Price Performance in the CAISO's Energy Markets

April 3, 2019

Market Quality & Renewable Integration

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Acronyms

BAA	Balancing authority area
CB	Convergence bid
DAM	Day-ahead market
DOT	Dispatch operating target
ED	Exceptional dispatch
EIM	Energy imbalance market
FMM	Fifteen-minute market
HASP	Hour ahead scheduling pre-dispatch
IFM	Integrated forward market
LMP	Locational marginal price
MCC	Marginal congestion component
MLC	Marginal Losses component
RTD	Real-time dispatch
RUC	Residual unit commitment
SMEC	System marginal energy component
VER	Variable energy resource

Background and scope

The CAISO will be conducting an analysis of certain aspects of price formation in its electricity markets. In this context, the term price formation refers to the underlying principles that define the formation of electricity prices under locational marginal pricing. The Federal Energy Regulatory Commission launched a price formation effort in 2014 to address areas such as scarcity and shortage pricing, fast-start resource pricing, offer bids and caps, among others[1]. The California ISO, like other ISOs and RTOs, actively participated in each of these initiatives.

CAISO stakeholders have also raised concerns about electricity prices in the CAISO markets in various forums and policy initiatives. These concerns have primarily been centered on whether real-time prices adequately reflect constrained system conditions and the fact that real-time prices have trended lower than day-ahead prices. Most recently, the CAISO worked to develop new market rules for intertie energy deviation settlements that raised additional concerns as documented in the CAISO Market Surveillance Committee opinion[2] regarding price formation in the CAISO markets. The main concern consists of price deviations across the different CAISO's markets, which will be the main focus of the CAISO's analysis. This will allow to identify and analyze the dynamics and drivers of the price deviations. The CAISO analysis will not focus on other aspects of price formation such as pricing fast start units. The outcome of this analysis will inform potential action items to address the identified price performance issues.

The analysis will focus on the real-time market for the CAISO balancing area and not on the Energy Imbalance Market (EIM) balancing authority areas specifically. However, the analysis of the real-time market will have lessons for price performance in the EIM as well. The period for analysis will be the calendar year of 2018. Using at least a full calendar year will account for seasonal variations. Some of the concerns raised by stakeholders were more specifically based on previous performance so there may be a need to broaden the analysis period past 2018 to identify any factors that may have exacerbated the recent trend of price performance issues.

Throughout this effort, the ISO will actively engage with market participants to define the scope, and discuss the results of the analysis.

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[1] FERC initiative on price formation can be found at https://www.ferc.gov/industries/electric/indus-act/rto/energy-price-formation.asp

[2] MSC Opinion Intertie Deviation Settlement: http://www.caiso.com/Documents/MSC-OpiniononIntertieDeviationSettlment-Jan18_2019.pdf#search=MSC%20intertie

Identification of price related issues

Based on the CAISO market design for the Day-Ahead Market (DAM) and the Real-Time Market (RTM), prices between these markets are expected to converge to a reasonable degree, subject to changes in system conditions. The level of price convergence across markets, and the degree to which prices reflect actual system conditions are natural indicators of robust price performance in the CAISO markets.

The RTM is composed of a series of sequential sub-markets that are run at different times, granularities, and forward looking horizons. There is a fifteen-minute market (FMM) in which both internal generation and intertie resources can be economically cleared based on submitted bids. The outcome of this market is financially binding for both internal and intertie resources. The FMM runs for a horizon of up to four and a half hours ahead and as short as one hour ahead, and runs approximately 37.5 ahead of the binding interval. For intertie resources participating on an hourly basis, the financially binding schedules are determined in the hour ahead scheduling process (HASP) instead of the FMM. However, the FMM clearing prices are used to settle hourly resources. For internal resources, the FMM schedules are financially binding but they do not set physical operational instructions for energy because they are ultimately subject to the five-minute real-time dispatch (RTD). FMM commitment instructions -start-ups, shutdowns and transitions- are, however, physically and financially binding. In the RTD market, both dispatches and prices are operationally and financially binding. The RTD runs for a horizon of up to one hour and five minutes and runs 7.5 minutes ahead of the binding interval. The CAISO follows a standard multi-step settlements process in which the DAM is settled fully and subsequent markets are then settled incrementally, i.e., FMM schedules settle with respect to the integrated forward market (IFM) awards, and RTD settles with respect to FMM. The CAISO settles the volumetric difference of hourly schedules relative to IFM schedules, based on FMM prices. When prices diverge persistently across the multi-step settlements, there will naturally be incentives for resources to arbitrage across markets. Convergence bidding is intended, in part, to help converge prices between the DAM and RTM.

Prices in the CAISO market consist of three main components – a system marginal energy cost (SMEC), a marginal congestion cost (MCC) and marginal cost of losses (MCL). The SMEC reflects the marginal cost of providing energy to meet demand. The MCC is based on the binding constraints in the system and may vary by location. The MCL reflects the sensitivity of a location on system losses. Price convergence at the system level can be measured using the SMEC, which will illustrate price convergence to meet aggregate supply and demand.

Figure 1 shows the monthly simple averages of SMEC compared across the various CAISO markets. Overall, IFM prices in 2018 tended to be higher than real-time prices for most times of the day, with the largest divergence observed in the summer months. Within the various runs of the real-time market, the trend of price divergence is less extreme and has a less persistent trend as compared to the IFM.

Figure 1: 2018 monthly comparison of average system-wide prices across the CAISO markets

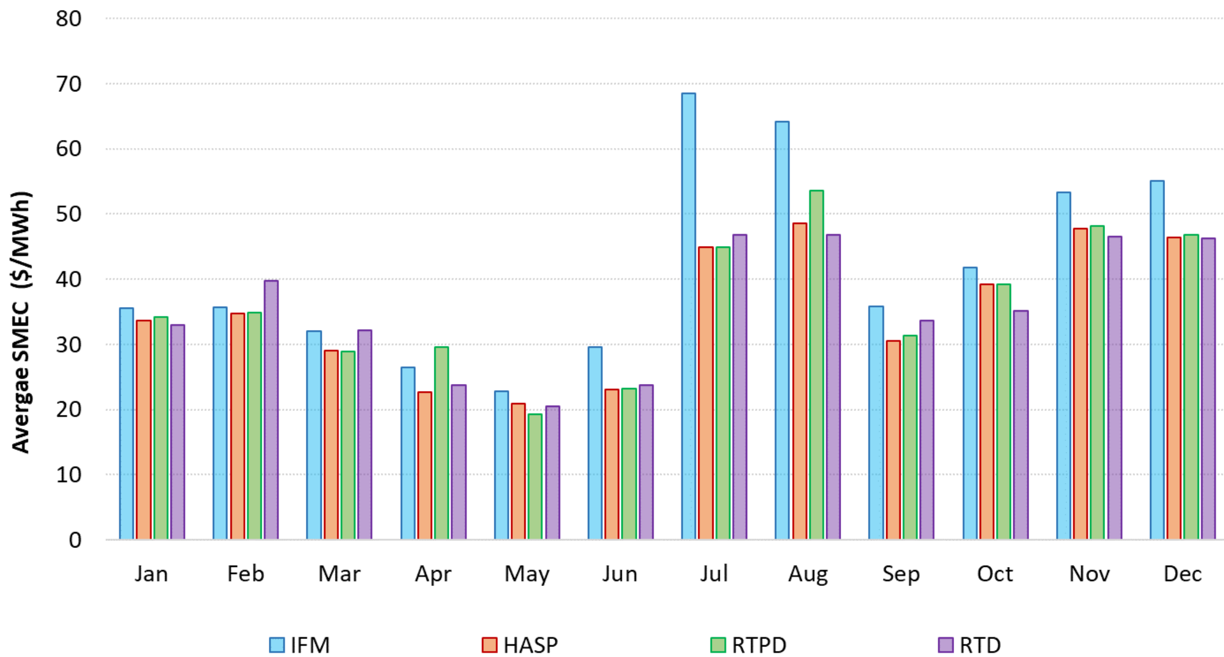
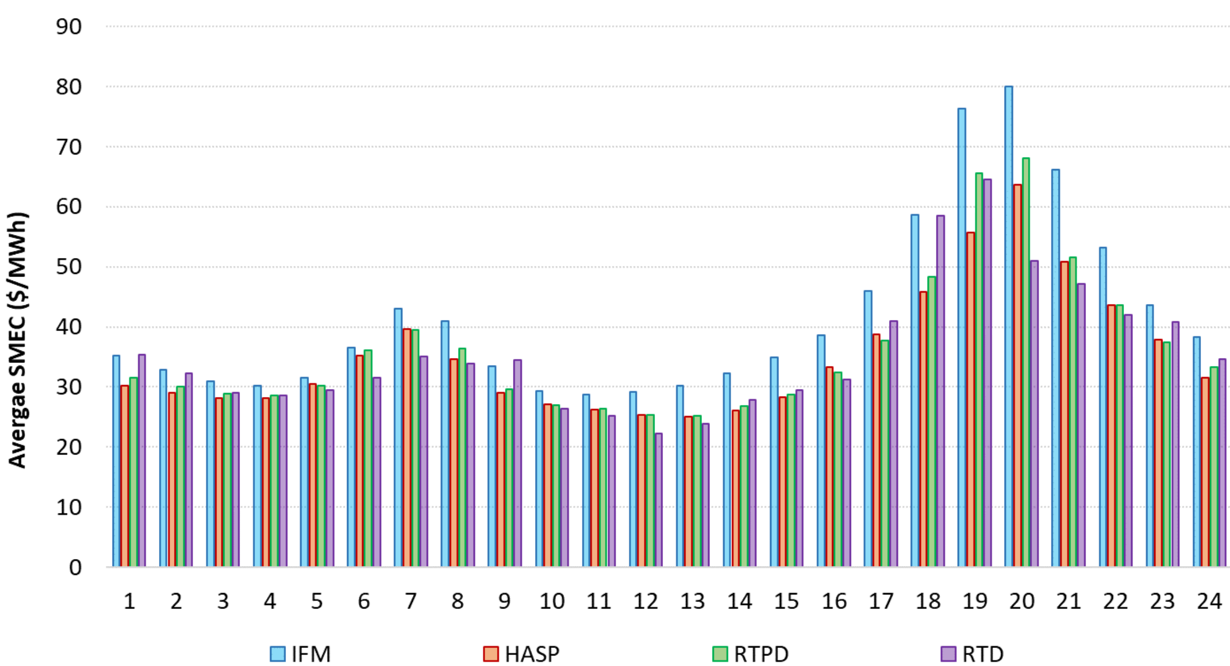


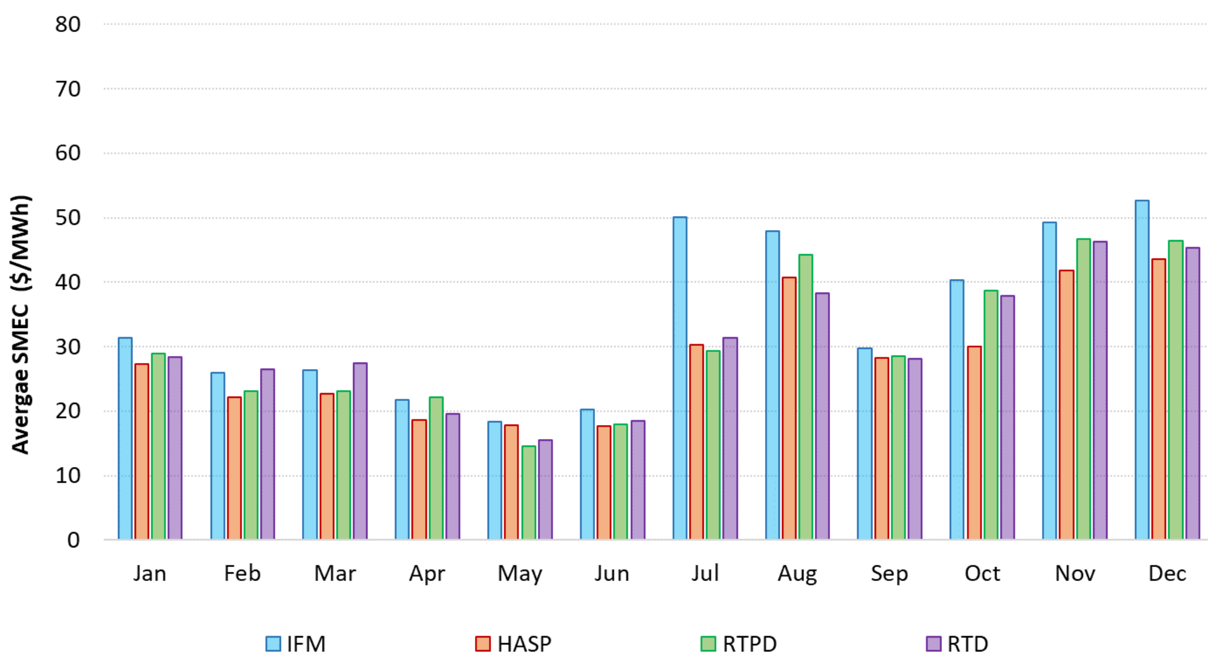
Figure 2 illustrates the price convergence on an hourly profile, which shows that IFM prices are persistently higher than real-time prices and this divergence is more pronounced during peak hours.

Figure 2: 2018 hourly comparison of average system-wide prices across the CAISO markets



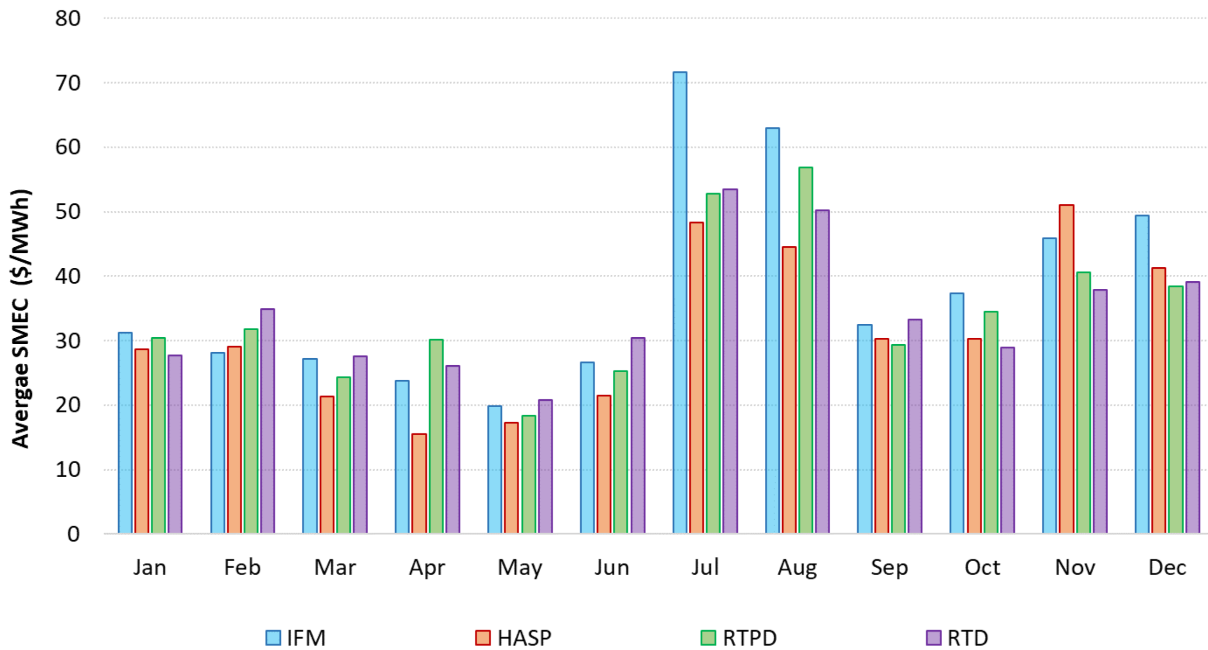
Figures 3 and 4 illustrate price convergence at representative scheduling points for the interties of Malin and Paloverde. The price performance on scheduling points of interties may be different from a price performance at the SMEC level because there may be specific design features in the CAISO markets related to the treatment of interties, which may lead to congestion in one market but not in the others.

Figure 3: 2018 hourly comparison of average LMP on Malin scheduling point



As stated earlier, the SMEC reflects the marginal cost to meet supply and demand. In some but not all of the CAISO markets both the demand and supply side can be adjusted. Adjustments to either demand or supply can influence the market clearing prices. System demand typically refers to the market requirements, which the IFM accounts for bid-in demand, bid-in exports, and virtual demand. In the RUC process, the demand considers the CAISO forecast for CAISO demand, exports, and any adjustment done by operators based on expected system conditions. In the RTM, the requirements include the CAISO load forecast, exports and any adjustments done by operators.

Figure 4: 2018 hourly comparison of average LMP on PaloVerde scheduling point



These adjustments can effectively increase or decrease the requirements that the market optimization uses to clear demand against supply. Operators may use load adjustments to true up the market and the real-time system based on projected or observed system conditions. In the DAM, the adjustment is referred as RUC net short while in the real-time market it is referred to as load imbalance conformance.

Figure 5: 2018 trend of load conformance imbalance in the FMM market

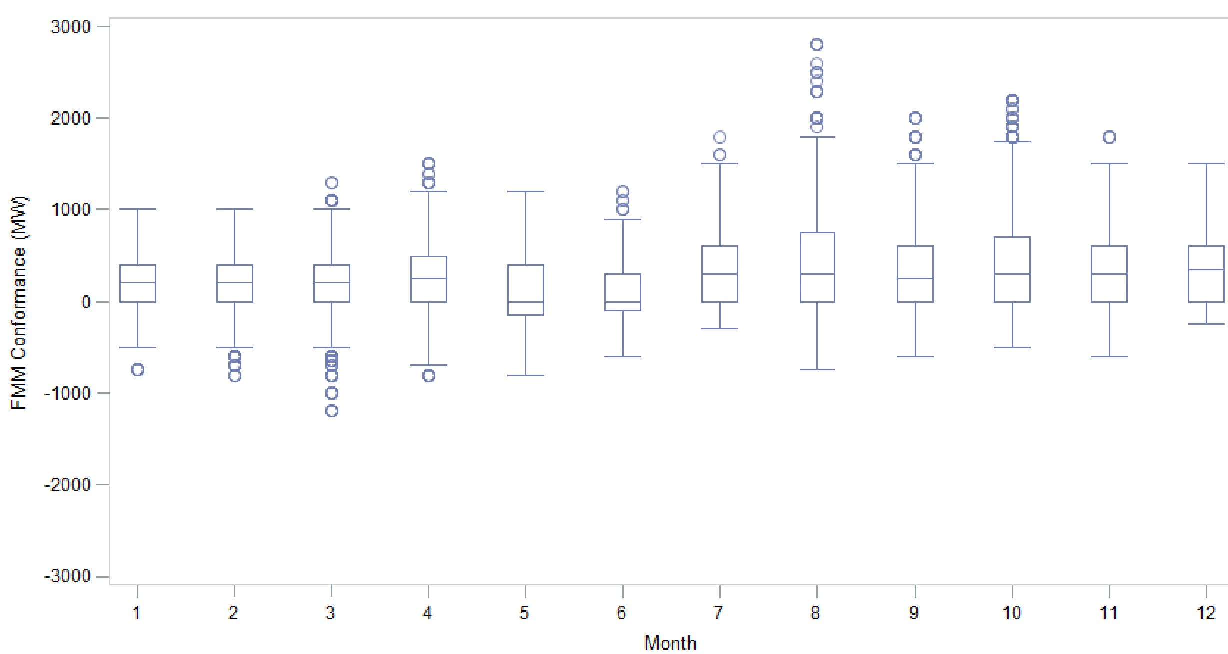
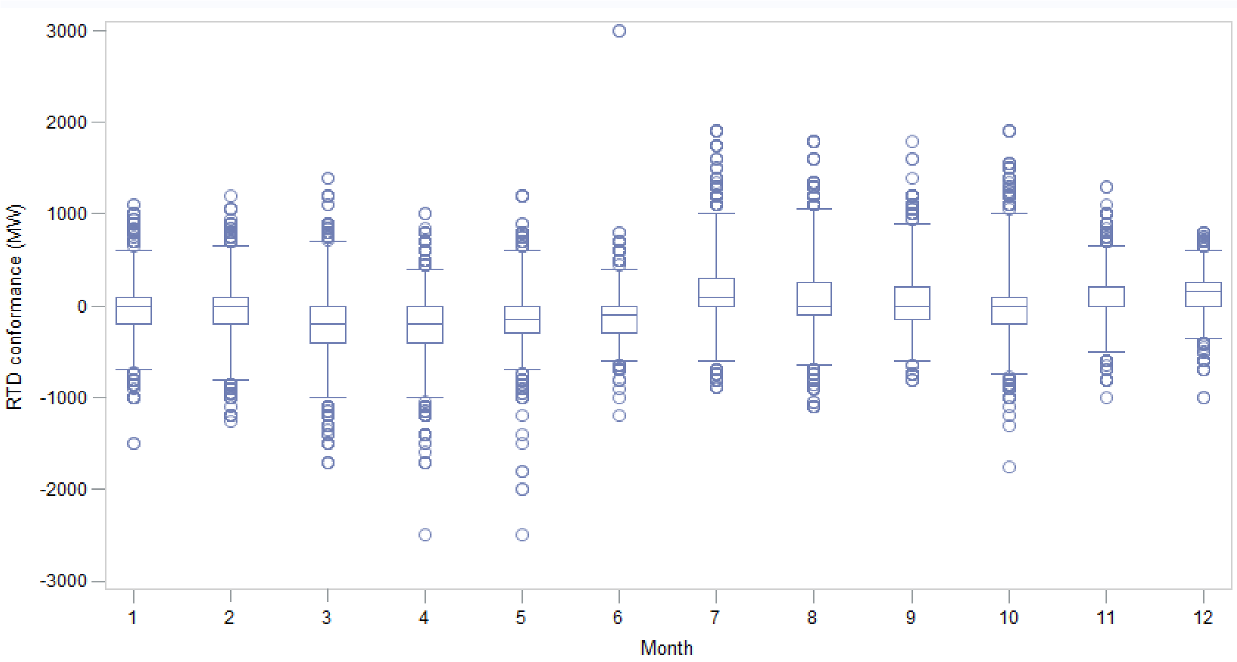


Figure 6 and Figure 6 show the pattern of load conformance imbalance in the FMM and RTD markets for 2018 and organized by month. The box shows the 25th and 75th percentile while the whisker cover the 5th and 95th percentile. The dots cover for the 5th percentile of tails of the samples. This trends show that the real-time market have been frequently clearing with an adjustment to the load forecast as the final requirement to clear the market.

Figure 6: 2018 trend of load conformance imbalance in the RTD market



Operators may also take actions to influence the available supply when there is a need to procure more or less energy. Such actions that modify resource availability in the supply stack may influence the marginality of the power balance of the market and lead to potentially higher or lower market clearing prices.

Actions taken by operators that affect the supply side include

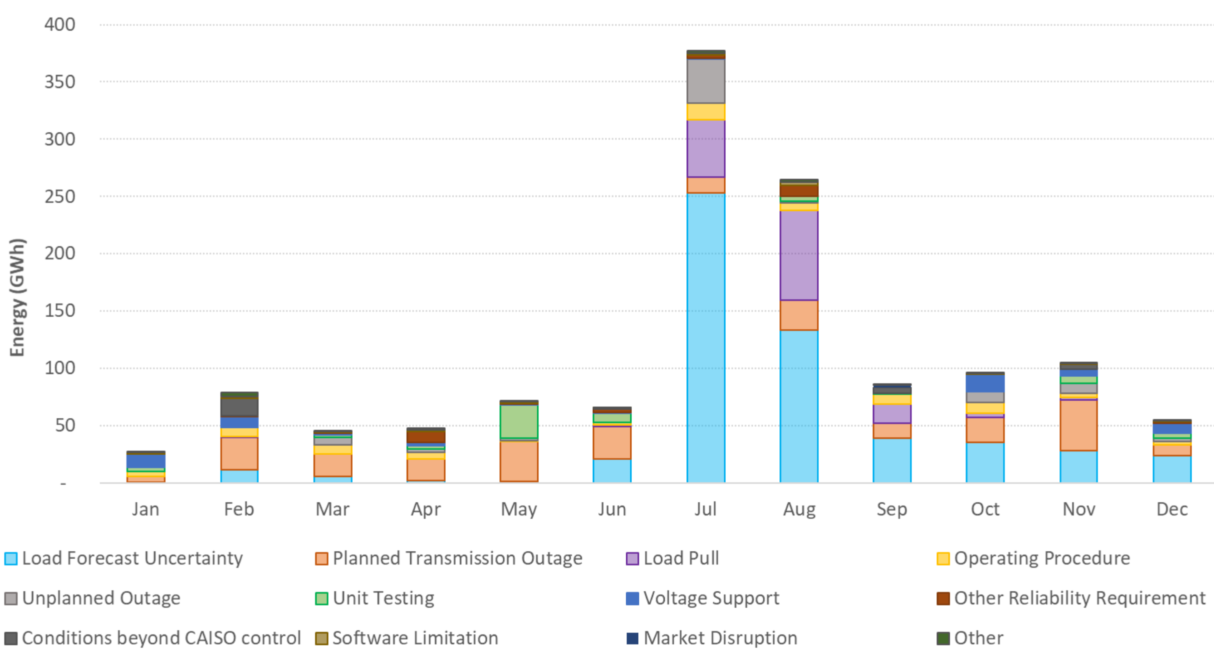
i) Exceptional dispatches (EDs): Operators can instruct specific resources to follow certain dispatch instructions to start up, shut down, transition to a higher or lower configuration, operate at a specific MW dispatch, not exceed a specific MW value and/or not fall below a specific MW value. Generally, EDs are issued during the real-time market; *i.e.* post-day-ahead market, but there may be conditions in which EDs can be d prior to the day-ahead market.

   This type of operator action can insert out-of-merit generation into the supply stack that otherwise would not have been available given the economics of the market. This in turn may distort the otherwise economical market clearing price, potentially resulting in lower prices (when more capacity is exceptionally dispatched) or higher prices (when EDs limit the available supply). Furthermore, EDs may cause discrepancy between the capacity cleared in the DAM and the capacity used to clear the RTM, and hence driving price divergence.

Out-of-the-market intertie dispatches is a variation of EDs in which operators may agree to buy/sell additional energy with scheduling coordinators. When looking to address system – wide conditions the reference typically are bids that did not clear in the HASP market and may be potentially available, and when looking to address congestion specific interties may be more appropriate. These dispatches on interties are at a given negotiated price. The negotiated price is paid only to the intertie resources that were dispatched out of the market, and does not set the price for the rest of the market. The agreed upon intertie energy is made available to the market as tagged (fixed) energy (as opposed to an economic bid that can be cleared based on market prices) and is used in the overall power balance. Generally, such manual dispatches on interties are made after the HASP market run. Depending how quickly the tag is submitted, the intertie energy may not be available for the first or second FMM intervals of the trading hour. Typically, however, it will be available for all RTD intervals of the trading hour. The out-of-market negotiated energy at the ties is a less frequent event than the EDs issued for internal resources and are generally occur with constrained system conditions or projected high levels of uncertainty. These will lead to a supply discrepancy between the HASP, and the FMM and RTD markets, which in turn may influence the clearing prices, with higher prices in the HASP market and lower prices in the FMM and RTD markets.

Figure 7 shows the monthly volume of energy issued with all EDs, including intertie schedules, during the 2018 calendar year, organized by reason. The largest volume of EDs occurred during the summer months[1].

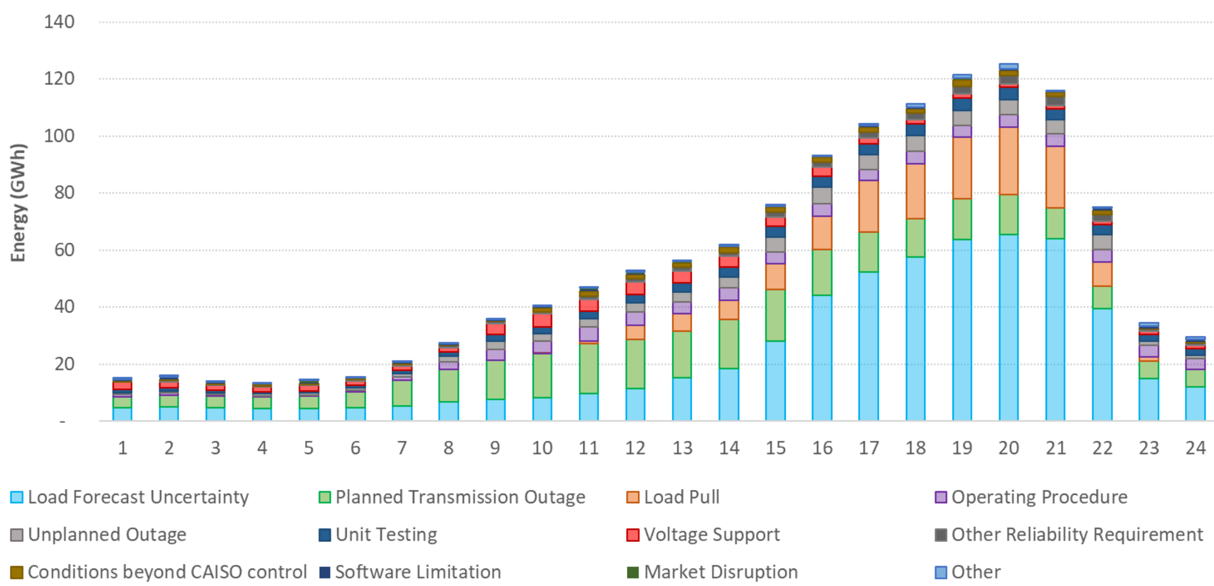
Figure 7: Volume of Exceptional Dispatches in the CAISO market



[1] Following discussion on the summer performance, the ISO worked on better classify prospectively the reasons for exceptional dispatches because the load forecast uncertainties group was accounting for other types of uncertainties such as fire risks.

Figure 1Figure 8 shows the volume of energy issued with all exceptional dispatches averaged across hourly intervals during the 2018 calendar year. Exceptional dispatches are issued in higher volumes during peak hours.

Figure 8: 2018 Volume of exceptional dispatches in the CAISO market



ii) Blocking instructions. There is a variety of market instructions that operators may block based on their current evaluation of system conditions; instructions include start-ups, shutdowns, upward and downward transitions, dispatch operating target (DOTs), and intertie schedules. Blocking an instruction effectively unwinds the specific economically-determined instruction made by the market and results in subsequent markets dispatching the resource as if that instruction had not been issued. For instance, if a shutdown instruction is blocked, effectively the resource continues to be seen as online in subsequent market runs. Since the market clearing price was determined prior to blocking, this type of actions may cause the price signal to not be reflective of system conditions; such actions may make more or less supply available compared to the supply used to determine the economic price signals.

The IFM clears supply with bid-in demand based on the economics of both supply and demand bids. The cleared IFM demand may not align with the ISO load forecast for next trading date, thus, the RUC process is in place to ensure sufficient capacity is procured to meet the forecasted load. Resources committed in the RUC process, or after the IFM, may result in additional capacity being available in the RTM than IFM. This can, consequently, may lead to lower RTM prices relative to the IFM.

In addition to operator actions, other dynamics and design features of the CAISO market may lead to a misalignment of supply capacity made available through the different markets. These include:

i) Variable Energy Resources (VERs): currently, VER resources have the flexibility to economically bid into the IFM. However, the CAISO has observed that VER resources are consistently underbidding in the IFM as compared to the capacity made available by these resources in the RTM. The ISO has since developed and implemented a true-up process in RUC where IFM schedules for VER resources are increased to the forecasted generation values to avoid over-committing generation in RUC. To the extent of the accuracy of the day-ahead VER forecast, this functionality prevents over-generation conditions in the RTM because the under-bid IFM VER generation will be present in the RTM along with the RUC commitments. An additional consideration for VERs is timing of the creation of their real-time forecast. The forecast used in FMM may be a projection of up to 75 minutes ahead of the binding interval, while the RTD forecast may be a projection of about 7.5 minutes. The forecast of VER production can change significantly under extreme weather conditions within the FMM timeframe, such that large divergence will be observed when compared to the forecast used in RTD.

ii) Resource deviations: as part of the market clearing process, the CAISO markets determine the optimal awards in IFM, optimal schedules in HASP and FMM, optimal dispatches in RTD, and optimal commitments in IFM, RUC and FMM. Depending on a set of defined market rules, these instructions may be operationally binding. For instance, a long-start unit will be issued a binding startup instruction for the defined operating day in the day-ahead market, and because the real-time market horizons are too short to optimally determine when the unit should be started, the RTM will expect the unit to be online per its day-ahead instruction. The FMM may also issue transitions or commitments that are binding, while the RTD issues dispatch instructions that are binding. The expectation is that resources follow these commitments and dispatches. The CAISO markets are sequential and are built on the premise that optimal binding instructions from one market will create a dependency on subsequent market runs. For instance, once a transition is issued by the FMM, the RTD market will assume the resource is indeed transitioning as expected and the RTD dispatches will be issued on such projected commitment in the configuration already transitioned. When any of these commitment or dispatches are not followed, it creates a domino effect that materializes in a misalignment between the markets projection and the actual system conditions. The market design has functionality to account for these deviations to some extent, but frequently operators need to take actions to realign the market to actual system conditions. Resource deviations are detrimental to the efficiency of the market, may create operational challenges, and is one of the main driver for operator's manual interventions in the market. The deviations include

a. Intertie deviation: the CAISO recently completed a stakeholder initiative to address this type of deviation. Intertie deviation may be observed in two basic scenarios: partial decline and no-show. The first is intertie resources partially accepting or declining the optimal market schedule determined based on economic drivers. Although this action is not ideal, it provides a signal to the market with an opportunity to procure the lost capacity in subsequent market runs. The second type of deviation is a no show, which is the case with intertie resources being awarded in the market but taking no action to inform the market of their partially decline. They simply do not tag the award, and the lost energy is not accounted for in the market. This is a less than ideal situation because the market has no opportunity in advance to procure the missing energy. This puts pressure on the real-time market and results in constrained system conditions because when some interties do not show the market, there may be limited supply available to be dispatched to make up for the lost capacity. The energy from missing interties has to be procured from non-tie resources, which may be ramp constrained or limited by inter-temporal constraints. This type of deviation is one of the drivers for operators to either make load adjustments or to manually dispatch interties to secure more capacity, even on a proactive basis to mitigate for the asymmetrical risk of being short of capacity.

b. VER deviation: VERs dispatches are heavily driven by their forecast. Forecast accuracy is a key factor to consider when determining the optimality of VERs dispatches. Accuracy improves as the forecast and dispatches approach the real-time market. In recent years, VERs have increased their economical participation in the CAISO markets, where previously these resources were typically bid into the market as self-schedules up to their forecast. The CAISO completed a tariff language clarification recently to reinforce the need for VER resources to follow their dispatch instructions. An existing operational concern is that several VER resources often do not follow their dispatch instructions. This creates a mismatch between capacity available in the market and actual system conditions. Decrement dispatches on VERs, also referred to as negative supplemental dispatched, are instructions to reduce production below their forecast. These deviations together with the uncertainty created by the fast changes of VERs availability, may require operators to proactively account for deviations through the use of load conformance or EDs.

c. Conventional resources deviation: conventional generation such as gas resources have the operational attributes to be able to follow instructions such as commitment and dispatches. Still, deviations from the expected instructions can occur and create a misalignment between what the market cleared value and what the actual system observes. When this deviation occurs, operator are required to mitigate for it and may have to use available tools such as load conformances, exceptional dispatches, or blocking instructions.

iii) Real-time transfers: the CAISO real-time market footprint has been expanded to include the Energy Imbalance Market (EIM) that includes the CAISO balancing authority area (BAA)as well as several other balancing authority areas. The EIM market is a vehicle for a more optimal dispatch of system resources across a broader area. There are several associated benefits, both economical and operational associated with the EIM. In the DAM, the optimal clearing of the market relies solely on internal and intertie resources in the CAISO BAA, while in the real-time market the supply pool is expanded to consider the economical transfers among several participating balancing authority areas optimized through the EIM market. This will effectively modifies the supply stack used to meet CAISO demand and can create a difference with respect to the DAM. A second level of complexity arises when the EIM transfer changes. The real-time market may have optimized resources over a time horizon taking into account certain transfer capability; once changes on such capability happen, the market needs to re-optimize for that change.

iv) Convergence bids: convergence bids or virtual bids participate only in the IFM and are liquidated in the real-time market at the FMM prices because they are not backed up by physical resources. The main goal of convergence bidding is to help converge the day-ahead and real-time markets by identifying price difference to arbitrage, which may lead to more efficient market outcomes. Convergence bids are not used in the RUC process but they can effectively influence the commitment in the day-ahead market by displacing generation or creating more demand requirements.

v) Non-market changes: during certain conditions or system events there may be exogenous factors impacting the price performance, such as flex alerts and demand response programs. These factors may not be known by the time the DAM is run and can effectively lessen the upward pressure on the supply stack to set the prices.

vi) Load forecast accuracy: changes to the load forecast itself can lead to misalignments between markets given the fact that different markets use different look-ahead horizons. During instances of poor weather forecasts leading to inaccurate load forecasting, the divergence between the day-ahead and the real-time markets could be significant; the CAISO has analyzed extreme days in the past when missed temperatures forecast had a significant impact on the load forecast accuracy. These inaccuracies, in turn, may lead operators to conservatively mitigate for such risks and uncertainties by securing more capacity.

Proposed plan for analysis

The following sub-section is intended to cover the proposed plan for this effort. First, the initial scope of the analysis effort has been identified and will be further revised based on feedback from stakeholders and the Market Surveillance Committee. The second sub-section proposes deliverable phases and proposed schedules.

Scope of analysis

The following items have been identified as the initial scope of this effort:

1. Metrics to determine price performance – As previously stated, given the design of the CAISO markets, price convergence across the different markets is a good indicator of a robust and optimal market. There is a need to define metrics and meaningful ways to measure and identify price convergence issues.

2. Operator interventions on the supply side. Over the years, the CAISO has developed different metrics and discussed to quantify the volume of manual interventions in the CAISO markets. For example, EDs are closely tracked and reported in different forums including the FERC monthly reports (Table 1 and Table 2), 120-days FERC report, monthly market performance report, and Market Performance Forum Meetings. Anecdotally, the ISO has discussed implications of EDs and other market interventions. In this analysis effort, the ISO is seeking to not only more comprehensively quantify the extent of market interventions but most importantly to correlate, identify, and to the extent possible, quantify their effect on price performance; namely, the impact on price divergence created by these market interventions, including -
    a. Exceptional dispatches of internal resources.
    b. Manual dispatches of interties resources; this will include the various items raised by the market surveillance committee about price formation concerns on interties.
    c. Blocking of instructions.

3. Divergence of load requirements. All of the CAISO markets optimally dispatch supply to meet the load forecast or bid-in load plus any operator adjustments. The CAISO will analyze
    a. the market requirements for which the market cleared against in the various markets to determine the effect of load requirement differences on price divergence. This will be closely related to the analysis done on the divergence of supply capacity.
    b. the effect of RUC net short adjustments in the RUC process and load conformance imbalance in real-time markets.
    c. the effect of load accuracy at different market timeframes. System load itself can change among markets with no market intervention and such changes can create uncertainty on system conditions, which in turn may lead operators to take actions to mitigate risks.

4. Divergence of supply capacity. The CAISO will analyze the divergence of supply capacity made available across the markets either through the economics of the market or manual interventions to analyze its impact on price convergence and the potential incentives or arbitrage opportunities that may be created across markets. This will include -
    a. VER deviations across markets
    b. Conventional resource deviations
    c. The continuation of analysis on price formation previously discussed in the Intertie Deviation Initiative for intertie resources, including the incentives and opportunities created by divergence among these markets.

5. Dynamics of markets. The CAISO will also analyze -
    a. the marginality of the markets; i.e., identifying resources which set the market clearing prices, and conditions when prices are not reflective of fuel based conditions.
    b. the effect of having only real time market consider EIM transfers into the CAISO system and the resulting contribution to price divergence as compared to the day-ahead market.
    c. the impact of convergence bids, and bidding more generally, in the different CAISO's markets, and the potential effect on price performance.
    d. impacts of flex alerts, demand response into the market clearing of the real-time markets.

Stages of analysis

The analysis effort will be approached with two deliverables. In the first deliverable, the analysis effort will be focused on measuring the various factors that may play a role in price formation. This will consist of an initial report with a series of metrics, indices and trends of the multiple factors described in previous sections of this report. In the second phase, the analysis objective will be to determine to the extent possible, the correlations, causes, and effect of the areas identified in the first phase on price formation. The analytical effort is itself an organic process that may be redirected based on findings throughout the analysis. In very contained and insulated scenarios, the CAISO may be able to rerun some markets by adjusting inputs or develop back of the envelope approximations to potentially quantify the effect of certain factors. This analysis and associated discussions will inform potential solutions or enhancements to improve the price performance.

Proposed schedule

In order to provide opportunities for engagement and to shape the direction of this analysis, as well as to discuss the analysis findings, the CAISO is planning to carry this analysis effort through a more formal stakeholder engagement. The proposed timeline below highlights the main milestones.

Task	**Schedule**
Draft proposal for analysis	Monday April 3, 2019
Discussion at MSC meeting	Friday April 5, 2019
Stakeholder call	Wednesday April 10, 2019
Stakeholder comments	Wednesday April 17, 2019
Posting of first report	Thursday June 14, 2019
Stakeholder call	Thursday June 21, 2019
Final report	Wednesday July 31, 2019
Stakeholder call	Wednesday August 7, 2019