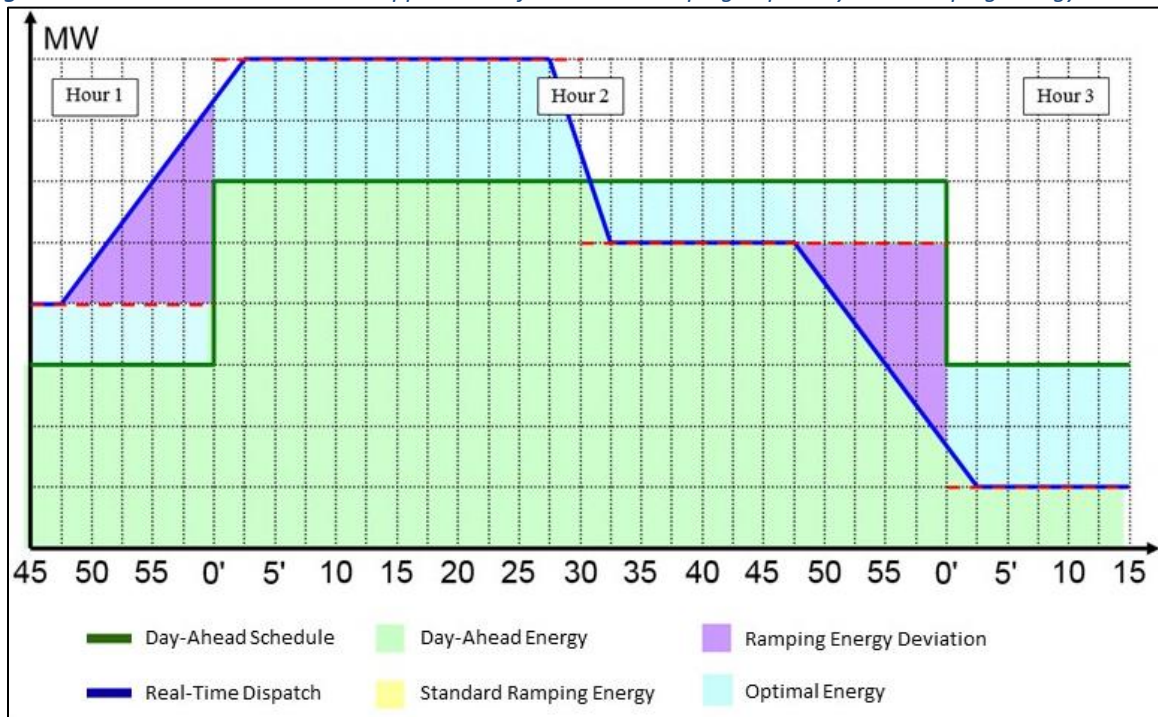


Figure 8 shows how expected energy may be calculated for resources that are participating in the real-time market. In this instance, standard ramping energy and ramping energy deviation no longer apply. For illustration purposes the same dispatch scenario is shown in the second diagram.

Figure 8: Real-Time Market without Application of Standard Ramping Capability and Ramping Energy Deviation



2.11. Demand Response

The CAISO received Board approval, as part of the *Energy Storage and Distributed Energy Resources* (ESDER3) initiative,¹⁰ to implement two additional scheduling options for demand response resources which recognize that the resource cannot respond to the five-minute real-time dispatch, but nonetheless can be dispatched in real time if additional notification time of binding awards can be provided.

Eligible Demand Response Resources in Day-Ahead Market

All demand response models can participate in the fifteen-minute day-ahead market. In the Master File, the resource will select the appropriate model based upon the notification time needed in the real time

¹⁰ The *Energy Storage and Distributed Energy Resources* initiative is available here: http://www.caiso.com/informed/Pages/StakeholderProcesses/EnergyStorage_DistributedEnergyResources.aspx.

market: hourly, fifteen-minute, or five-minute. In the day-ahead market, the hourly block option will be scheduled if the resource is economic over the four fifteen-minute intervals of the operating hour, not whether an individual fifteen-minute interval is economic. The fifteen-minute and five-minute resources are able to submit four different bid curves for each operating hour and can have different schedules for each fifteen-minute interval in the operating hour.

Baseline Duration

Currently, the baseline duration used for the net benefits test is hourly to align with the scheduling and bidding granularity of the hourly day-ahead market. The CAISO proposes to modify the baseline calculation to align with the scheduling/bidding granularity of the demand response resource. Hourly block resources will continue to have the baseline calculated hourly. For fifteen-minute and five-minute resources, the baseline will be calculated for each fifteen-minute interval to align with the new fifteen-minute granularity used for day-ahead schedules and bidding.

2.12. Other Design Considerations

The following design considerations are also proposed within this initiative:

- **Administrative pricing rules:** In the event that the fifteen-minute market or real-time dispatch is unable to produce market results, the CAISO will use the relevant day-ahead fifteen-minute interval price.
- **Make-whole payments:** In the event of price corrections, make-whole payments will only be made for Load and hourly block exports. Fifteen-minute bidding exports will be eligible to receive bid cost recovery.
- **Load aggregation point pricing in the real-time market:** Currently, the CAISO calculates a real-time hourly load aggregation point price based upon the weighted average of the fifteen-minute market and real-time dispatch prices based upon the load forecast used to clear the relevant market interval in the operating hour. With the move to a fifteen-minute day-ahead scheduling granularity, the CAISO proposes to calculate a fifteen-minute load aggregation point price based upon the weighted average of the fifteen-minute-market and the three relevant real-time dispatch prices based upon the load forecast used to clear the market intervals during that fifteen-minute period.
- **CRR clawback rule:** Congestion revenue rights will be settled for each fifteen-minute day-ahead interval. In addition, cleared convergence bids will be awarded by fifteen-minute interval and settled at fifteen-minute locational marginal price. Convergence bids are automatically reversed at the fifteen-minute market price for the corresponding real-time fifteen-minute interval. The congestion revenue rights clawback rule will be evaluated for each fifteen-minute interval.

- **Hour Ahead Scheduling Process (HASP) Reversal Rule:** The HASP reversal rule (*i.e.*, “HASP clawback”) is intended to address implicit virtual bidding. The HASP clawback will move from an hourly integrated forward market to a fifteen-minute market comparison to the day-ahead market. This will allow the HASP clawback rule to compare fifteen-minute integrated forward market schedules to fifteen-minute schedules in the real-time market.
- **Resource adequacy must-offer obligation:** The CAISO will continue to insert bids into the real-time market for resource adequacy resources with real-time market must offer obligations. To correspond with the fifteen-minute scheduling granularity and bidding change, the market will automatically input four bids of equal value for the entire hour to meet the resource adequacy must-offer obligation requirement.
- **Resource Adequacy Availability Incentive Mechanism (RAAIM):** The CAISO proposes to assess a resource’s availability based upon fifteen-minute MW availability by comparing resource adequacy capacity obligation with the resource’s fifteen-minute bids. The ISO would average the resources’ fifteen-minute MW availability for all resource adequacy products into a single monthly availability percentage (%) value. The switch to fifteen-minute bidding granularity predicates settlements need to modify assessment calculations hourly to fifteen-minute assessments. For example, generic resource adequacy assessments are currently conducted using five hourly assessment intervals, which will need to change to twenty fifteen-minute assessments in the day-ahead calculation.
- **Existing Transmission Contract Calculator:** The CAISO proposes enabling transmission limits to be established for each fifteen-minute interval. This will allow intertie and path limits to be increased or decreased based on operational needs with fifteen-minute granularity, if needed.

3. Fifteen-Minute Granularity Impacts to the Energy Imbalance Market

The energy imbalance market (EIM) extends the CAISO's real-time market to other balancing authority areas (BAA) in the West. Prior to the start of the real-time market, each EIM entity submits 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 CAISO's hourly day-ahead schedules, which were the reference point for imbalance energy. Since the CAISO is proposing to move to fifteen-minute granularity for the day-ahead market, the CAISO proposes to also change the EIM base schedule granularity from hourly to fifteen-minute. If an EIM entity wanted to continue to submit hourly base schedules, this would be done by submitting the same value base schedule for all four intervals of the operating hour. The change to fifteen-minute base schedules will also require modifications to other elements of the EIM design as discussed below.

3.1. Resource Sufficiency Evaluation

The CAISO performs a series of tests – known as the Resource Sufficiency Evaluation – on an hourly basis to determine if a BAA is “leaning” on the EIM for capacity, flexibility or transmission. The resource sufficiency evaluation examines balancing, capacity, and flexible ramping capabilities. The CAISO proposes to modify the frequency of the resource sufficiency evaluation from an hourly basis to a fifteen-minute basis.

If a BAA passes the resource sufficiency evaluation, it can participate in the energy imbalance market and will have access to other resources in the EIM footprint to economically meet load and ramping needs. If the BAA fails the resource sufficiency evaluation for a given fifteen-minute interval, the EIM transfer limits will be set by the market operator such that incremental transfers cannot occur in that fifteen-minute interval in the direction of the BAA that failed the test. Accordingly, the BAA must rely solely on its own resources to meet imbalances and ramping.

Currently, when a BAA fails any of the resource sufficiency evaluation tests, transfers are limited for the entire operating hour. Moving forward, the CAISO proposes to evaluate each test on a fifteen-minute interval basis and limit transfers only the corresponding fifteen-minute interval in which a failure occurred, as opposed to limiting transfers for the entire hour in which a failure occurred.¹¹ For example: if the BAA fails the upward test for a given fifteen-minute interval, then imports into that BAA are limited during that fifteen-minute interval to the previous fifteen-minute market transfer quantity. If the

¹¹ The CAISO is completing business practice manual changes to implement 15-minute testing for the flexible ramping test and the capacity test. For additional information related to these changes, reference the EIM Resource Sufficiency Evaluation Enhancements materials available at: <http://www.caiso.com/informed/Pages/MeetingsEvents/MiscellaneousStakeholderMeetings/Default.aspx>.

BAA fails the downward test for a given fifteen-minute interval, then exports out of that BAA are limited during the fifteen-minute interval to the previous fifteen-minute market transfer quantity.

Implementation of the fifteen-minute resource sufficiency evaluation tests will require the following policy changes:

- Base schedules will need to be submitted with fifteen-minute granularity instead of hourly granularity.
- The histogram of inertia declines used in the capacity test will utilize fifteen-minute data. The incremental requirement is currently calculated using hourly decline data. Going forward, the CAISO proposes to use 15-minute data to develop the histogram of inertia declines. However, the incremental requirement will be set for each operating hour. The requirement will be the same for all four 15-minute intervals in the operating hour.

3.2. Over and Under Scheduling Charges

The intent of the over and under scheduling charges¹² is to ensure that EIM BAAs have sufficient supply to independently meet energy imbalances. Currently, if the EIM entity uses the CAISO load forecast and the hourly base scheduled load is within 1% of the CAISO load forecast, the EIM BAA is exempt from charges. If the EIM entity uses its own load forecast or has hourly base schedule load that differs from the CAISO 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 2 MWh) 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 no over or under scheduling charges.

The CAISO proposes to modify the determination of whether an EIM entity's load imbalance reaches the penalty thresholds from an hourly evaluation to fifteen-minute evaluation. The fifteen-minute base schedule load forecast will be compared to the fifteen-minute actual load. The minimum load imbalance level will remain 2 MW. The CAISO is not proposing any changes to the percentage thresholds or locational marginal price multipliers of the charge.

¹² 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>

3.3. Settlement of Regulation Energy

The addition of the Sacramento Municipal Utility District (SMUD) to the EIM will necessitate automation of the calculation and settlement of energy resulting from resources that provide regulation-up and down. Energy resulting from providing regulation is currently settled at the real-time dispatch (five-minute) 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 BAAs. Currently, EIM scheduling coordinators can inform the CAISO through a manual dispatch after the market interval has determined the amount of energy that a resource has provided in response to the BAA's regulation signal. This allows the CAISO to then classify the deviations from dispatch as instructed imbalance energy, which does not result in uplift costs being shifted between EIM BAAs.

The CAISO proposes that the hourly resource plan 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 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 CAISO will use this information to automatically calculate regulation energy, which is classified as instructed imbalance energy.¹³ This eliminates the need for the EIM scheduling coordinator to inform the CAISO through a manual dispatch to ensure the deviations are classified as instructed imbalance energy.

¹³ 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>

4. EIM Governing Body Role

The Second Revised Straw Proposal published on August 27, 2018 explained that the appropriate classification for this initiative is **hybrid non-EIM specific** with an additional element that is severable from the remainder of the initiative and is **primary** to the EIM. There is no change to the proposed classification. The rationale for the classification is described below.

While the majority of this proposal involves changes to the CAISO's day-ahead market -- which management agreed would classify as advisory¹⁴ -- this proposal also introduces changes to two EIM-specific rules of the real-time market: fifteen-minute base schedules, and the settlement of regulation energy.

The fifteen-minute base schedule rule change is critical to the core elements of the proposal and must be approved in conjunction with the remainder of the proposal elements. In other words, this rule is not severable from the remainder of the initiative (except for the settlement of regulation energy, discussed below), 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 CAISO market.

The change to the granularity of EIM base schedules is an EIM specific rule and therefore falls within the primary authority of the EIM Governing Body. Accordingly, the CAISO proposes to classify the majority of the initiative as hybrid-non EIM specific. As explained in the Guidance Document, a hybrid non-EIM specific initiative is appropriate "when the driver for 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."¹⁵ In this classification, the EIM Governing Body would need to approve the EIM-specific part of the proposal first, before the entire initiative goes to the Board for approval. The EIM Governing Body would have the option of providing advisory input on the other parts of the hybrid proposal.

The remaining element of the proposal, the settlement of regulation energy ([Section 3.3](#)), is severable from the remainder of the initiative. It introduces an EIM specific rule that eliminates the need for EIM entity scheduling coordinators to inform the CAISO of regulation energy through a manual dispatch. Therefore, this piece of the proposal falls within the primary authority of the EIM Governing Body.

¹⁴ 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 classification recommendation changed in the publication of the *Second Revised Straw Proposal* published August 27, 2018 based on staff's recognition that it was proposing EIM specific rule changes.

¹⁵ <http://www.westerneim.com/Documents/GuidanceforHandlingPolicyInitiatives-EIMGoverningBody.pdf>

To recap, the CAISO would expect to ask the EIM Governing Body to approve both fifteen-minute base schedule submissions and the settlement of regulation energy. The EIM Governing Body would also have the option of providing an advisory opinion to the CAISO Board on the initiative's other elements. If the EIM Governing Body approves the parts it has decisional authority over, the CAISO would ask its Board to approve, with a full discussion, fifteen-minute scheduling granularity changes and fifteen-minute base schedule submission. In addition, the changes to the settlement of regulation energy would be placed on the Board's consent agenda.

Stakeholders are encouraged to submit a response to the EIM classification of this initiative as described above in their written comments following the stakeholder conference call for the Third Revised Straw Proposal, particularly if they have concerns or questions.

5. Stakeholder Engagement

5.1. Schedule

Stakeholder input is critical for developing market design policy. **Table 4** includes the proposed schedule for phase 1 of the Day-Ahead Market Enhancements stakeholder process and includes opportunity for stakeholder involvement and feedback.

Table 4: Schedule for DAME Phase 1

Item	Date
Post Second Revised Straw Proposal for DAME Fifteen-Minute Granularity	August 27, 2018
Stakeholder Conference Call	September 4, 2018
Stakeholder Comments Due	September 18, 2018
Post Third Revised Straw Proposal for DAME Fifteen-Minute Granularity	February 28, 2019
Stakeholder Meeting	March 7, 2019
Stakeholder Comments Due	March 21, 2019
Post Draft Final Proposal	April 9, 2019
Stakeholder Conference Call	April 16, 2019
Stakeholder Comments Due	April 30, 2019
EIM Governing Body Meeting (hybrid non-EIM specific)	June 27, 2019
CAISO Board of Governors Meeting	July 24, 2019
Implementation	Fall 2020

The CAISO proposes to present its proposal to the EIM Governing Body and CAISO Board of Governors on June 27, 2019 and July 24, 2019 respectively.

5.2. Next Steps

The CAISO is committed to providing ample opportunity for stakeholder input into its market design, policy development, and implementation activities. The CAISO requests stakeholders to submit written comments on this Third Revised Straw Proposal by March 21, 2019. Stakeholders should submit written comments to InitiativeComments@caiso.com.