Energy Storage and Distributed Energy Resources Phase 4

Straw Proposal

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Market & Infrastructure Policy

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Revision History

Date	Revision
04/26/2019	Initial publish
05/09/2019	Updated ***Section 4.1.1***. Corrected the state-of-charge and self-schedule bid-cost recovery ineligibility criteria. Also, clarified that the CAISO will respect the *physical* minimum and maximum output resource constraints rather than the *economic* minimum and maximum throughout the section.

1 Introduction

The focus of the California Independent System Operator's (CAISO) energy storage and distributed energy resources (ESDER) initiative is to lower barriers and enhance the abilities of these resources to participate in the CAISO's market.[1] The number and diversity of these resources continue to grow, and they represent an important part of the future grid.

The ESDER initiative is an omnibus initiative covering several related but distinct topics.

This paper presents the elements included in the fourth phase of the ESDER initiative. It describes the CAISO's efforts to continuously improve and enhance its interaction and participation models for both storage and distributed energy resources in the CAISO's market.

ESDER 4 addresses the following topics:

1. Adding a state of charge parameter in the non-generator resource model;
2. Applying market power mitigation to energy storage resources;
3. Streamlining interconnection agreements for non-generator resource participants
4. Establishing parameters to better reflect demand response resource operational characteristics;
5. Vetting qualification and operational processes for variable-output demand response resources; and
6. Discussing the non-24x7 settlement implications of behind the meter resources within the non-generator resource model.

2 Stakeholder Process

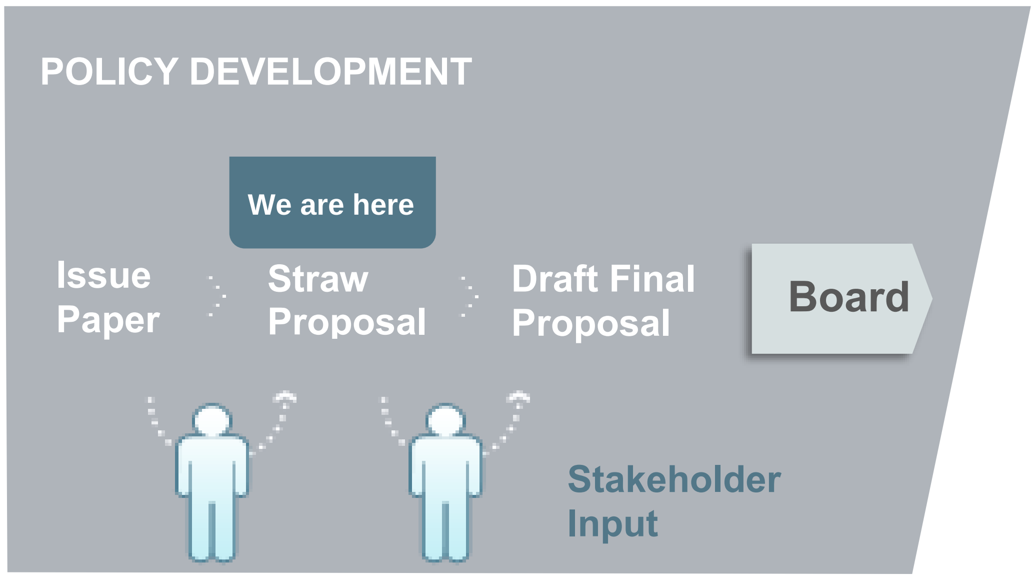
The CAISO is at the "Straw Proposal" stage in the ESDER 4 stakeholder process. Figure 1 below shows the status of the straw proposal within the overall ESDER 4 stakeholder initiative.

The purpose of the straw proposal is to present the scope and solutions of issues related to the integration, modeling, and participation of energy storage and

[1] DERs are those resources on the distribution system on either the utility side or the customer side of the end-use customer meter, including rooftop solar, energy storage, plug-in electric vehicles, and demand response.

DERs in the CAISO's market. The CAISO reviewed stakeholder feedback received through comments and working group meetings to identify and prioritize the proposals the CAISO will pursue in this initiative. After publication of the straw proposal and a stakeholder call, the CAISO will continue to hold working group meetings as necessary to refine the in-scope items. As appropriate, the CAISO may organize focused working groups to address complex issues or those elements that have cross-jurisdictional concerns as we move through the initiative process.

Figure 1: Stakeholder Process for ESDER 4 Stakeholder Initiative



3 Energy Imbalance Market Classification

CAISO staff believes that ESDER 4 involves the Energy Imbalance Market (EIM) Governing Body's advisory role to the Board of Governors (Governing Body – E2 classification). This initiative proposes changes to the non-generator resource and proxy demand resource model, with the aim of reducing barriers to participation and enhancing the ability to provide services in the day-ahead and real-time markets. While proposed enhancements will be applicable to EIM participants, there are no changes specific to EIM balancing authority areas.

All of the new proposed features would apply generally throughout the ISO market, and thus be advisory for the EIM Governing Body.

4 Non-Generator Resource Model

The CAISO introduced the non-generator resource model in 2012 to allow for wholesale market participation of energy storage resources. Although the CAISO believes the non-generator resource model effectively integrates energy storage resources today, the increasing number of storage devices participating in the wholesale market warrants further investigation of whether possible enhancements to the model are necessary to ensure that the CAISO is using these unique resources optimally to meet the reliability needs of the grid.

4.1 Real-time market state-of-charge management

The real-time market optimization horizon may impede scheduling coordinators from optimally managing their non-generator resource over the day. The real-time market optimizes schedules over a one hour and five minute time horizon that does not consider conditions later in the day. Additionally, the market does not ensure that the resource's state-of-charge at the end of the time horizon is sufficient to meet future dispatches beyond the real-time market horizon. For instance, based on the resource's bids, the real-time market may find that it is optimal, over the short-term, to leave a non-generator resource fully discharged early in the day. However, leaving the resource in this discharged state could prevent the optimal use of the resource over the entire day given the limited real-time outlook.

A scheduling coordinator may want to manage a non-generator resource's state-of-charge throughout the day so that the device has enough energy to meet its day-ahead schedules later in the day. For example, if a scheduling coordinator could specify their resource's state-of-charge level at the end of an operating hour, it could ensure that the real-time market does not dispatch the resource below the state-of-charge needed to meet the resource's day-ahead schedule.

4.1.1 *Proposal*

The CAISO proposes allowing scheduling coordinators to submit end-of-hour state-of-charge parameters for non-generator resources in the real-time market to manage the optimal use of their non-generator resources throughout the day. Scheduling coordinators will be able to submit the end-of-hour state-of-charge value for non-generator resources with their bids in the real-time market horizon. The hourly end-of-hour real-time market state-of-charge parameter will be optional and available to scheduling coordinators whom choose to use it. .

Scheduling coordinators are able to update their real-time bids at any point after the day-ahead market and up until the respective real-time market closes. The real-time market will use the submitted end-of-hour state-of-charge when the real-time market's horizon optimizes to the end of the respective hour.

This state-of-charge parameter is different from the minimum and maximum state-of-charge parameters that are currently available, which are energy limits represented by MWh. Instead of ensuring that resources receive an economic dispatch within a minimum and maximum state-of-charge, the market will dispatch non-generator resources economically or uneconomically to achieve the scheduling coordinator's hourly end-of-hour state-of-charge when provided. Non-generator resources may not receive energy schedules they would have otherwise received without the parameter because the elected state-of-charge parameter will take precedence over economic outcomes in the market optimization.

The real-time market will respect all resource constraints in determining the non-generator resource optimal dispatch. Every resource is constrained in some way, whether it be ramp limited, power maximum limited, or energy limited. The hourly end-of-hour state-of-charge parameter adds another resource constraint to the market optimization. The real-time market will respect modeled resource constraints while honoring a scheduling coordinators' bid-in end-of-hour state-of-charge.

The real-time market will always respect a non-generator resource's minimum and maximum state-of-charge values. In other words, the market optimization will ignore hourly end-of-hour state-of-charge values if they fall outside the resource's set minimum and maximum state-of-charge values. For instance, if a scheduling coordinator submits an end-of-hour state-of-charge of 90% for a resource with a maximum state-of-charge of 80%, the market will consider the submitted end-of-hour state-of-charge to be 80%, not 90%. A 90% end-of-hour state-of-charge would be infeasible based on the resource's modeled parameter.

Additionally, if a scheduling coordinator submits an end-of-hour state-of-charge of 100%, but the market would need to charge the resource at a value lower than its ~~economic~~ physical minimum in order to achieve that 100% state-of charge, the market will charge the resource at its ~~economic~~ physical minimum value. The market is not able to charge the non-generator resource to 100% by the end of the hour based on its bid when the resource's ~~economic~~ physical minimum limited the dispatch and, therefore, limits the ability for a full charge of the device.

The market will respect ancillary services awards when a scheduling coordinator provides hourly end-of-hour state-of-charge values that are not feasible. The market will maintain a state-of-charge if the resource is providing ancillary services such that the resource can provide the full awarded MW amount over a 30-minute period. If a scheduling coordinator were to submit an end-of-hour state-of-charge of 10%, but the resource's ancillary service awards require a 20% state-of-charge to ensure the ancillary service's award can be met, the market will maintain the more limiting 20% state-of-charge.

The CAISO proposes to exclude intervals where state-of-charge bid parameters or self-schedules create uneconomic dispatches from a non-generator resource's bid-cost recovery settlement. If the CAISO must dispatch a resource uneconomically, only to meet a non-generator resource's bid-in state-of-charge value or self-schedule, it is doing so to meet the scheduling coordinator's strict requirement regardless of market prices. For instance, if a scheduling coordinator offered to charge a resource at $5/MWh and submitted a 100% state-of-charge by the end of the hour, the market may charge that resource at a market price of $10/MWh to meet the scheduling coordinator's strict charging requirement. Therefore, the resource should bear the associated costs rather than require the CAISO to uplift the associated costs to aggregate demand.

A non-generator resource will be ineligible to receive bid-cost recovery if the CAISO must dispatch a resource uneconomically only to meet the bid-in state-of-charge value. The non-generator resource will be ineligible for bid-cost recovery in an interval where:

a. the charge or discharge is uneconomic;
b. the submitted end-of-hour state-of-charge is greater than the current state-of-charge while the awarded value is at ~~economic~~ physical ~~maximum~~minimum; or
c. the submitted end-of-hour state-of-charge is less than the current state-of-charge while the awarded value is at the ~~economic~~ physical ~~minimum~~maximum.

A non-generator resource will be ineligible to receive bid-cost recovery if the CAISO must dispatch a resource uneconomically to meet a self-schedule. The non-generator resource will be ineligible for bid-cost recovery in an interval where:

a. the charge or discharge is uneconomic;
b. the submitted next interval self-schedule requires more charge than the current state-of-charge while the awarded value is at ~~economic~~ physical ~~maximum~~minimum; or
c. the submitted next interval self-schedule requires less charge than the current state-of-charge while the awarded value is at ~~economic~~ physical ~~minimum~~maximum.

Finally, the CAISO proposes to publish non-generator resource hourly end-of hour state-of-charge bid information on OASIS along with all other bid information in accordance with existing timelines.

4.2 Effects of Multi-Interval Optimization

The CAISO employs a multi-interval optimization. Under this structure, a resource is economic over the multi-interval market horizon when considering its single binding interval dispatch in relation to each of the future advisory interval dispatches. This may lead to a non-generator resource receiving an uneconomic result if prices in future advisory intervals do not materialize as anticipated. For instance, there can be instances when a resource receives an award to charge at a price that may be higher than its bid for the financially binding interval, yet the optimization sees future intervals with greater economic incentive for the resource to discharge, thus being overall economic over the market horizon. If future prices do not materialize as anticipated, this can result in a revenue shortfall in the binding interval. The CAISO's real-time bid-cost recovery settlement mechanism addresses such shortfalls, paying the scheduling coordinator the difference between earned market revenues and the bid-cost at the end of each day. The CAISO believes that it is appropriate and reasonable to dispatch resources out-of-the-money in individual intervals given the multi-interval optimization is attempting to optimally maximize the resource's use and minimize costs over a longer horizon, knowing the market compensates the resources for losses through the bid-cost recovery settlement mechanism.

In its comments, LS Power stated that it feels that bid-cost recovery as currently implemented does not work for non-generator resources because it does not make non-generator-resources whole to their marginal cost. To the contrary, the real-time bid-cost recovery mechanism makes non-generator resources whole relative to their bids in instances where the multi-interval optimization yields an uneconomic dispatch. Summed over the course of the day, a non-generator resource's energy revenues plus bid-cost recovery payments covers a non-generator resource bid-in cost. The CAISO can only make resources whole to costs that scheduling coordinators actually represent to the CAISO in their bids. To the extent a scheduling coordinators fails to represent their resource's costs in their bids to the CAISO, it could lead to insufficient market revenues; however, the scheduling coordinator has the means to avoid this through their bids to ensure at the end of the day their costs are covered.

LS Power also stated that scheduling coordinators for non-generator resources are unable to bid in variable operations and maintenance costs, which it notes it can represent as a cost per megawatt-hour. The CAISO's existing market allows for scheduling coordinators to bid resource costs on a per megawatt-hour basis, so it is unclear why scheduling coordinators are not able to represent per megawatt-hour costs in their bids.

LS Power stated that the multi-interval optimization has a negative effect on a scheduling coordinator's ability to use a non-generator resource to meet contractual obligations outside of CAISO's wholesale market because it may leave the resource at an undesirable state-of-charge. The CAISO believes that its proposal in ***Section 4.1*** will address this concern by allowing scheduling coordinators to manage a non-generator resource's state-of-charge using a biddable parameter in the real-time market.

The CAISO believes its multi-interval optimization remains highly effective at maximizing resource usage in harmony with bid-in costs and does not propose to allow resources to opt-out of the CAISO's multi-interval optimization.

4.3 Non-generator resource Participation Agreements

Non-generator resources currently must execute the participating generator agreement and participating load agreement to participate in the CAISO markets. To reduce administrative burden and improve efficiency, the CAISO is proposing that non-generator resources will participate in the CAISO market solely under the participating generator agreement. Only non-generator resources acting as dispatchable demand response will execute the participating load agreement (and not a participating generator agreement). These modifications will not affect the current treatment of non-generator resource and dispatchable demand response in any CAISO market systems. Non-generator resources that have already executed participating generator agreements and participating load agreements will not be required to execute new agreements or terminate existing agreements.

5 Market Power Mitigation for Energy Storage

To ensure that wholesale prices are just and reasonable under the Federal Power Act, the CAISO and other organized wholesale markets have mitigation measures to minimize the exercise of market power and non-competitive outcomes.[2] The CAISO employs a tool called local market power mitigation,

[2] For example, a generator may have the ability to exercise market power when supplying energy within a transmission-constrained area if it is a pivotal supplier.

which replaces market bids with marginal cost based default energy bids when potential market power is detected. This tool helps to ensure that market prices are economic in uncompetitive situations.

Currently, the CAISO does not apply local market power mitigation measures to energy storage resources. However, with increasing numbers of energy storage resources participating in the markets, the CAISO must consider potential market impacts and the applicability of mitigation tools to storage resources. To apply local market power mitigation, we must determine the cost components to include in the default energy bid for storage resources.

Costs for Storage Resources

Costs for storage resources fall into three separate components and include:

1. Procurement costs
2. Losses
    - Round-trip
    - Parasitic
3. Potential costs related to replacement components

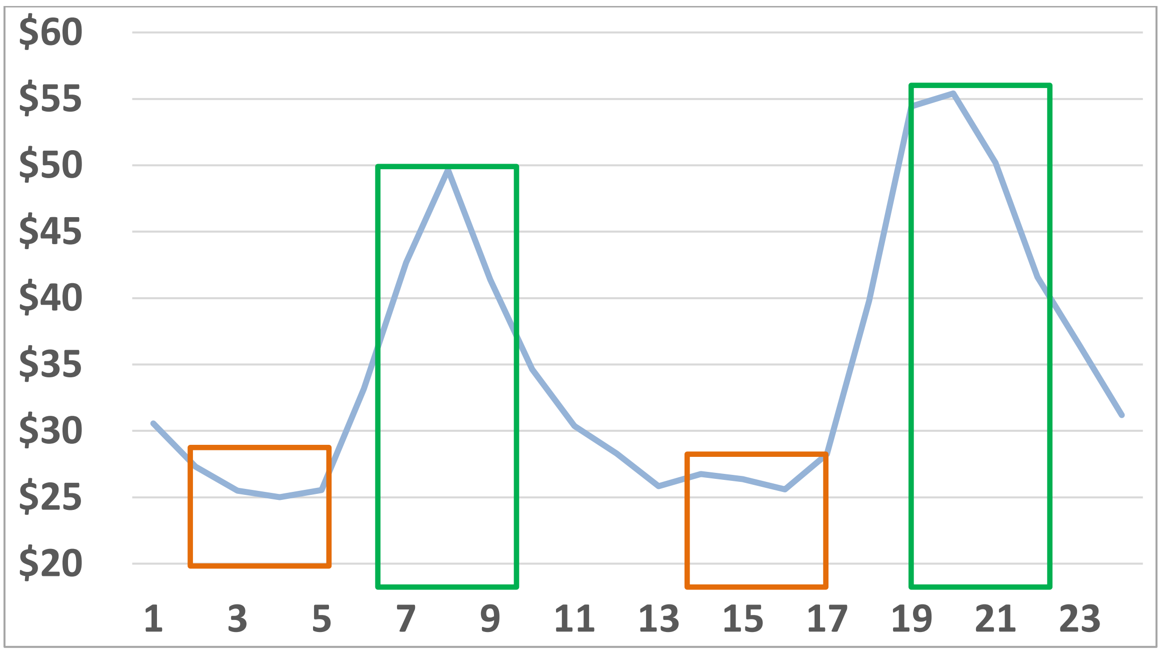
Generally, the first two costs are relatively straightforward to calculate, but the third may be variable and difficult to estimate. It is reasonable to assume that a profit maximizing resource will choose to charge when prices are low. This may occur in the real-time market when prices spike to negative values and may occur during periods of the day when prices are generally lowest, such as early morning hours or peak solar hours. Batteries also have losses associated with charging and discharging the battery, or “round-trip efficiencies,” and parasitic losses that occur anytime the battery has a non-zero state of charge. For modelling purposes, round-trip efficiency losses may generally be reduced to a single multiplier, and parasitic losses may be negligible for most new batteries built on the grid.[3] With information about costs to procure energy and losses, a calculation can be performed to determine what prices a resource owner would need to sell energy and earn positive revenues on that energy.

Figure 2 shows day-ahead prices for a sample day, and the charge/discharge activity that a storage resource with these two costs may have during that day.

[3] Parasitic losses may be more applicable for some existing storage resources currently on the system. Most new lithium ion storage builds have relatively little parasitic losses.

In this highly simplified example, suppose there is a storage resource with four hours of charge and discharge capability, and that it bids in a way to maximum revenues during the day. Such a resource may charge very early in the morning, discharge during the morning peak, charge again during the peak solar hours, and discharge during the evening peak. This behavior would be rational as long as the price spreads between the charge and discharge periods were sufficiently high to overcome the costs incurred from round-trip losses. This scenario is outlined in Figure 2, where the blue line represents market prices, the red boxes represent intervals that the resource is charging, and the green box represents intervals when the resource is discharging.

Figure 2: Day-ahead SMEC Prices on March 15, 2018



The discussion above does not consider any implications for potential replacement costs that the resource owner might incur from charging and discharging. Batteries built onto the grid degrade with use. Each charge and discharge of a battery is called a "cycle" and as batteries cycle, the performance of individual cells that make up the battery slowly deteriorate. This degradation makes replacing individual cells, and eventually the entire resource, necessary for continued operation. Current warranties for batteries may guarantee some level of performance for a battery over a specific number of cycles during a period. This number of cycles may be thought of or translated to a total amount of generation (MWh) produced by the resource until the need for expected replacement costs.

Additionally, each cycle may have more or less impact on the batteries' performance based on the depth of discharge. The depth of discharge refers to how far the battery is discharged before recharging. A deep discharge, where the storage resource moves form a nearly full state of charge to a nearly empty state of charge, may degrade components of the resource significantly faster than many shallow charges and discharges of the same volume.

Replacement costs for storage resources are hard to quantify. Resource owners and developers have complex models to anticipate what technology costs will be in the future, with general anticipated timeframes for replacement and installation costs in future years. Many of these models anticipate these prices rapidly falling as storage technology matures.

Currently, resources may include major maintenance adders in default energy bids. The CAISO calculates expected values of maintenance, based on historic or expected future maintenance, for items that have costs attributable to each start-up or each run hour for a specific resource, and then allows these values to be applied to start-up and minimum load bids, and the variable cost option default energy bid. However, there is a key difference between these costs and bids for storage resources, as there is no equivalent concept of a start-up or minimum load for storage resources.

The CAISO also includes variable operations and maintenance for all resources of a specific technology type for resources that select the variable cost option default energy bid. These variable operations and maintenance costs are included as an adder that is applied to the energy component of these bids for each resource. This or a similar construct may be appropriate to use for storage resources, but there are some key differences between how these values currently work today and a potential application in the future. Because these values are fixed for all resources of the same technology type, they would not accurately reflect potential replacement costs for all storage resources currently participating in the market. For example, some resources may be very close to needing significant replacement that might be very costly, but others might not need replacement for many years when technology prices have decreased significantly.

The CAISO continues to consider this key question: Should the CAISO include fixed costs related to replacing battery components when quantifying resources' costs when they optimally bid into the market, or is this something that should be recovered through the resource adequacy framework or another payment structure?

Default Energy Bid

The CAISO considered three options for calculating default energy bids for energy storage resources:

1. A semi-customizable default energy bid eligible to all storage resources
2. The current variable cost option combined with new adders
3. An updated variable cost option specific to individual resources

This approach will incorporate estimates of future prices and charge/discharge durations to compute a default energy bid for each storage resource. The paper outlines two additional approaches that may be considered to calculate default energy bids for storage resources.

When considering a default energy bid, it is important to remember resource owners are not required to submit cost based market bids (i.e. bids that are closely aligned to their default energy bids). Such a requirement would be completely contrary to the markets and principles for participation. Resource owners may effectively manage resources via market bids to potentially save stored energy for later hours, charge more during certain hours, optimally balance between energy and ancillary service markets. Simply, a resource will want to bid in a way to maximize profit. A resource's bid is only mitigated when there is a potential to exercise local market power. The objective of the default energy bid is to encourage maximum resource participation in the market without distorting profit maximizing bidding strategies, while preventing resources from extracting rents from the market by exerting market power.

The CAISO proposes proceeding with the first option listed above for a default energy bid for storage resources. This option would depend on the duration of discharge that a storage resource has and the expected future prices for the resource. To be eligible for this default energy bid, a storage resource will be required to submit a request for this default energy bid to the CAISO, and submit verification of the maximum amount of discharge time for the resource when it is fully charged.

Under this default energy bid, the CAISO will verify that the discharge duration is equal to the maximum amount of charge (in MWh) for the resource divided by the Pmax of the resource. The default energy bid is calculated using the above value coupled with expected real-time future prices. It will correspond to the anticipated price during an interval of time representing 50 percent of the calculated discharge duration. The calculation will include an additional 10 percent adder, similar to other default energy bids. The adder will account for potential uncertainty. Calculating the default energy bids in this manner should prevent a resource from performing particularly deep discharges, and should not be overly burdensome for cycling resources. Bidding at these levels and following dispatches would generally run a storage resource less than half of one cycle per day.

Figure 3: Real-Time RTPD SMEC Prices on March 15, 2019

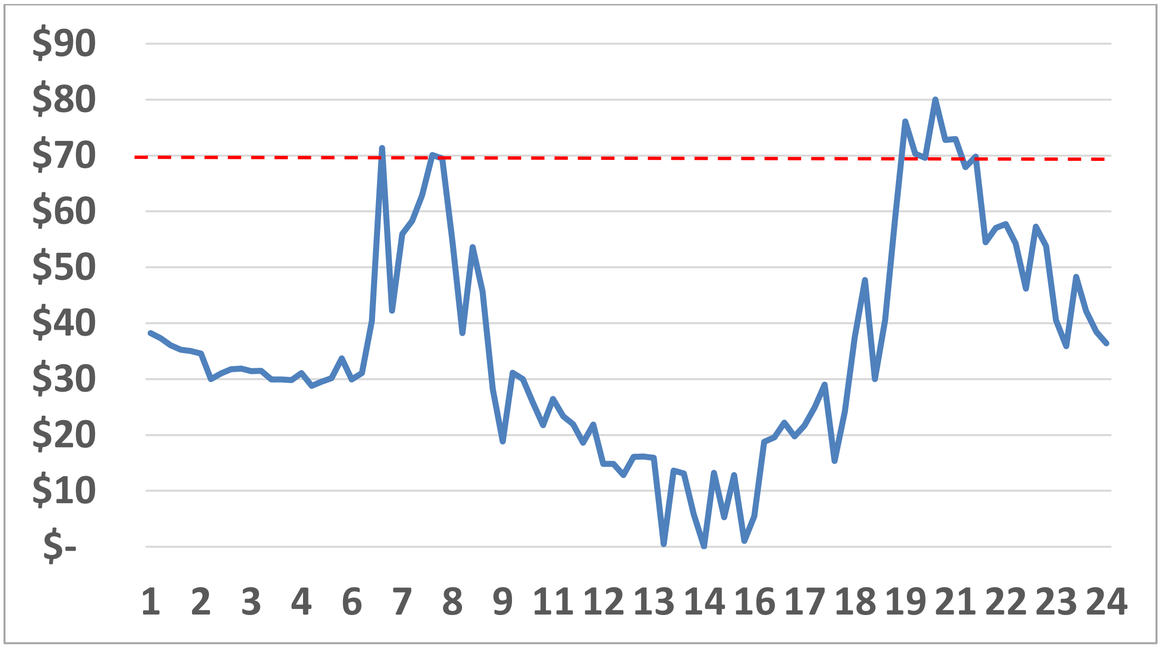


Figure 3 shows real-time energy prices during a sample day on March 15, 2019. The red dashed line represents the proposed default energy bids for storage resources. If the resource were bidding in at the default energy bid level, it would only be dispatched when prices were high during a few intervals in the morning and a few consecutive intervals during the evening ramp. As noted above, the storage resource would still have the ability to bid above the default energy bid to run less, if desired, and the resource would still be governed by minimum state of charge constraints.

The second default energy bid option is for storage resources to use the existing variable cost option and for the CAISO to expand additional adders relevant to storage resources. This could include making updates to existing variable operations and maintenance costs, major maintenance adders, or the addition of a new adder specific for batteries. Industry wide averages for replacement capacity could be calculated and applied to the existing variable operations and maintenance framework. These costs may be estimated for a specific time in the future, such as a specific number of years, and would be applicable to all storage resources with the variable cost options default energy bid selected. The CAISO could adjust the existing paradigm for major maintenance adders and begin storage resource specific adders that would be applicable to the energy components of variable cost default energy bids and only available to storage resources. Lastly, the CAISO could set up a new construct to include expected future maintenance costs in the energy component of storage resources with variable cost based default energy bids.

The third default energy bid option would be to model all costs for battery resources, similar to how gas resources are currently modeled with the variable cost default energy bid option. The CAISO would calculate how expensive a typical charge would be for a resource,[4] collect resource specific data characterizing parasitic losses and round-trip efficiency losses, and collect/validate data regarding cell and resource replacement costs. The model could calculate an actual expected marginal cost for each storage resource, which then could be used to inform the default energy bid. The CAISO is not proposing to implement this model, but has considered such an approach while developing this proposal. The CAISO believes that implementing such a model would be overly complex for storage resources, and that the above options are relatively more efficient.

6 Demand Response Resources

6.1 Operational Characteristics

Certain demand response resources may not have a minimum operating level similar or analogous to conventional resources, in which it registers a Pmin/Minimum Load value of 0 MW in the CAISO Master File. Experience has shown that a Pmin of 0 MW presents challenges for these resources to reflect specific operational limitations when operated at minimum load in the CAISO markets. Today, all resources committed in the residual unit commitment (RUC) process are dispatched to their Pmin so that they are available for dispatch and can ramp in real-time when needed. For demand response, the market instructs the demand response resource to its Pmin (respecting its minimum run time) and assumes the resource is ready to be dispatched and reduce load when instructed.[5]

The scenario above can result in a rational and economic dispatch where a demand response resource receives a dispatch to curtail load in one interval and

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[4] The CAISO may also estimate these costs in real-time from actual charging behavior.

[5] Definition of minimum run time
http://www.caiso.com/Documents/Section34_RealTimeMarket_asof_May2_2017.pdf

an instruction to return to its Pmin of 0 MW in another interval, and then another subsequent dispatch to curtail load again in another interval. While the market systems acting rationally and see the demand response resource as economic and capable of moving between its Pmin and Pmax in any interval the resource is online, certain demand response resources are inflexible and are only able to provide a single sustained response from its Pmin.

Option one: Using existing and soon to be implemented functions

In ESDER 3, the CAISO designed the hourly and 15-minute bidding options for proxy demand resources to extend notification times and longer duration interval dispatches. Additionally, with the implementation of the Commitment Cost and Default Energy Bid Enhancements[6] and Commitment Cost Enhancements[7] initiatives, resources will reflect start up and minimum load costs. Moreover, the CAISO tariff already expressly allows proxy demand resources to submit Minimum Load values.[8]

A proxy demand resource could elect an hourly bid option and define a non-zero dollar commitment cost at a Pmin of 0 MW. The proxy demand resource would no longer be a zero cost option in the CAISO's residual unit commitment optimization. If the resource were committed in the residual unit commitment, the proxy demand resource would be dispatched off its Pmin in hourly blocks.

The challenges here include the inability of a demand response resource to reflect its inability to provide multiple and variable dispatches to the grid because a demand response resource would not be able to curtail once instructed back to Pmin. Lastly, scheduling coordinators for demand response resources have hesitated to submit commitment costs and have asked the CAISO to provide guidance.

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[6] Commitment costs and default energy bid enhancements (CCDEBE) policy page http://www.caiso.com/informed/Pages/StakeholderProcesses/CommitmentCosts_DefaultEnergyBidEnhancements.aspx

[7] Commitment cost enhancements (CCE3) reference material http://www.caiso.com/informed/Pages/StakeholderProcesses/CommitmentCostEnhancements.aspx

[8] The CAISO tariff defines Minimum Load for proxy demand resources as "the smallest discrete load reduction possible for the Proxy Demand Resource."

The benefit of this proposal is the ability for a demand response resource to implement these changes when the policy proposals (ESDER 3, CCDEBE, CCE3) are approved by FERC and implemented.[9]

Option two: Non-zero Pmin with minimum load costs (minimum load cost)

During the March 18, 2019 working group meeting, the CAISO presented a scenario in which demand response resources could register a Pmin close to its Pmax and assign a minimum load cost.[10] The optimization will consider the non-zero Pmin and associated minimum load cost to determine if it is economic to dispatch a resource to its Pmin (close to Pmax). Additionally, the resource could utilize the maximum daily energy limit to identify a MW/hour quantity it can only be awarded to account for the limited run time of a demand response resource.

The challenge of this proposal is the concern from scheduling coordinators about determining and providing an accurate minimum load cost, similar to their concerns about providing commitment costs.

The benefit of option two is the ability of scheduling coordinators to use parameters that exist today without any dependencies on current or future implementation timelines.

In response to Southern California Edison's comments of the limitations of the maximum daily energy limit, if the resource identifies its Pmin at .01 MW below its Pmax, the CAISO will consider the minimum load cost and non-zero Pmin in the residual unit commitment process. If the resource is committed, it will be dispatched to its Pmin, and the CAISO will respect the maximum daily energy limit. Additionally, inflexible demand response resources that are not able to respond to varying dispatches will receive a consistent award at the non-zero Pmin value.

Option three: Maximum Run Time Parameter

Stakeholders have requested the CAISO to include a maximum run time parameter to resolve the issue of demand response resources being dispatched beyond program limitations. The issue occurs when the market observes a Pmin

[9] CCE3 has been approved by FERC and implemented. ESDER 3 and CCDEBE have not been filed with FERC, as both await technology development.

[10] Tariff Appendix A "Minimum Load Costs – The costs a Generating Unit, Participating Load, Reliability Demand Response Resource, or Proxy Demand Resource incurs operating at Minimum Load, which in the case of Participating Load, Reliability Demand Response Resource, or Proxy Demand Resource may not be negative. Minimum Load Costs may be adjusted pursuant to Section 30.7.10.2, if applicable."

of zero as an “on” state and moves dispatches between its Pmin and a non-zero value. Introducing a maximum run time parameter would allow a proxy demand resource to identify the maximum number of hours the resource could be “on.”

Challenges of option three include implementation and the market implications of a maximum run time, which would apply to all resource types. Option three would require the most implementation effort in comparison to option one or two and raises concerns of introducing an additional parameter, further stressing the market’s optimization engine. More importantly, if a proxy demand resource maintains a Pmax of zero and has a maximum run time parameter, the market may commit a resource to its Pmin of 0 MW and keep the resource “on” until its max run time hour is reached. This would result in a demand response resource instructed to a Pmin of 0 MW and not providing any curtailment to the CAISO.

A benefit of option three is the ability for the proxy demand resource to signal to the market its program hour limitations. The market will consider both minimum and maximum run times to determine when to schedule the demand response resources.

CAISO Proposal

The CAISO prefers options one and two because demand response resources can utilize existing or soon to be implemented parameters. With current implementation delays, demand response providers will have to understand the extended time needed to incorporate new parameters such as the maximum run time. The CAISO is willing to further vet option three, but will require stakeholder input on resolving the concern of a Pmin of 0 MW.

6.2 Variable-output demand response

Variable-output demand response resources are those whose maximum output can vary. For instance, certain demand response resources’ output may vary with weather, similar to wind and solar resources. An AC cycling demand response program can reduce more load on a hot day when air-conditioner use is high versus on a moderate day when air conditioner use is low. When a variable-output demand response resource bids its resource adequacy qualifying capacity (qualifying capacity) into the day-ahead market, depending on conditions, like weather, the resource may be unable to deliver its full stated capacity in real-time.

The central tenet of the resource adequacy program is to ensure sufficient energy is available and deliverable when and where needed. An inability to deliver energy associated with resource adequacy capacity because of certain dependencies is a significant issue. If the resource cannot bid its full qualifying capacity and deliver it under its must offer obligation, the resource will be assessed penalties through the Resource Adequacy Availability Incentive Mechanism (RAAIM). To address this issue, the CAISO and the CPUC/local regulatory authorities must modify demand response resource adequacy and market participation rules to align with the following two principles.

1. The qualifying capacity valuation methodology for demand response resources must consider variable-output demand response resources' reliability contribution to system resource adequacy needs.
2. Market participation and must offer obligations must align with variable-output demand response resource capabilities.

Operational capabilities of variable-output demand response resources are similar wind and solar resources because maximum output is dependent on some condition like weather, temperature, solar insolation, product production, etc. Increasing penetrations of variable resources, including certain types of demand response, make it important to quantify the contribution of these resources and their ability to serve system load. For wind and solar resources, this assessment is done by determining the resources' Effective Load Carrying Capability (ELCC).[11] Once an appropriate qualifying capacity value is determined for wind and solar by applying the ELCC, the resource can fulfill its must offer obligation by bidding the amount it is physically capable of providing per its forecast. In this paper, the CAISO proposes to demonstrate how a similar methodology should be applied to variable-output demand response.

This issue will need further vetting and decision-making at the CPUC and with other local regulatory authorities since local regulatory authorities have jurisdiction over establishing resource adequacy qualifying capacity values. To encourage and advance this issue, the CAISO is seeking stakeholder input for its recommendations to the CPUC regarding the appropriate methodology for establishing qualifying capacity values for variable-output demand response. It also will discuss how to operationalize and accommodate variable-output demand response as a resource adequacy resource in the CAISO market once the CPUC and local regulatory authorities have adopted such a methodology.

Determining the Qualifying Capacity value for variable-output demand response

Local regulatory authorities are responsible for determining the qualifying capacity values for resource adequacy resources. To set the qualifying capacity

[11] ELCC is explained in detail below.

for demand response resources, the CPUC adopted load impact protocols as a defined set of guidelines to estimate the load impacts of Investor Owned Utility demand response programs. Load impact protocols are a combination of ex post and ex ante assessments of load impacts used to determine the load reduction capability of each demand response program. Ex post impacts consider historical demand reductions during actual demand response events. Ex ante load impacts estimate load reduction capability for each month using 1-in-2 and 1-in-10 peak conditions. Ex ante impacts are forward looking and based on historical load impact performance. Load impact protocols generally rely on regression analysis to predict average customer load and estimate demand response program load impacts using independent variables including weather conditions, month, time of day, and day of the week.

For demand response auction mechanism resources, the qualifying capacity is set to the MW amount contracted as resource adequacy. Without a uniform method for establishing the qualifying capacity value based on the resource's contribution to system reliability, demand response auction mechanism resources may receive a qualifying capacity value that is not reflective of a resource's ability to deliver the energy associated with that capacity. Therefore, it is important to develop appropriate qualifying capacity methodologies for both utility and demand response auction mechanism based resources.

The CPUC employs an ELCC methodology to establish the qualifying capacity value of wind and solar resources. ELCC is a probabilistic approach used to quantify the reliability impact of a generator or class of generators. As a first step to determining the ELCC, the CPUC performs a loss of load expectation (LOLE) study to determine the expected average number of events during which system capacity is unable to meet CAISO system load. A commonly accepted LOLE reliability target is 0.1 days per year.

The ELCC quantifies the contribution of the generator or group of generators to resource adequacy by assessing the resource's ability to avoid a LOLE event considering inputs such as expected load, forced outage rates, transmission constraints, etc. When calculating the ELCC for wind and solar, the CPUC uses a ratio of the ability of a generator to avoid LOLE compared to a perfect generator and assigns a monthly, system-wide ELCC value to wind and solar resources to determine the qualifying capacity.

ELCC % = (MW of Perfect Generator) / (MW of resource being studied)

The ELCC value is a percentage applied to the nameplate capacity of a resource to determine the qualifying capacity. For example, a perfect generator would have an ELCC equal to 100%. A generator with an ELCC of 50% would be half as good at reducing LOLE as a perfect generator. If a solar generator had a nameplate capacity of 100 MW and a 50% ELCC, the resource adequacy qualifying capacity would equal 50 MW.

The CAISO believes the ELCC method can and should be applied to variable-output demand response resources. This type of assessment is appropriately applied to resources whose output is variable. Its application to variable-output demand response will provide a more accurate assessment of the actual load impact and load-sustaining capability variable-output demand response resource can provide the system.

The current load impact protocols rely heavily on historical data from past demand response events, including test events. Importantly, the load impact protocols do not consider a resource's contribution in all hours and do not necessarily align with the loss of load expectation (LOLE) study performed by the CPUC for its ELCC calculations. The ELCC evaluates a resource's ability to reduce the LOLE, rather than evaluating a resource's maximum load impact capability based on historic events that may or may not align with future system reliability needs.

Additionally, the load impact protocols assess the load impact of an individual resource rather than the reliability contribution of a portfolio of variable resources. The ELCC considers the ability of a portfolio of variable resources, which could include variable-output demand response under the CAISO's proposal, to reduce the LOLE. It is important to consider the portfolio of resources because the reliability contribution of a resource or class of resources can vary depending on the makeup of resources in the portfolio used to meet the resource adequacy need. The CAISO requests additional detail and reasoning from stakeholders who believe the load impact protocols on their own provide a more appropriate method for setting the qualifying capacity value for variable-output demand response over application of an ELCC methodology.

The ELCC methodology is an industry standard for valuing variable capacity resources for the purposes of resource adequacy. The CPUC uses an ELCC methodology to capture the variable nature of wind and solar resources when determining those resources' contribution to resource adequacy. The CAISO proposes similar treatment of variable-output demand response in determining their qualifying capacity values since the ELCC can capture the incremental benefit of a variable-output demand response resource to system reliability across multiple hours while considering the impact of the entire demand response and variable energy resource portfolio.

The CAISO initially proposes to use bids as the data set for the ELCC calculation. As outlined in the section below, the CAISO proposes to allow variable-output demand response resources to bid to their forecast. Because demand response resources bid the amount they are physically capable of providing, the bids should accurately reflect the capability of the resource. Although the CAISO does not consider the load impact protocols the most effective method for determining qualifying capacity values for variable-output demand response, the CAISO sees value in using a variation of the load impact protocols for determining an individual resource's load impact capability to develop a profile used for forecasting purposes. This profile could then be used as an input into the ELCC to evaluate variable-output demand response's reliability contribution.

Market participation and must offer obligations for variable-output demand response

Resource adequacy resources have must offer obligations to bid their resource adequacy capacity as specified in their supply plan into the CAISO market. Demand response resources on supply plans are required to bid in the hours specified within their program, typically aligned with the CAISO's availability assessment hours from 4:00 pm to 9:00 pm. If the resource does not bid according to its must offer obligation in these hours, it could be assessed a non-availability charge through RAAIM. Because the current qualifying capacity valuation for variable-output demand response does not accurately reflect what the resource can actually provide each hour, resources risk being assessed RAAIM penalties in hours they cannot bid all of their resource adequacy capacity.

Alternatively, the CAISO allows VERs to bid the amount they are physically capable of providing as specified through a forecast in order to meet their must offer obligation. Scheduling coordinators for VERs must either use a forecast provided by the CAISO or submit their own CAISO-approved forecast. The CAISO uses this forecast as the upper economic limit on bids. Therefore, the maximum dispatchable output for a resource could be above or below the qualifying capacity value depending on the resource's forecasted output. Wind and solar resources are exempt from RAAIM penalties for generic (local and system) resource adequacy.

Because the local regulatory authority should adopt an ELCC methodology for determining the qualifying capacity for variable-output demand response, the CAISO is considering here how to accommodate variable-output demand response resources in the CAISO market similar to VERs, in which the resource bids to its forecast. Because demand response resource performance is largely dependent on consumer behavior, the CAISO does not have the appropriate visibility into individual resource capabilities to forecast load reduction for these resources. As such, the CAISO proposes that scheduling coordinators for the resources would submit their own forecasts to the CAISO. Although the CAISO does not believe the load impact protocols are appropriate as the sole mechanism for determining the qualifying capacity value of variable-output demand response, methodologies used in the load impact protocols may be appropriate for developing these load curtailment forecasts. As suggested in CLECA's comments to the issue paper working group meeting,[12] if load impact protocols were modified to develop a profile of load impacts rather than a single capacity value, the load impact protocol profile could be used as a forecast for variable-output demand response.

The must offer obligation for variable-output demand response would not require the resource to bid up to the resource adequacy capacity quantity but rather to the forecast quantity. The forecasted value could be at, above, or below the capacity value specified in the supply plan. Under this proposal, the CAISO is considering exempting variable-output demand response that bids to its forecast from RAAIM, similar to wind and solar. Nevertheless, the CAISO should adopt a variable bidding option for variable-output demand response resources only if the Commission adopts an appropriate qualifying capacity valuation methodology using the ELCC.

Because the CAISO proposes the scheduling coordinator for the resource would submit the forecast that would set the resources must offer obligation, it is important to establish adequate controls to ensure the forecast accurately reflects resource capability. The CAISO is considering ways to eliminate any incentives for submitting inaccurate forecasts including auditing provisions, testing procedures, and performance penalties. The CAISO welcomes stakeholder feedback on such controls that should be put in place.

7 Behind the Meter Technology Applications

Based on a joint proposal from the CAISO and CPUC staff, the California Public Utilities Commission (CPUC) adopted a decision on multiple-use applications that included eleven rules to guide the formation of multiple-use applications, including energy storage.[13] In examining the application of these multiple-use application rules in the CAISO market, stakeholders have questioned whether non-generator resources should be able to choose in which market intervals to

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[12] Comments by CLECA to the ESDER 4 Issue Paper Working Group, April 1, 2019. http://www.caiso.com/Documents/CLECAComments-EnergyStorage-DistributedEnergyResourcesPhase4WorkingGroup-Mar18-2019.pdf

[13] http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M206/K462/206462341.pdf

they participate. Currently, non-generator resources are 24x7 wholesale market resources (comparable to all other supply resources). Non-generator resources are financially settled for charge or discharge in a given interval, regardless of whether the resource received a CAISO dispatch instruction. Stakeholders have expressed that they would like this rule to change so that resources could participate in the wholesale market some time, but participate in other markets other times without being subject to wholesale settlement. Stakeholders especially would like behind-the-meter resources to be able to participate in other markets without 24x7 wholesale settlement because their point of interconnection allows them to provide retail and distribution services most easily.

If the CAISO were to consider a non-24x7 settlement for non-RA behind-the-meter resources under the non-generator resource model, there are several issues and questions that need to be answered and resolved:

1. As a behind the meter resource under the non-generator resource model, any wholesale market activity will affect the load forecast. How will load serving entities account for changes to their load forecast and scheduling due to real time market participation of behind the meter resources?
2. How would a utility distribution company prevent settling a resource at the retail rate when the behind-the-meter device is participating in the wholesale market?
3. If a behind-the-meter resource is settled only for wholesale market activity, what would prevent a resource from charging at a wholesale rate and discharging to provide retail or non-wholesale services? How would this accounting work?

Before moving forward, the CAISO is requesting stakeholders to provide greater input and insight to the questions listed above.

8 Next Steps

The CAISO will hold a stakeholder web conference on May 7, 2019 to review the straw proposal and encourages stakeholders to submit comments by May 17, 2019. The CAISO will hold an additional working group meeting (will be announced via market notice) to refine proposals before the revised straw proposal is published.