Day-ahead market enhancements Straw Proposal - Stakeholder Comments

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Southern California Edison (SCE) offers the following comments on the California Independent System Operator (CAISO) Day-ahead market enhancements Straw Proposal[1] and meeting[2]. There are fundamental flaws within the most recent CAISO proposal that require redress:

1. Is the energy locational marginal price (LMP) communicating the value of energy only or the value of energy and reliability capacity to the market?
2. When congestion arises in the network, is it a signal that transmission capacity binds on a path due to energy, reliability or both?
3. When virtual bidders submit bids, is there an expectation of those market participants to comingle energy and reliability capacity as a gauge of congestion pricing along any path established by any source and sink pair?
4. Can the price outcomes from the market design provide appropriate signals for market entry and exit in relation to resource retirement and investment?
5. What tradeoff is the CAISO willing to make in relation to forecast quality and reliability without commensurate significant increases in procurement costs relative to the status quo?
6. Price formation issues: Should the CAISO load forecasts set market price for commercial transactions? What are implications to load for hedging its transaction risks when the load is charged at a price above its bid price in the day-ahead market?
7. What tradeoffs does the CAISO expect market participants to make in support of the proposed market design for the day-ahead market?
8. Given the discussion at the 3/5 stakeholder call, SCE does not understand how the various DA energy flows factor into creating the value of a CRR[3].

Generally, the CAISO needs to provide the economic rationale for the signals that the price outcomes provide in the day-ahead market in the short-term and long-term in relation to the marginal cost of supplying each product or service and market entry and exit based on the economic incentives the market design offers. The current proposal lacks such foundation.

[1] http://www.caiso.com/InitiativeDocuments/StrawProposal-Day-AheadMarketEnhancements.pdf
[2] http://www.caiso.com/InitiativeDocuments/Presentation-Day-AheadMarketEnhancements-Feb10-2020.pdf
[3] http://www.caiso.com/InitiativeDocuments/Presentation-Day-AheadMarketEnhancements-Mar5-2020.pdf

As a consequence, consistent with SCE's prior comments, SCE cannot support the CAISO's existing proposal or prior proposals. Instead SCE provides an alternative to the CAISO's proposal, discusses its serious concerns and seeks clarification on many issues.

CAISO's proposed co-optimization is intended to reflect key auction principles that result in the unique determination of price outcomes at the margin. Unfortunately, the co-optimization does not consistently result in the marginal generating resource setting the locational marginal price of energy. In some cases, the price outcome reflects the energy offer of the marginal generating resource plus a premium. This result is inconsistent with marginal cost pricing and the standard auction theory and auction design known to the economics discipline.

Throughout these comments, SCE's understanding is limited by the lack of depth in the details provided by the CAISO.

Viable options to meet Uncertainty

SCE clarifies its understanding that RCU, RCD, IRU, IRD are all energy products, not capacity products. Capacity products cannot be mathematically added/subtracted to the existing Energy (EN) product, as shown in the proposal[4]. Hence, all the products proposed by the CAISO are energy products. Thus, these energy products must, at minimum, conform to the existing Locational Marginal Price (LMP) framework.

1. Revised CAISO Option 1 with exogenously set requirements for Imbalance Reserve Product (DA Flexiramp product) and for Reliability Capacity Product, as well as zonal constraints for procurement.

$$Minimize\ Cost = MIN\ C(x) \quad (1)$$

Subject to

$$\sum_{i,z} EN_{i,z,t} + \sum_{i,z} VS_{i,z,t} = \sum_{i,z} L_{i,z,t} + \sum_{i,z} VD_{i,z,t} + Loss_{z,t} \quad (2)$$

Flexible Ramp and Reliability Constraints

$$0 \leq \sum_{i,z} FRU_{i,z,t} \geq FRUR_t \quad (3)$$

$$0 \leq \sum_{i,z} FRD_{i,z,t} \geq FRDR_t \quad (4)$$

$$0 \leq \sum_{i,z} RCU_{i,z,t} \geq RCUR_t \quad (5a)$$

[4] A capacity product will have the MW dimension, an energy product will have the MWh dimension. Addition subtraction implies that all products are of the same dimension.

$$0 \leq \sum_{i,z} RCD_{i,z,t} \geq RCDR_t \qquad (5b)$$

This proposal:

1. Allows for a simultaneous optimization.
2. Incorporates both flexibility and reliability products with independent exogenous requirements, allowing the CAISO the freedom to set either limit as they choose.
3. Incorporates zonal procurement.

Detailed ramping constraints and zonal procurement constraints are presented in the Appendix to these comments.

2. Revised CAISO Option 1 with Imbalance Reserve Product for both flexibility headroom and reliability.

$$EN_i + EN_j = L_i + L_j + Loss$$
$$IRUR \geq= Max\ (IRURReq, RCU_{Req})$$
$$IRDR \geq= Max\ (IRDRReq, RCD_{Req})$$

RCU and RCD are historic needs for the time granularity that IR is procured for. This has several advantages:

1. It allows for a simultaneous optimization.
2. Proposes a single, straightforward Uncertainty product.
3. Virtuals do not influence the reliability procurement of RCU/RCD since those are historically dependent targets.

3. Option 3 – The CAISO's existing Pay For Performance model[5]

As presented on page 3 of its prior comments[6], SCE supports consideration of the CAISO's existing Pay For Performance model to meet the needs stated by the CAISO within this initiative. In essence, the CAISO wishes to be able to better align resources for the satisfaction of Real Time needs. The existing Pay For Performance model has several advantages:

1. It is a proven, Federal Energy Regulatory Commission (FERC)-approved, mechanism toward meeting Real Time Uncertainty. It is known to meet the superior requirements of a four-second operating reserve, thus, can clearly meet the requirements of any less-demanding needs.
2. It does not require radical change of the market design and consistent with solutions used by other FERC-regulated entities.

[5] Similar to the second viable option, in this model, the capacity needs of both Imbalance Reserve and Reliability Capacity are combined into a single need. This need will enter through the Capacity Requirement (SRPR term in Appendix formulation). In turn, this need will determine the actual energy awards (SRPM term in Appendix formulation).

[6] http://www.caiso.com/InitiativeDocuments/SCECommentsDay-AheadMarketEnhancements-Aug13-Aug19Meetings.pdf

3. It is flexible and will allow the CAISO to reserve energy in the Day Ahead (Capacity is reserved in the Pay For Performance) and deploy it, as needed, in Real Time. Mileage within the existing Pay For Performance model is essentially the energy provided by a resource. The model currently allows the CAISO to accurately deploy according to energy needs and will continue to do so if implemented for DAME needs.
4. The constraints within the Pay For Performance model are consistent with economics principles, including allowing equitable compensation and conforming to the existing LMP framework.

Detailed constraints are presented in the Appendix to these comments.

Dependency on CAISO determined, non-market variables

The crux of the problem with the CAISO's "Option 2" proposal hinges on three unique physical variables: CAISO load forecast, energy, load. Any further energy products can still always be demonstrated as a linear sum of energy. Energy is constrained not just by load but by the exogenous variable, CAISO load forecast. Thus, no matter how many energy products are created, they can all be represented as a single mathematical sum that is constrained by CAISO load forecast. Game theoretically, this is does not allow any interaction between the two players, supply (energy) and demand (load). This is because supply, being constrained by CAISO load forecast, thereby already has its decisions made for it. This leaves load as a single player, and thus no decision-making ability either, since it has no interaction that will be meaningful. The only way to have an economically meaningful interaction between two such variables is to first allow a stage in which supply and demand interact without CAISO load forecast subsuming the role of load and thereby completely constraining energy.

Given the graphic presented in Figure 1 of the straw proposal, it seems that any forecast with significant error has the potential to influence the level of reliability capacity and imbalance reserve procurement in either direction despite the claim that requirements for the products will be established through analysis of historical data. What measures will the CAISO take to ensure that the level of procurement of the reliability products contributes to market efficiency improvements other than the minimization of the out of market actions (I.e., exceptional dispatch) of the system operators?

The CAISO claims that its proposal is beneficial because it increases resource procurement through market constraints rather than out-of-market. There has been no demonstration that the CAISO proposal is efficient. Less so, given that the CAISO proposes not one but two products that are dependent on an exogenous, non-market variable – the CAISO load forecast. First, the CAISO proposes procurement on two brand news products. Second, such procurement may, very likely, reach sufficiently high levels that dwarf today's Energy procurement. Third, there is no demonstration that the specifically proposed functional forms will be beneficial to the market. Given all these facts, can the CAISO provide empirical support that today's out-of-market operator actions are more harmful to market economics than its proposal? More so, can the CAISO demonstrate this given how it is proposing increasing market reliance on the CAISO's own load forecast?

The CAISO is proposing a radical change to the FERC-wide LMP framework

The CAISO proposes to pay resources for Energy as well as for RCU, RCD, IRU, IRD[7]. As proposed by the CAISO, the new LMP formulation = Energy ± 'Amount Willing to INC/DEC Energy from DA schedule' + Congestion + Loss. As SCE understands, LMP is an energy construct with the physical dimension of energy. 'Willingness' is not an energy construct. Hence, SCE does not understand how such a proposal is mathematically feasible. However, based on the limited understanding of the CAISO's presentation of the mechanics, the additional REN-based component is the willingness to change from an already awarded energy schedule. Hence, SCE cannot comprehend how the additionally proposed component to LMP cannot be 'Willingness'. At the least, SCE can comprehend the new LMP formulation = Energy ± 'Amount Willing to INC/DEC Energy from DA schedule' ± Some Unknown + Congestion + Loss. However, this does not positively contribute to clarity on the CAISO proposal.

The addition of '± Amount Willing to INC/DEC Energy from DA schedule' is a radical change. Such a proposal will require the additional burden of proof as to why the existing LMP framework is neither just nor reasonable. Should it be approved by the FERC, remaining ISO/RTOs would be required to adopt the new LMP even though they may not have the same market design as the CAISO or even as each other.

Beyond the regulatory requirement of defending the new LMP proposal, there are economic concerns that would have to be addressed at the FERC. Specifically,

1. **The new LMP proposal is dependent on individual resource behavior rather than reflective of the supply stack** – Resource A, B are at the same node. A gets a non-zero RC award but B does not get a RC award. Energy, Congestion, Loss remain the same but 'Amount Willing to INC/DEC Energy from DA schedule' varies. This variation depends on individual resource bidding behavior. However, Energy (dependent on clearing resource of the entire supply stack), Congestion (dependent on topography and behavior of entire supply stack), Loss (dependent on topography of entire supply stack), are all dependent on aggregate resource information. The minimal implication is that the new LMP proposal is not robust. The maximal implication is that the price signals do not make economic sense.
2. **'Amount Willing to INC/DEC Energy from DA schedule' is an energy product with a capacity attribute** – Of the three components of LMP, 'Amount Willing to INC/DEC Energy from DA schedule' is not comparable to Congestion or Loss. Compared to Energy, 'Amount Willing to INC/DEC Energy from DA schedule' is not a simple energy offer but a willingness to change an already awarded DA schedule. This willingness is a

[7] Pages 13, 14, 17-19. http://www.caiso.com/InitiativeDocuments/StrawProposal-Day-AheadMarketEnhancements.pdf

capacity attribute. Why is a capacity attribute proposed in an unambiguously energy formulation?

3. **'Amount Willing to INC/DEC Energy from DA schedule' is a non-market artifact** – Whether the CAISO chooses to reserve energy from deployment in either DA or RT, it is still just energy. The energy has been awarded based on the economics of the supply stack (opportunity cost) and any energy deployment is compensated based on the economics of the supply stack. In contrast, 'Amount Willing to INC/DEC Energy from DA schedule' depends on the CAISO's non-market determination of need. Should a completely market-centric pricing model accommodate ISO/RTO-specific risk information (load forecast)?
4. **'Amount Willing to INC/DEC Energy from DA schedule' is exactly equal to allowing a resource a second DA Energy schedule** – Providing a RCU/RCD award is exactly equal to the CAISO telling the resource, "you have the capacity headroom so you will be allowed a second DA Energy schedule based on your willingness to supply and a non-market load forecast". The sum of the two DA Energy schedules will equal the final DA Energy schedule. This is exactly the same as the sum of the DA Energy schedule and the RCU/RCD award equaling the final energy schedule for the resource. What is the value of this option, allowing a second DA schedule, to the resource? Any pricing of such resource needs to be incorporated in the compensation to the resource, incorporated in the LMP framework, and also accounts for the magnitude of the influence on LMP of the non-market attribute that is the CAISO load forecast.

In addition to the above concerns, there are issues with the CAISO's explanation of the economic interpretation of LMP. At the 3/5 stakeholder call, the CAISO presented several scenarios on bid-in load and load forecast[8]. Since all these scenarios have to be taken as accurate.

While EN LMP reflects:

tradeoff between energy and RCU; marginal value of energy to load; tradeoff between energy and RCD

Whereas REN LMP reflects: marginal cost of RCU; marginal price of RCD; lost marginal value to load of REN power balance constraint

We can simplify the above expressions as:

EN LMP reflects tradeoff between energy and REN and the marginal value of energy to load

REN LMP reflects marginal cost of REN and lost marginal value to load of REN power balance constraint

Two points arise from this understanding:

1. "tradeoff between energy and REN" is optimization-specific and has no economic meaning since physical load can only choose to procure energy, not REN.

[8] Pages 7-10. http://www.caiso.com/InitiativeDocuments/Presentation-Day-AheadMarketEnhancements-Mar5-2020.pdf

2. "lost marginal value to load of REN power balance constraint" is optimization-specific and has no economic meaning since physical load cannot value a product that it does not choose.

SCE is concerned that such expressions may show a lack of robustness of this newly proposed LMP construct which would jeopardize its defense at the FERC.

The CAISO's formulation allows Virtual Supply and Demand to bet against the CAISO load forecast

As demonstrated in prior comments[9], the CAISO's formulation allows Virtuals to set the Reliability Capacity awards. Reiterating,

$D(CAISO\ load\ forecast) = REN = EN_i + RCU - RCD$,

Thus, $RCU - RCD = REN - EN_i$,

Thus, $RCU - RCD = REN + EN_j - L_j - L_i + Loss$

Thus, ***Reliability Capacity Up – Reliability Capacity Down = CAISO load forecast + Virtual Supply – Virtual Demand – Physical Load + Loss***

Further, from Figures 1 and 2[10].

$IRU = IRUReq - REN\ and\ IRD = IRDReq + REN$,

Where, IRUReq = IRU requirement and IRDReq = IRD requirement.

Thus, $IRU = IRUReq + EN_j - L_j - L_i + RCD - RCU$

Thus, ***Imbalance Reserve Up = Imbalance Reserve Up Requirement + Virtual Supply – Virtual Demand – Physical Load + Reliability Capacity Down – Reliability Capacity Up***

And, $IRD = IRDReq - EN_j + L_j + L_i + RCU - RCD$

Thus, ***Imbalance Reserve Down = Imbalance Reserve Down Requirement – Virtual Supply + Virtual Demand + Physical Load + Reliability Capacity Up – Reliability Capacity Down***

Virtual Supply and Virtual Demand impact both Reliability Capacity as well as Imbalance Reserves. Yet, the CAISO proposes that Virtuals will not be paid the prices of Reliability Capacity or Imbalance Reserves.

A corollary is that Virtual Supply and Demand should be included in all cost allocation of RCU, RCD, IRU, IRD procurement.

Cost allocation

"To address this concern, the proposed day-ahead market enhancements will include virtual demand in the cost allocation of the portion of reliability energy not corresponding to reliability capacity up/down. Thus, the reliability energy payment will be offset by the cost allocation to

[9] http://www.caiso.com/InitiativeDocuments/SCECommentsDay-AheadMarketEnhancements-Aug13-Aug19Meetings.pdf

[10] Pages 13, 14. Straw.

virtual demand."[11]
It seems that the CAISO views this cost allocation strategy as a viable approach to mitigate gaming opportunities by virtual bidders. This strategy begs the questions: Will virtual bidding shrink into non-existence? Are there better ways to resolve gaming opportunities given the market design?

"These imbalances are due to net load uncertainty and ramping differences between hourly day-ahead market and fifteen-minute real-time market schedules. These imbalances have grown over recent years due to increasing amounts of variable energy resources."[12]
"Therefore, the CAISO proposes to not pay a resource that does not bid into the day-ahead market for its reliability capacity up award so it is not forced to participate in the real-time market. Since the resource will not be paid for reliability capacity up, the cost allocation to load will likewise be reduced."[13]
As demonstrated earlier, $REN = IRUReq - IRU \; and \; REN = IRD - IRDReq$

Thus, Reliability Energy is dependent on the Imbalance Reserve targets as well as Imbalance Reserves procured. Imbalance Reserves are procured to meet uncertainty due to Variable Energy Resources (VERs). Hence, any cost allocation of Reliability Energy should include VERs, regardless of whether they self-schedule or economically bid. In sum, cost allocation of both REN and IR should include all VERs and all Virtual Bids.

Corrective capacity
"Corrective capacity was developed in the CAISO's Contingency Modeling Enhancements (CME) initiative, which the CAISO has not yet filed with FERC and plans to implement concurrently with the market changes resulting from this day-ahead market initiative."[14]

How will the CAISO proposal change if there is a delay in acceptance of the CME?

"The post-corrective contingency energy schedules of physical resources with corrective capacity bids are related to the base-case energy schedules as follows:

$$0 \leq CCU_{i,t}^{(c)} \geq EN_{i,t}^{(c)} - EN_{i,t}$$
$$0 \leq CCD_{i,t}^{(c)} \geq EN_{i,t} - EN_{i,t}^{(c)}$$
$$0 \leq CCU_{i,t}^{(c)} \geq REN_{i,t}^{(c)} - REN_{i,t}$$
$$0 \leq CCD_{i,t}^{(c)} \geq REN_{i,t} - REN_{i,t}^{(c)}$$

[11] Page 20. Straw.
[12] Page 5. Straw.
[13] Page 24. Straw.
[14] Page 9. Straw.

"[15]

"If a portion of the resource is self-scheduled for energy or ancillary services, the resource will be required to economically bid the rest of the resource's obligation for energy, ancillary services, reliability capacity and corrective capacity."[16]

Hence,

$$CCU_{i,t}^{(c)} \geq Max(EN_{i,t}^{(c)} - EN_{i,t}\ , REN_{i,t}^{(c)} - REN_{i,t}\ , 0)$$
$$CCD_{i,t}^{(c)} \geq Max(EN_{i,t} - EN_{i,t}^{(c)}\ , REN_{i,t} - REN_{i,t}^{(c)}\ , 0)$$

Thus, a CC schedule is always larger than the Energy Schedule differential between the contingency state and the non-contingency state, the CAISO Load Forecast (REN = D) differential between the contingency state and the non-contingency state, and zero. SCE has a few questions regarding this formulation.

First, why would the CAISO Load Forecast vary between contingency and non-contingency states?

Second, why do Imbalance Reserve schedules not enter the formulation? IR schedules are DA schedules, as defined by the CAISO[17].

As demonstrated earlier, any DA energy schedule should have cost allocation including all Virtuals and all VERs. This also applies to CC, which is a substitute of other energy products and procured for needs created by Virtuals and VERs.

"For example, the current approach is N-1 deliverable whereas base case deliverability may be adequate."[18]

What are the implications of this criterion with respect to CC (N-1-1)?

"Market participants will submit separate bids for energy, ancillary services, RCU, RCD, IRU, IRD, CCU, and CCD."[19]

How is CC procured and how is its price formed? The discourse in the technical appendix does not address these questions and only dwells on the post contingency energy schedules.

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[15] Page 21. Technical appendix. http://www.caiso.com/InitiativeDocuments/DraftTechnicalDescription-Day-AheadMarketEnhancements-AppendixC.pdf
[16] Page 24. Straw.
[17] See Table 1 and Figures 1 and 2 of Straw.
[18] Page 21.
[19] Page 27.

Bidding

1. Can products in opposing directions be procured from the same resource within any dispatch interval? For example, given the examples provided within the proposal, can a resource with an energy and reliability up capacity award be also awarded an imbalance reserve down award in the same interval? If yes, what interpretation or market signal are such awards intended to convey to market participants?

   In the examples provided in Figures 3 and 4, it is apparent that if a virtual bid is the marginal bid in the energy market, the tight coupling between the energy and reliability capacity payment that holds for a physical resource eligible to provide reliability capacity is broken. What assurances exist that the appropriate price signals will be transmitted in the market when there is scarcity in the reliability products and imbalance reserve products? Essentially, if virtual bids dominate the supply stack, then reliability capacity awards will dominate energy awards. With the predominance of virtuals and reliability capacity, this is a clear case of the market serving as predominantly a betting mechanism for virtuals against CAISO load forecast, rather than a mechanism for efficient procurement of physical energy to meet load.

   Further, it seems like resources that are marginal in the energy market and have not submitted flexible capacity bids will be eligible for flexible capacity payments provided that the resource is not operating at its maximum output for reliability capacity up or at the minimum operating limit for reliability capacity down. Is this the intended design? If yes, one needs to strengthen the incentive for resources to bid both energy and reliability capacity in the market thereby preventing the possibility for anti-competitive prices in the reliability capacity market and/or energy market.

2. "Unlike the real-time market, resources will not be allowed to submit their own forecast to be used for settlement purposes."[20]

   SCE generally agrees. VERs should have the same rules as load when incorporated into the net load forecast for REN. SCE requests further clarification. Will the CAISO's recommendation to use virtual bids to eliminate differences between the CAISO forecast for VERs and the VER resource owner's forecast be mandatory or can the VER choose if and when to use virtual bids?

   "The CAISO does not believe it would be appropriate to subject a resource that did not want to participate in the day-ahead market to a real-time must offer obligation.

[20] Page 25.

Therefore, the CAISO proposes to not pay a resource that does not bid into the day-ahead market for its reliability capacity up award so it is not forced to participate in the real-time market. Since the resource will not be paid for reliability capacity up, the cost allocation to load will likewise be reduced."[21]

The CAISO's proposed formulation links EN and REN prices (as well as IR prices). A self-scheduled resource still drives procurement of all four products, EN, RC, IR, CC. They should have a RT MOO. Failure to have such a requirement is a disconnect in the proposed model and discriminatory. Further, SCE asks, what happens in the instance where the resource is marginal but did not submit any flexible capacity bid and there is a clearing price for reliability capacity derived from other cleared reliability capacity bids?

3. "It would be more efficient to award the upward flexible ramping product to the lowest cost resource not scheduled for energy because that is the next resource in the bid stack that will be dispatched if uncertainty materializes."[22]

   SCE supports this treatment.

4. "All resources (except RA resource that has specific bidding obligations, see bidding rule above) can opt out of bidding for reliability capacity, imbalance reserves, and corrective capacity."[23]

   What does the CAISO propose if there is scarcity in one or all of the newly proposed products?

5. "It also proposes to develop a default capacity bid to use when mitigating reliability capacity and imbalance reserve offers."[24]

   How does this approach relate to the proposal in CCDEBE? In addition, since the payment for energy and reliability capacity are coupled, will the same approach to developing a default energy bid apply and only a default energy bid for imbalance reserve will be necessary? What exactly does mitigation entail within this new day-ahead market design?

Further clarification questions and comments

[21] Page 25.
[22] Page 22.
[23] Page 26.
[24] Page 33.

6. SCE is concerned about the CAISO's nodal deliverability proposal[25]. With the proposed nodal procurement, there is a significant risk of procured resources being stranded for transmission constraints even though there are no binding energy constraints. What does an increased congestion price for any source and sink pair really mean when the energy and reliability up capacity constraints bind and the energy flows are lower than the transmission capacity along that path given nodal procurement for reliability capacity and imbalance reserves? SCE recommends a less granular procurement that is known to work, such as zonal.

7. "Additionally, resources providing system and local resource adequacy will be required to economically bid for reliability capacity and corrective capacity. Resources providing flexible resource adequacy will be required to economically bid (not self- schedule) for the previous products and imbalance reserves."[26]

   The CAISO should clarify the real-time must offer obligation for resources receiving day-ahead capacity awards (such as reliability capacity, or imbalance reserve, or both). For instance, are these resources expected to self-schedule their DA capacity awards in the RTM?

8. "the imbalance reserve requirement would be excessively high (or low) for a majority of hour intervals using the histogram approach."[27]

   SCE requests the CAISO confirm that this is similar to the approach used by RT FRP. If so, and if the CAISO can establish that there is significant procurement error, why is the CAISO not revisiting RT FRP procurement?

9. "The CAISO envisions that X will be fully adjustable by system operators. Instead of resorting to out-of-market actions to resolve anticipated shortfalls in capacity or ramping needs, operators can procure more imbalance reserves through the market by adjusting the imbalance reserve up requirement."[28]

   How often can X be adjusted? Is there a limitation? If there is none, operators could adjust every fifteen minutes and completely override the regression in all intervals.

10. Improve market efficiency[29].

    This claim is not demonstrable by the CAISO unless it does a cost-benefit analysis, which

[25] Page 21.
[26] Page 24.
[27] Page 36.
[28] Page 40.
[29] Page 41.

stakeholders requested and the CAISO declined to provide.

11. "As shown in Figure 15, the IFM prices are persistently higher than real-time prices starting in 2018 and continue in 2019. We believe this occurs because operators are reliant on out of market actions to procure additional capacity to meet potentially large imbalances.[30]

    The Price Performance Analysis Report presented many more reasons for price divergence beyond out-of-market actions. Some include, convergence bidding, RT FRP issues, among others. Further, Figure 15 does not provide data post implementation of the load conformance limiter[31].

12. The proposal makes use of a quantile regression rather than a histogram approach in the estimation of the imbalance reserve up requirement. Though the approach appears to be an improvement relative to the histogram approach, it may not avoid the strong covariance relationship among the variables net load, load, wind and solar imbalance. These relationships can be corrected within the ordinary least squares environment though the proposal lacks any explanation of how such matters are resolved by applying the quantile regression. SCE appreciates more details on how the quantile regression resolves the autocorrelation problems among the variables if the ordinary least squares approach is applied.

Appendix

Viable Option 1 ramping constraints and zonal procurement constraints

Ramping Constraints

$$LEL_{i,z,t} + FRD_{i,z,t} \leq EN_{i,z,t} \leq UEL_{i,z,t} - FRU_{i,z,t} \quad (6)$$

$$LEL_{i,z,t} + FRD_{i,z,t} \leq L_{i,z,t} + RCU_{i,z,t} - RCD_{i,z,t} \leq UEL_{i,z,t} - FRU_{i,z,t} \quad (7)$$

$$GAF\left(EN_{i,z,t} - EN_{i,z,t-1}\right) \leq RRU_{i,z}\left(EN_{i,z,t-1}, T_{15}\right) - \delta FRU_{i,z,t} \quad (8)$$

$$GAF\left(EN_{i,z,t} - EN_{i,z,t-1}\right) \geq -RRD_{i,z}\left(EN_{i,z,t-1}, T_{15}\right) + \delta FRD_{i,z,t} \quad (9)$$

$$GAF\left(\left(L_{i,z,t} + RCU_{i,z,t} - RCD_{i,z,t}\right) - \left(L_{i,z,t-1} + RCU_{i,z,t-1} + RCD_{i,z,t-1}\right)\right) \leq RRU_{i,z,t}\left(\left(L_{i,z,t-1} + RCU_{i,z,t-1} + RCD_{i,z,t-1}\right), T_{15}\right) - \delta FRU_{i,z,t} \quad (10)$$

[30] Page 42.

[31] effective 2/27/2019, docket ER19-538

$$GAF\ \left(\left(L_{i,z,t} + RCU_{i,z,t} - RCD_{i,z,t}\right) - \left(L_{i,z,t-1} + RCU_{i,z,t-1} + RCD_{i,z,t-1}\right)\right)$$
$$\leq RRU_{i,z,t}\left(\left(L_{i,z,t-1} + RCU_{i,z,t-1} + RCD_{i,z,t-1}\right), T_{15}\right) - \delta FRD_{i,z,t} \qquad (11)$$

Minimum zonal procurement requirement

$$FRUR_{z,t} \leq \sum_i FRU_{i,z,t} \geq FRUR_t \qquad (12)$$

$$FRDR_{z,t} \leq \sum_i FRD_{i,z,t} \geq FRDR_t \qquad (13)$$

$$RCUR_{z,t} \leq \sum_i RCU_{i,z,t} \geq RCUR_t \qquad (14)$$

$$RCDR_{z,t} \leq \sum_i RCD_{i,z,t} \geq RCDR_t \qquad (15)$$

where t = {1,2, 3, …,,,,.,T}

NOTATION

i	Resource index
t	Time period index
z	Zone index
δ	Shared ramp coefficient for Flexible Ramp capability
T_{15}	Flexible Ramp time domain (15 minutes)
T_{60}	Duration of the time period (60 minutes)
GAF	Granularity adjustment factor (GAF = $T_{15}/T_{60} = 1/4$)
$LEL_{i,z,t}$	Lower Economic Limit of resource *i* in zone *z* and time period *t*
$UEL_{i,z,t}$	Upper Economic Limit of resource *i* in zone z and time period *t*
$EN_{i,z,t}$	Day-ahead energy schedule of resource *i* in zone *z* and time period *t.* Has a positive value for supply (generation plus imports) and a negative value for demand (demand response plus exports)
$VS_{i,t}$	Day-ahead energy schedule of a Virtual Supply resource *i* in zone *z* and time period *t*
$VD_{i,z,t}$	Day-ahead energy schedule of a Virtual Demand resource *i* in zone z and time period *t*

$L_{i,z,t}$ Day-ahead energy schedule of Non-Participating Load resource *i* in zone *z* and time period *t*

D_t Demand forecast for time period *t*

$RCU_{i,z,t}$ Reliability Capacity Up award for resource *i* in zone z and time period *t*

$RCD_{i,z,t}$ Reliability Capacity Down award for resource *i* in zone *z* and time period *t*

$RCUR_{z,t}$ Reliability Capacity Up minimum zonal requirement in time period *t*

$RCDR_{z,t}$ Reliability Capacity Down minimum zonal requirement in time period *t*

$RCUR_t$ Reliability Capacity Up system requirement in time period *t*

$RCDR_t$ Reliability Capacity Down system requirement in time period *t*

$FRU_{i,z,t}$ Flexible Ramp Up award for resource *i* in zone z and time period *t*

$FRD_{i,z,t}$ Flexible Rap Down award for resource *i* in zone *z* and time period *t*

$Loss_t$ Transmission losses for time period *t*

$FRUR_{i,z,t}$ Flexible Ramp Up requirement for resource *i* in zone *z* and time period *t*

$FRDR_{i,z,t}$ Flexible Ramp Down requirement for resource *i* in zone z and time period *t*

$FRUR_{z,t}$ Flexible Ramp Up minimum zonal requirement for time period *t*

$FRDR_{z,t}$ Flexible Ramp Down minimum zonal requirement for time period *t*

$FRUR_t$ Flexible Ramp Up system requirement for time period *t*

$FRDR_t$ Flexible Ramp Down system requirement for time period *t*

$RRU_i(\tau)$ Lowest ramp up capability within the applicable operating range of resource *I* in time period *t* for the time domain τ

$RRD_i(\tau)$ Lowest ramp down capability within the applicable operating range of resource *I* in time period *t* for the time domain τ

Viable Option 3 (CAISO's existing Pay For Performance model) constraints

This involves approaching the need for Slow Regulation Product using the existing framework of Mileage constrained Regulation[32]. From that stakeholder initiative, the CAISO proposed a robust framework allowing individual resources to be constrained by capacity and mileage performance when providing Regulation. SCE builds on this framework as a viable translation to the CAISO's DA needs as well. In particular, the volume of capacity that's procured to hedge uncertainties, or net load forecast error, or both, can be treated as a target that should be met under the formulation of a Slow Regulation Product. To ensure the capacity can be deployed and actually sourced from resources that can provide the needed ramping capability, the concept of mileage is applied. Thus, we have the Slow Regulation Product procurement minimization (first equation) subject to the constraints (remaining equations):

$$min\left(\sum_i (BSRPC_i \times SRP_i + BSRPM_i \times SRPM_i) + cost\ of\ energy\ and\ other\ AS\right)$$

Such that,

$$\sum_i SRP_i \geq SRPR$$

$$\sum_i SRPM_i \geq \min\left(SRPMR_{i,t-1}, m \times SRPR, \sum_i m_i \times BCSRP_i\right)$$

$$m_i \times SRP_i \geq SRPM_i$$

$$0 \leq SRP_i \leq BCSRP_i$$

Where,

i = resource index

$$BSRPC_i - Bid\ price\ for\ Slow\ Regulation\ Product\ Capacity$$
$$SRP_i - Slow\ Regulation\ Product\ Capacity\ award$$
$$BSRPM_i - Bid\ price\ for\ Slow\ Regulation\ Product\ Mileage$$
$$SRPM_i - Slow\ Regulation\ Product\ Mileage\ award$$
$$SRPR - Slow\ Regulation\ Product\ Capacity\ Requirement$$
$$SRPMR_{i,t-1} - Slow\ Regulation\ Product\ Mileage\ Requirement\ from\ prior\ week$$
$$m - system\ resource\ multiplier = typical\ mileage\ dispatch\ of\ procured\ RUC\ capacity$$
$$m_i - resource - specific\ mileage\ multiplier$$
$$BCSRP_i - Bid\ capacity\ for\ Slow\ Regulation\ Product$$

[32] Page 9 of http://www.caiso.com/Documents/Addendum-DraftFinalProposal-Pay_PerformanceRegulation.pdf