Energy Storage and Distributed Energy Resources Phase 4

Revised Straw Proposal

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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 ability of these resources to participate in the CAISO's market.[1] The number and diversity of these resources continue to grow and 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. State-of-charge parameter for the non-generator resource model;
2. Streamlining interconnection agreements for non-generator resource participants;
3. Applying market power mitigation to energy storage resources;
4. Maximum daily run time parameter for demand response;
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.

1. State-of-Charge Parameter

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

The real-time market optimization horizon may impede scheduling coordinators from managing their non-generator resource over the day given resources in real-time are not optimized over the entire operating day. Instead, the furthest unit commitment outlook is the CAISO's Short Term Unit Commitment (STUC), which looks out approximately 4.5 hours. Thus, the real-time market is incapable of ensuring a resource's state-of-charge is sufficient to meet future dispatches beyond the different

[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.

real-time market unit commitment and dispatch horizons.[2] For instance, based on the resource's bids, the real-time market may find that it is most economic, over the short-term, to leave storage resource fully discharged early in the day. However, leaving the resource discharged could prevent the optimal use of the resource later in the day given the limited outlook of the real-time market horizon.

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 or its obligations as a transmission asset later in the day.[3]

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.[4] Scheduling coordinators will be able to submit an end-of-hour state-of-charge value with their bids in the real-time market. In addition, the scheduling coordinator can represent the end-of-hour state-of-charge parameter as a minimum and maximum range.

Scheduling coordinators are able to update their real-time bids at any point after the day-ahead market and up until the relevant real-time market closes. The 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. The CAISO will not extend the end-of-hour state-of-charge to the day ahead market. A scheduling coordinator will have the ability to submit its initial state-of-charge in the day-ahead market to match its end-of-hour state-of-charge from real-time.[5] This will align the resources end of day state-of-charge with its following day-ahead schedule to ensure feasible market dispatch and scheduling of the resource.

The scheduling coordinator will submit an end-of-hour state-of-charge to reflect a minimum and maximum range. If the scheduling coordinator desires a target state-of-charge, then the minimum and maximum state-of-charge values should be set the same.

The state-of-charge parameter is different from the current upper charge and lower charge limits, which are energy limits represented by MW. Instead of ensuring that resources receive an economic dispatch within an upper charge and lower charge limit, the proposal will allow the market to dispatch non-generator resources economically or uneconomically to achieve the scheduling coordinator's hourly end-of-hour state-of-

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[2] For more details about rea-time market timelines, please see CAISO Business Practice Manual for Market Operations, section 7.1.1- Real-Time Market Timelines.

[3] The CAISO has a policy initiative that is investigating how a storage device could act as a transmission asset, yet still participate in the CAISO market. See the Storage as a Transmission Asset Initiative at: http://www.caiso.com/informed/Pages/StakeholderProcesses/StorageAsATransmissionAsset.aspx

[4] End-of-hour state-of-charge parameter will only apply to non-generator resources participating as non-regulation energy management.

[5] Day ahead market bids are submitted 12 hours before the start of the day and real-time market bids for the last hour of the day must be submitted 2 hours and 15 minutes before.

charge when offered to the CAISO. Non-generator resources may receive energy schedules they would not have otherwise "optimally" received since the elected state-of-charge parameter takes precedence over economic outcomes in the market optimization.

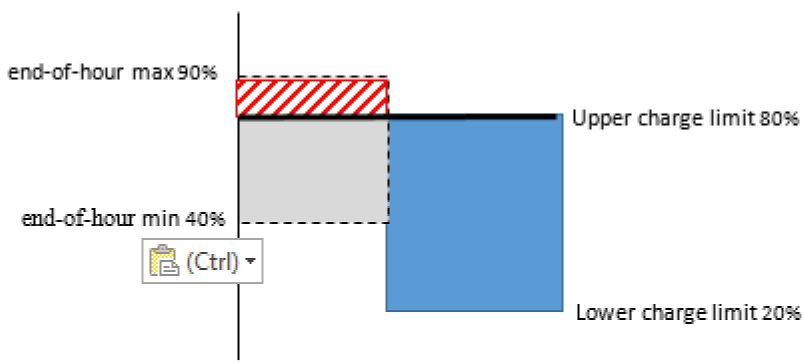
1.1 Resource Constraints with End-Of-Hour State-Of-Charge Parameter

The real-time market will respect all resource constraints when determining a non-generator resource's 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 the end-of-hour state-of-charge.

Upper and lower state-of-charge constrained

The real-time market will always respect a non-generator resource's upper and lower state-of-charge values. Consequently, the market optimization will ignore hourly end-of-hour state-of-charge values if they fall outside the resource's achievable upper and lower state-of-charge values. For instance, as shown in Figure 1, if a scheduling coordinator submits an end-of-hour state-of-charge of 90% for a resource with an upper 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.

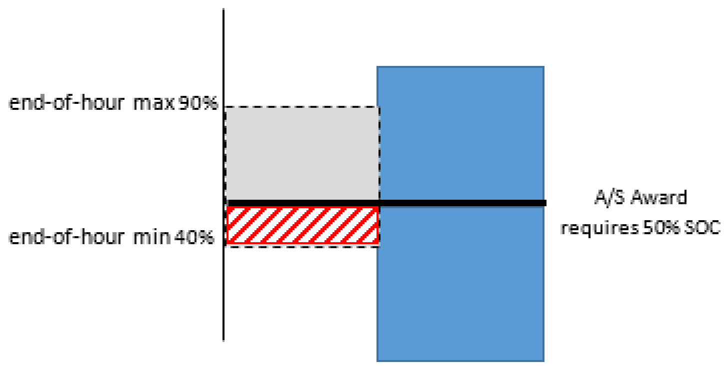
Figure 1: End-of- hour state-of-charge constrained by upper and lower charge limits



Ancillary service award constrained

The market will respect ancillary services awards when a scheduling coordinator provides 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. As illustrated in Figure 2 below, if a scheduling coordinator were to submit an end-of-hour state-of-charge of 40%, but the resource's ancillary service awards require a 50% state-of-charge, to ensure the ancillary service's award can be met, the market will maintain the more limiting 50% state-of-charge.

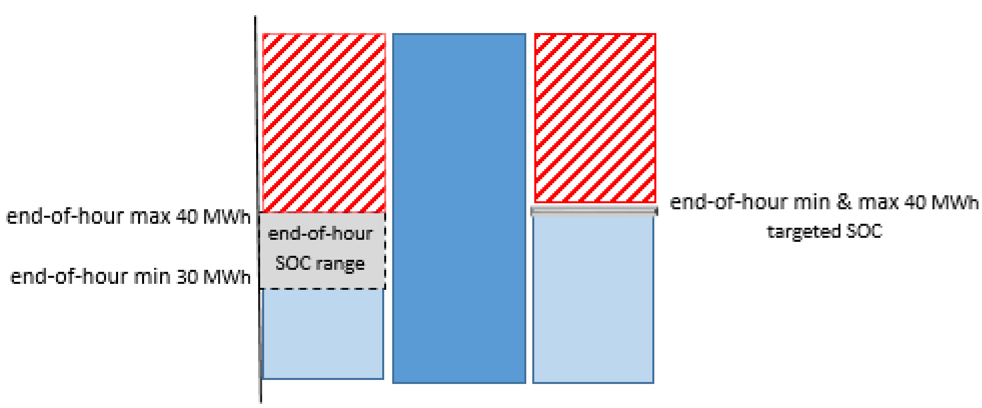
Figure 2: End-of-hour state-of-charge constrained by ancillary service award



Range in state-of-charge bid

The scheduling coordinator will submit the end-of-hour state-of-charge parameter as a range. Meaning, the state-of-charge in MWh will represent a minimum and maximum value the market will respect. For example in Figure 3, if a scheduling coordinator wants to meet a specific state-of-charge of 40 MWh, it will submit a minimum value of 40MWh and maximum value of 40MWh. The market will optimize the non-generator resource to meet the targeted value. If a scheduling coordinator needs a resource to have a minimum state-of-charge of 30 MWh regardless of market prices and a desire to charge up to 40 MWh if it is economic, the bid will represent a range of 30-40 MWh. Dispatches up to the minimum value of 30 MWh may or may not be economic for the resource. If market prices are economic for the resource in the 30-40 MWh range, the market will dispatch the non-generator resource up to a value within the range of 30-40 MWh.

Figure 3: End-of-hour state-of-charge bid range



The CAISO will 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.

1.2 Bid Cost Recovery Rules

The CAISO will exclude a non-generator resource's bid cost recovery settlement in intervals where an end-of-hour state-of-charge bid parameter or self-schedule creates an uneconomic dispatch. If the CAISO must dispatch a resource uneconomically to meet a non-generator resource's state-of-charge bid, or to maintain a state-of-charge necessary to meet a self-schedule, it is doing so to meet the scheduling coordinator's strict requirement regardless of market prices. Therefore, the resource should bear the associated costs of this movement rather than require the CAISO to uplift the costs to aggregate demand.

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

a. the submitted end-of-hour state-of-charge is greater than the current state-of-charge and the resource was dispatched to charge uneconomically; or

b. the submitted end-of-hour state-of-charge is less than the current state-of-charge and the resource was dispatched to discharge uneconomically.

The CAISO in its development of the end-of-hour state-of-charge parameter recognized that today, non-generator resources can self-schedule and receive bid cost recovery even though the market must optimize around the self-schedules. Therefore, a self-scheduled non-generator resource will be ineligible for bid-cost recovery in an hour where:

a. the next-hour submitted self-schedule requires more charge at the beginning of the next hour than the current state-of-charge and the resource was dispatched to charge uneconomically for any interval in the current hour; or

b. the next-hour submitted self-schedule requires less charge at the beginning of the next hour than the current state-of-charge and the resource was dispatched to discharge uneconomically for any interval in the current hour.

1.3 End of day state-of-charge parameter

Some stakeholders commented that they would like the ability to bid into the market at "true spread bids." The CAISO understands this as a request that storage resources are neither required to be net buyers nor net sellers of energy, but rather they be energy neutral in a day when the market clears energy schedules for storage resources. In other words, every MW of energy that the resource is buying or selling in the market is not being purchased or sold at prices that are at least as great as the "spread" they are bidding into the market.

For example, a storage resource bids to charge at $20/MWh and to discharge at $50/MWh. The resource might either be 1) discharged during more hours than is scheduled to charge (and this difference could be significant), or 2) may charge for more energy than the resource is scheduled to discharge.

Based on discussions with stakeholders, both scenarios are probable. If prices are particularly low (i.e. lots of hours with prices below $20/MWh) then the storage resource would be scheduled to charge during the cheapest hours of the day, and may not be scheduled to discharge; or prices could be high (i.e. lots of hours with prices greater than $50/MWh) and the resource could be scheduled to discharge for the highest priced hours, but not scheduled to charge.

For most resources on the grid, bids in the real-time market represent the marginal cost to produce energy. For storage resources, these bids represent a willingness to store and buy energy while charging, and to provide and sell energy while discharging. If a storage resources is willing to buy energy at $20/MWh and is willing to sell energy at $50/MWh, and the market observes and respects those constraints, it is confusing why there would be a need for additional mechanisms to ensure that the quantities of energy bought and sold remain identical throughout the day.

Simple scenarios with inefficient outcomes resulting from this parameter can be constructed. If a resource is at the end of day state of charge during the penultimate interval of the day the resource would not be dispatched to charge in response to -$150/MWh energy prices or to discharge in response to $1,000/MWh scarcity prices, even though it would likely be economic for the resource to do so. Further, if a resource was at the end of day state of charge in the third to final interval of the day, and there is a price spike in that interval the resource could be dispatched to discharge and receive those high prices. However, in the next interval, the resource would be required to charge to return to the end of day state of charge for the day. Doing this could make system shortage conditions worse by adding negative generation to already stressed system conditions. This thought process could be extended further to earlier intervals. This logic may imply that an end of day state of charge parameter could lead to prolonged market scarcity in hours near the end of the day, and potential reliability issues.

The CAISO is currently not proposing an end of day state-of-charge at this time but recognizes that this is a stakeholder request. The CAISO would like to continue dialogue on the merits and implications of introducing this parameter.

2 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.

3 Market Power Mitigation for Storage Resources

To ensure that wholesale prices are just and reasonable, the CAISO and other organized markets have mitigation measures to minimize the exercise of market power and non-competitive outcomes.[6] The CAISO employs a tool called local market power mitigation (LMPM), which replaces market bids with marginal cost based default energy bids (DEBs) when it detects potential market power. The local market power mitigation tool helps to ensure that market prices are economic in uncompetitive situations.

Today, there are about 150 MWs of grid-connected storage resources installed on the system; none is currently subject to market power mitigation. This number does not include behind the meter storage resources installed in households or businesses. However, there are over 48,000 MW of storage generation in the CAISO interconnection queue, some of which could potentially be developed and deployed on the system within the next few years. [7] The CAISO believes that it is important and not too early to begin vetting and developing mitigation measures to manage potential market power of energy storage resources.

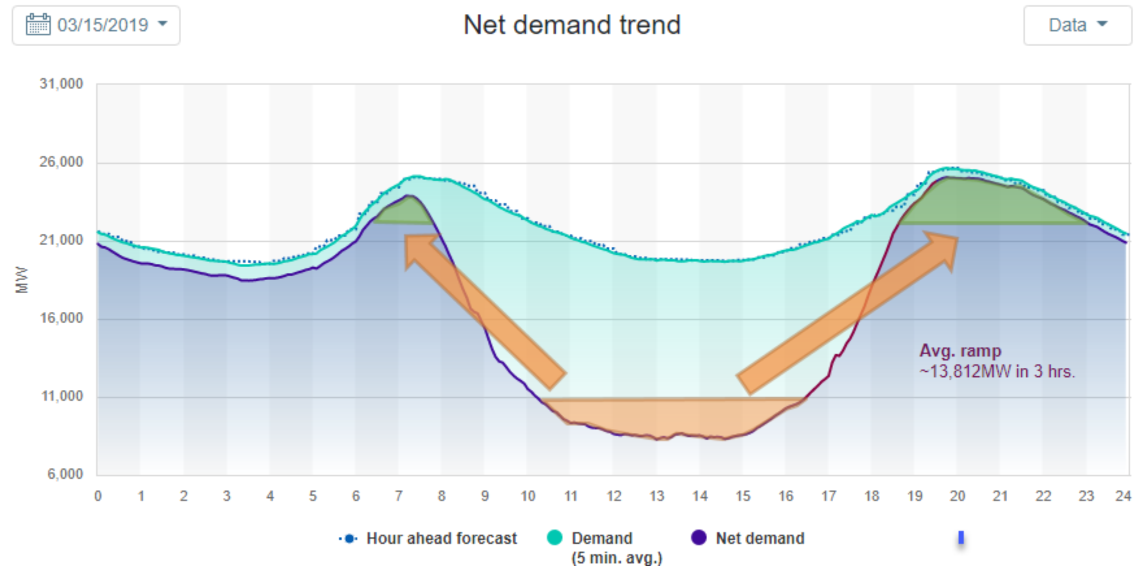
Storage resources can be versatile and have various opportunities to earn potential revenues in the CAISO day-ahead and real-time market. Some of these opportunities include arbitraging energy market prices and potentially moving large amounts of energy from low priced periods to high priced periods in the day to help with renewable integration. These resources are also generally flexible and have fast ramping capabilities to offer ancillary services to the market. Balancing potential revenue streams, in addition to potential fixed payments through the resource adequacy framework, can be challenging for certain storage resource types given their cost structure.

Prices in the day-ahead and the real-time markets generally follow predictable patterns that mirror net load.[8] The net load usually implies lower prices in the later morning hours, after solar generation comes online, followed by higher prices in the evening, after solar generation goes offline. In the spring, storage resources have the ability to buy energy when prices are lowest early in the morning, sell during the morning ramp, buy energy again when solar is fully online, and sell during the peak net load hours when prices are highest. Figure 4 below illustrates sample load and net load curves for a day in March. This chart shows that a resource could purchase energy during the lowest net load periods of the day (orange highlight) and sell during the highest net load periods of the day (green highlights). This specific day also shows that there could be

[6] 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.
[7] Currently the CAISO's interconnection queue (Up to cluster 12) has over 230 projects both stand alone and hybrid energy storage totaling up to 48,559 MW.
[8] Net load is gross load less solar and wind generation.

an opportunity for this resource to charge prior to the morning peak, during hours ending 3 to 5 (not highlighted).

Figure 4: Net load on March 15, 2019

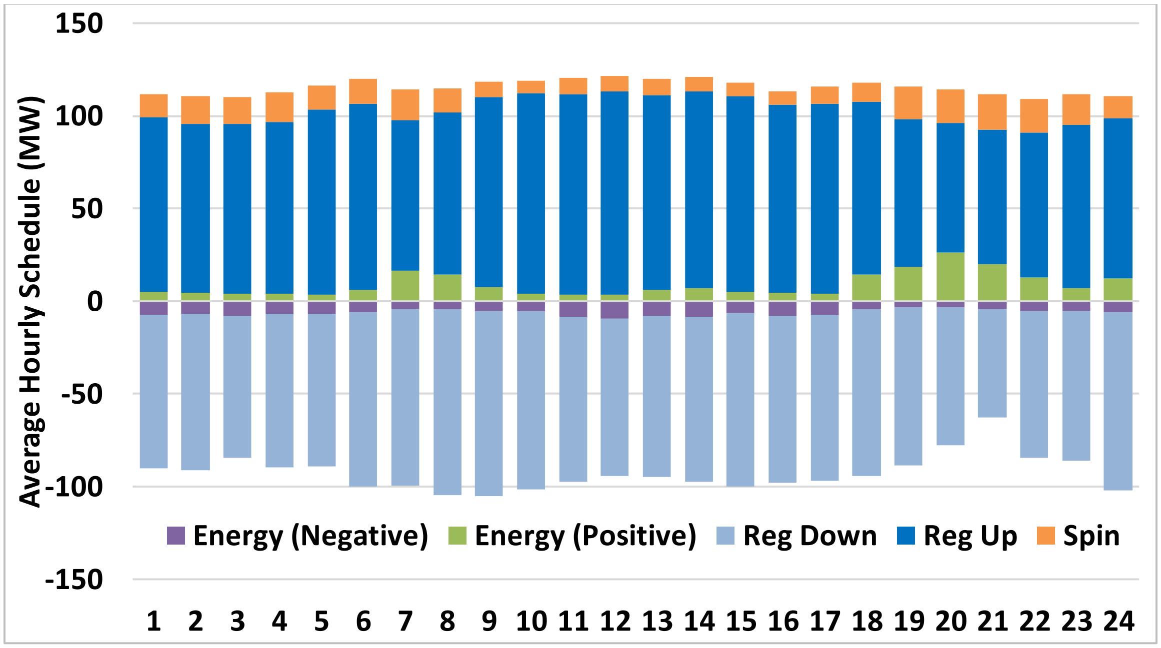


In the real-time market, storage resources may also have the opportunity to respond to short-term price spikes in low supply or oversupply conditions. In low supply conditions, the market often conveys high system marginal costs, which can be up to a $1,000/MWh penalty price for the power balance constraint. Conversely, in oversupply conditions, market prices can drop as low as -$150/MWh as a penalty price for the power balance constraint. Because storage resources have the ability to ramp quickly, they are well suited to take advantage of these prices in the real-time market.

Resources are able to collect revenue for providing ancillary services, such as regulation, by responding to automatic generation control signals in the market. Revenues from providing ancillary services to the market may be lower than revenues earned in the energy market, but generally come with awards that require the resource to provide less energy overall. This is advantageous for storage resources that have to purchase energy from the grid; encounter efficiency losses on energy purchased, and will eventually require maintenance because of charging and discharging.

As stated earlier, the CAISO operates about 150 MWs of storage resources today. Most participate as resource adequacy capacity. These resources receive compensation for their capacity, which make up a large component of the resource's total revenues. Although energy storage participates in the day-ahead and real-time markets, a majority of the 150 MWs sell very little energy into the system. As shown in Figure 5, most of the capacity for energy storage clears in the ancillary service market to provide regulation.

Figure 5: Average hourly schedules for storage resources (Jan-June 2019)



The data shown in Figure 5 supports the CAISO's assertion that energy storage resources are incentivized to reduce cycling through regulation services and only provide energy in the day-ahead or real-time market when prices are high. Several factors lead to this behavior. First, a majority of energy storage technologies participating in the market are lithium-ion based devices and have cycling limitations due to manufacturer warranties or performance guarantees. Second, storage resources receive a capacity payment from resource adequacy to reflect fixed costs. The majority of the fixed cost represent warranty contracts that specify an amount of cycling the resource can achieve over a pre-defined time horizon.[9] A typical warranty for a four-hour storage device may allow for one cycle, a full discharge and charge, per day over ten years of operation. If the resource exceeds the limit, it could void its warranty, or reduce the "guaranteed" calendar life of the battery.

The CAISO believes the current warranty constructs and capacity payments for battery storage resources may not reflect the true costs of owning and operating these devices. These physical and contractual constraints may be impeding these resources from wanting to shift large tranches of energy from the afternoon to evening in the energy market to help integrate renewable resources like solar PV. Further, it is unclear if actual price spreads in the electricity market are sufficient to clear any hurdle that would make it economic for these resources to shift large quantities of energy. This is in part due to data showing that the highest possible spreads to move 4 hours of energy during the day are just over $40/MWh, and the spreads in the morning hours – when they are present – are less than $20/MWh on average. The CAISO's objective is to build a

[9] CAISO staff learned this from discussions with multiple parties that operate storage resources in the market.

construct for storage resources that will accurately reflect true costs, and may be used to mitigate resources when true costs are below observed market prices.

Proposal

The CAISO is proposing a default energy bid applicable to all storage resources on the system. This default energy bid will be representative of marginal costs for storage resources, calculated from a methodology outlined in this policy initiative. Furthermore, each energy storage resource will submit parameters to the CAISO that are verified, stored in master file, and are subject to review to inform calculations for approximating actual marginal costs.

In the CAISO's initial straw proposal, several possible methodologies to model storage resource costs were introduced. These included additional adders on existing variable cost default energy bids, an estimated cost methodology to allow storage resources to discharge during certain high price hours, and a methodology to model true costs for a resource. After further considering stakeholder feedback, the CAISO proposes to set a default energy bid that reflects the true marginal cost of energy storage.

The CAISO's default energy bid proposal includes costs related to discharging lithium-ion storage resources, which are the most prevalent storage resources on the system and in the queue. As these resources charge and discharge, the physical make-up of the cells degrade, causing the cells to be less effective in total charging capability, which eventually requires cell replacement. Since this degradation cost is strictly associated with the operation of the resource, it is a marginal cost and should be included in the default energy bid. However, this cost is difficult to model because it is non-linear in nature, may increase with the total depth of discharge of the resource, and may be technology or chemistry dependent. Thus, further vetting is warranted as we continue to develop the proposal through this stakeholder initiative.

The details outlined for this default energy bid include a calculation that is dynamic, and that can change on an interval-by-interval basis with depth of discharge or specific dispatch instructions that are sent to a resource. Currently the CAISO does not update default energy bids at any time during the day, except in cases where there is extreme gas price volatility, in which default energy bids are updated once. This is a paradigm where the default energy bid for a resource would be changing continuously throughout the day. Further, default energy bids today allow scheduling coordinators to match bids with default energy bids. With this proposed construct, this is not possible. In addition to updating the default energy bids, bidding capabilities for storage resources will need to be enhanced as well. This is discussed in the proposal further below.

3.1 Default Energy Bid Formulation

To apply local market power mitigation, the CAISO determines cost components to include in the default energy bid for storage resources. Costs for energy storage resources fall into four separate components and are described in detail below:

1. Energy Costs
2. Energy Losses
   - Parasitic losses
   - Round-trip efficiency losses
3. Cycling Costs
4. Opportunity Costs

Each of these four components are included in a default energy bid calculation outlined in Equation 1. Each component is described in the text further below.

Equation 1: Storage Default Energy Bid

$$Storage\ DEB = Max\left[\left(\frac{En}{\lambda} + CD\right), OC\right] * 1.1$$

Where:

En: Estimated cost for resource to buy energy
λ: Round-trip efficiency losses
CD: Cost to discharge
OC: Opportunity Cost

Because energy storage could back down generation from 200 MW to 100 MW or charge at -100 MW to -200 MW to increase prices in local areas, the CAISO is proposing the default energy bid be applied to the entire output of a storage resource, not to only the discharging portion of the resource bid. The CAISO is proposing to mitigate resources from a charging to a discharging output.

The formulation for the default energy bid outlined in Equation 1 above includes a variable 'CD' to account for the cost for a resource to discharge. This value will be zero for the entire charging portion of the bid. Therefore, for any market interval the default energy bid will always be a constant value for the entire charging portion of the portion of the resource's operating range. This calculation will always ensure that the default energy bid is monotonically increasing with output.

3.1.1 Energy Costs

Storage resources are different from traditional resources on the CAISO system. For example, gas fired generators have an available fuel supply that is converted to energy, and the heat rate, which describes the efficiency of the resource, informs the resource's marginal cost. Storage resources "buy" energy from the grid and sell that energy back to the grid by discharging at a later point in time. When a storage resource discharges, the impacts to the grid are identical to a traditional generator running.

It is critical that a value approximating the costs of energy purchased through the wholesale market be included in the default energy bid for storage resources. For example, if a storage resource buys energy at the lowest prices of the day at $10/MWh, it will have significantly lower costs than when energy costs are $50/MWh. Energy purchased at higher costs implies that sales need to be made at higher prices to maintain the same price spread.

The CAISO proposes a methodology to estimate costs that a storage resource may pay to charge. This value will be applied to default energy bids used for storage resources.

The methodology will use current day-ahead prices to estimate the marginal cost a storage resource may pay to procure energy in the day-ahead up to its full capacity. In the case of a 4-hour storage resource, this formula would be the 4th expected lowest hour of prices in the upcoming day.[10] This is expressed in Equation 2.

Equation 2: Energy Costs

$$En_t^{\delta} = En_{t-1}^{\delta} * Max\left(\frac{DAB_t}{DAB_{t-1}}, 1\right)$$

where:

En: Expected energy price
DAB: Day-ahead bilateral hub
t: Interval (day)
δ: Storage duration for the resource (i.e. 4 hours)

The formula is flexible and can represent the marginal price a resource pays for energy in the previous day if the energy is already purchased, or if the resource purchased energy the upcoming day. Further, this calculation will be performed for each resource, and expected prices will be calculated based on past prices at this resources location.

Each storage resource will have a representative bilateral electricity hub that will be used to calculate these expected prices, such as North-of-path 15, South-of-path-15, mid-Columbia, etc. These hubs will serve to scale current observed prices to day-ahead prices. The scaling will not be applied if day-ahead bilateral prices were higher for the current day than the successive day. Not applying a scalar may represent marginal prices that a storage resource could have paid to purchase energy, if energy was purchased today.

This calculation is not representative of the average price that a resource pays for energy and the CAISO is planning analysis for a future iteration. However, the price estimates are generally reflective of prices that a resource might purchase energy at, and may even overstate the average amount paid if the resource is performing one cycle per day or less.

[10] For example, if prices were $45, $35, $32, $30, $27, $31, $40; the fourth lowest hour would be $32.

Currently, the CAISO is not considering a methodology that includes the actual expected load from prior days. This may not be necessary as these load values should be internalized in the bilateral hub prices that are used to scale past prices.

3.1.2 Energy Losses

Generally, parasitic and round-trip efficiency losses may impact energy storage resources. Parasitic loss is the energy lost over time when energy is stored in a battery. Parasitic losses are calculated anytime a storage resource is charged. Because parasitic losses reduce the amount of energy stored in the battery, compared to the energy used to charge the battery, this factor can be accounted to scaling up the estimated price paid for energy. The energy loss inflates the amount of money that must be recouped from the sale of the stored energy when sold.

Currently, the CAISO is not proposing a methodology to account for parasitic losses. These costs may be accounted for by the storage resource's average state of charge and a variable describing how much that state of charge degrades over time. The CAISO requests stakeholder suggestions on how to incorporate such a calculation into the proposed default energy bid.[11]

The CAISO is proposing to account for round-trip efficiency losses account for energy that is lost due to the inefficiencies of charging. For example, a resource purchases and withdraws 10 MWh of energy from the grid, but is only able to discharge a total of 9.5 MWh of energy. Round-trip efficiency losses are measured as a percentage and typically range from around 85%-95% for lithium-ion resources.

3.1.3 Cycling Cost

To date, the CAISO focused primarily on potential models for cycling costs because they represent the most complex component of marginal costs for storage resources. In this proposal, the CAISO outlines two methodologies to account for cycling costs based on academic research by Bolun et al. This research uses a 'rain-flow' model to account for depth of discharge, the primary contributor to storage cycling costs.[12]

Cycling costs are particularly relevant for lithium-ion batteries, and this methodology captures the idea that 'deeper' discharges may be more expensive than shallow discharges. As discussed above, as a storage resource charges and discharges, the metal that physically makes up the battery degrades. As this happens, the battery becomes less effective at holding charge, and eventually will be unable to meet CAISO interconnection specifications required for the resource. This will necessitate that the owner upgrade the storage resource so that it can meet its obligations. The research shows that degradation occurs faster when resources are discharged from very high

[11] 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.

[12] "Factoring the Cycle Aging Cost of Batteries Participating in Electricity Markets," Bolun, et al. https://arxiv.org/pdf/1707.04567.pdf.

states of charge to very low states of charge, compared to operating within a narrow band for state of charge, even when delivering identical quantities of energy (MWh) to the grid.

Example: Depth of Discharge Costs

Depth of discharge costs refers to the costs incurred from cell degradation when a storage resource discharges energy from an initial state of charge to another final state of charge. This example illustrates that total costs associated with depth of discharge may be quadratic, is incurred over large spans of time, and that a single calculation for depth of discharge may be dis-aggregated by other discharge periods.

This example presents a hypothetical storage resource that has a straightforward quadratic relationship between depth of discharge and total cost. Total costs associated with specific discharge of a certain depth are outlined in Table 1. The table shows that discharging the resource by 10% will only cost $1, while discharging the resource by 20% will cost $4. As the total depth of discharge increases, the total costs associated with that discharge also increases in a quadratic fashion.

Because total cost increases at a quadratic rate, the marginal cost increases linearly with the total depth of discharge. For example, the additional cost incurred from discharging just 10% of the total state of charge to 20% of the state of charge incurs an additional $3 of total cost. Therefore, total costs rise from $1 to $4. A discharge of 20% of the total state of charge to 30% will incur an additional cost of $5, increasing the total from $4 to $9.

Table 1: Costs associated with specific cycle depths

Cycle Cepth (CD)	Total Cost ($)	Marginal Cost ($)
10%	1	1
20%	4	3
30%	9	5
40%	16	7
50%	25	9
60%	36	11
70%	49	13

A numerical example with a resource and accompanying hourly energy schedules is outlined in Table 2. In this example, suppose a hypothetical resource is capable of storing and releasing up to 10 MWh of energy, and the resource is initially charged at 7 MWh (or at 70% state of charge). The resource then discharges from 7 MWh (70%) down to 3 MWh (30%) and the associated total cost is $16. As expressed above, the dependency for determining costs is not on the time that the discharge occurs, but the quantity of discharge in energy or change in state of charge. On the left side of Table 2, the discharge from 7 MWh to 3 MWh occurs in a single hour. In hour 2, the resource is scheduled to discharge 4 MW, but is not scheduled to discharge at any other time in the day. The right hand side of Table 2 shows an example where the discharge is spread over a 4-hour period, in hours 2 through 5. During each of these hours, the resource is scheduled to discharge at 1 MW. Table 2 illustrates the total costs and the marginal costs for both discharges. Notice, on the right hand side, that each successive hour that the resource is dispatched, the cost to operate increases.

Table 2: Marginal Costs for different dispatches

Hour	P (MW)	SOC (MWh)	SOC (%)	Cost		Hour	P (MW)	SOC (MWh)	SOC (%)	Cost
1	0	7	70%	0		1	0	7	70%	0
2	4	3	30%	16		2	1	6	60%	1
3	0	3	30%	0		3	1	5	50%	3
4	0	3	30%	0		4	1	4	40%	5
5	0	3	30%	0		5	1	3	30%	7
6	0	3	30%	0		6	0	3	30%	0
				16						16

Bolun goes on to illustrate that when charging and discharging at multiple intervals, the cost calculation approach “resets” when the resource begins to charge. For example, if the same example resource used above, discharges from 7 MWh to 3 MWh, then charges from 3 MWh to 5 MWh, then discharges from 5MWh to 1 MWh, the costs associated with the two discharges are equal to a single 6 MWh discharge plus a single 2 MWh discharge. The costs are not equal to two separate 4 MWh discharges. These costs are illustrated in Table 3. Note that the marginal costs accrued in hours 5 and 6 correspond to a 50% and 60% discharge, rather than a 30% and 40% discharge from Table 1.

Table 3: Multiple charge and discharge periods

Hour	P (MW)	SOC (MWh)	SOC (%)	Cost ($)
1	0	7	70%	0
2	4	3	30%	16
3	-2	5	50%	0
4	2	3	30%	4
5	1	2	20%	9
6	1	1	10%	11
				40

The Model

Based on the information above, the CAISO is proposing two options for modeling cycle costs. These models are illustrated by examples of how depth of discharge might contribute to total costs and marginal costs for a storage resource.

1. Total Depth of Discharge Model

This model assumes costs at the resource's maximum cycle depth and it increases as the state-of-charge decreases. The model's assumptions align with the concept of increasing marginal costs with lower state of charge values but may overestimate the cost for storage resources to discharge.

Equation 3: Total Depth of Discharge

$$CD_{i,t} = v_{i,t}\,\rho_i\left(\text{Max SOC} - SOC_{i,t}\right)$$

where:

v:	Value equal to 1 when the state of charge is decreasing
ρ:	Cell degradation cost (Constant)
Max SOC:	Maximum SOC available for dispatch (generally 100%)[13]
SOC:	State of charge
i:	Resource
t:	Interval

To illustrate this approach, assume there is a hypothetical storage resource capable of generating in the range between -24 MW (charging) to 24 MW (discharging), and the resource is capable of storing up to 100 MWh of energy. Suppose further that the resource operator determined that the cost for cell degradation is $20/MWh, which will be used for the value of ρ.

The total depth of discharge approach is a model where cycling costs are calculated dynamically, and are directly related to the state of charge for the resource at the day-ahead or real-time interval when the default energy bid is being calculated. The costs to discharge will increase as the state of charge value decreases.

Figure 6 shows the relationship between state of charge and total cost for discharge, as illustrated in Equation 3. In this example, when the resource is fully charged, at 100% state-of-charge, the cost to discharge would only be $0.20 for 12 MW or $0.40 for 24 MW, or a linear function including those values between 0 MW and 24 MW. At a later point in time, when the state-of-charge is lower at 40%, the cost to discharge increases to $12.20 for 12 MW or $12.40 for 24 MW. Each successive discharge, corresponding to lower total state of charges, corresponds to increasing costs for discharge.

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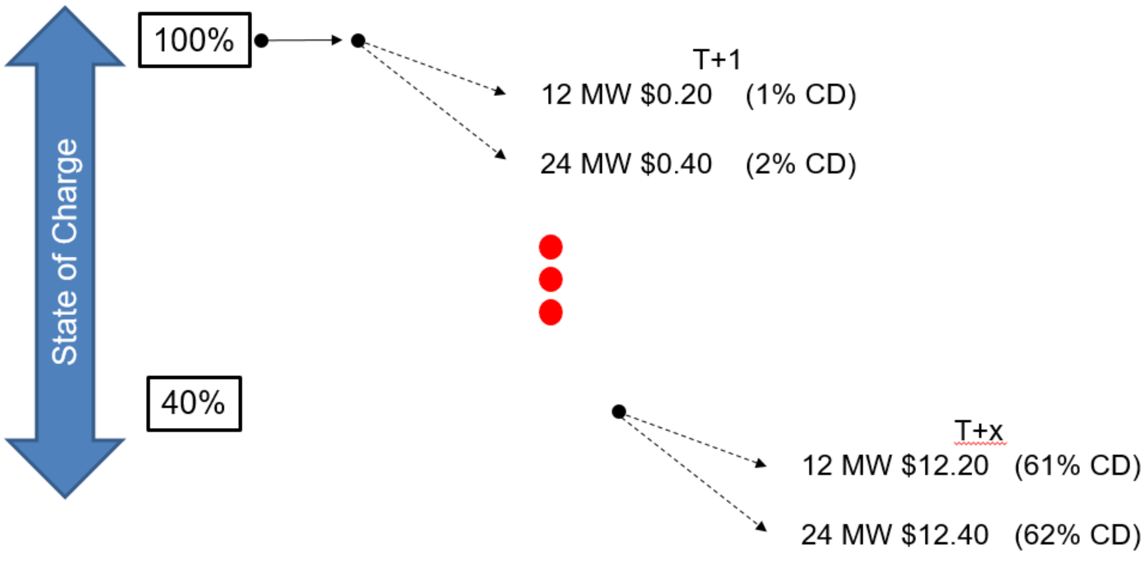
[13] Resources may not be able to offer the full state of charge into the market for a variety of reasons. Resources operating at the extreme values for state of charge may experience extreme cell degradation, in excess of the cell degradation modelled in this paper. Resources' scheduling coordinators submit maximum storage capability to the ISO and this value is stored in Master File. Energy storage values for these resources are used to determine a value that these resources may qualify for in the resource adequacy construct. Some resource owners may "oversize" storage project so that modelling state of charge energy values equal to 100% are at levels where the physical resource is actual capable of storing additional capacity, but it is not available to the market. This may also be the case for state of charge values close to 0%, where the resource may be physically capable of discharging more energy, but the energy is not available to the market.

Figure 6: Example of total depth of discharge approach



2. Individual Depth of Discharge Model

This model assumes maximum costs of cycle depth per dispatch during every interval. Costs are determined independently during each interval and are only based on how much the total amount of (MW) dispatch, regardless of prior dispatches and current state-of-charge. The model may overestimate costs for large dispatches when cycle depth is thin and underestimate costs for shallow dispatches when cycle depth is deep. This methodology may align more with the notion that a resource will incur costs any time the battery is discharging, and will generally not be incurring costs when the battery is idle.

Equation 4: Individual Depth of Discharge

$$\mathrm{CD}_{i,t} = v_{i,t}\,\rho_i\left(\mathrm{SOC}_{i,t-1} - \mathrm{SOC}_{i,t}\right)$$
$$= v_{i,t}\,\rho_i * \frac{P_{i,t-1} + P_{i,t}}{2} * \Delta t$$

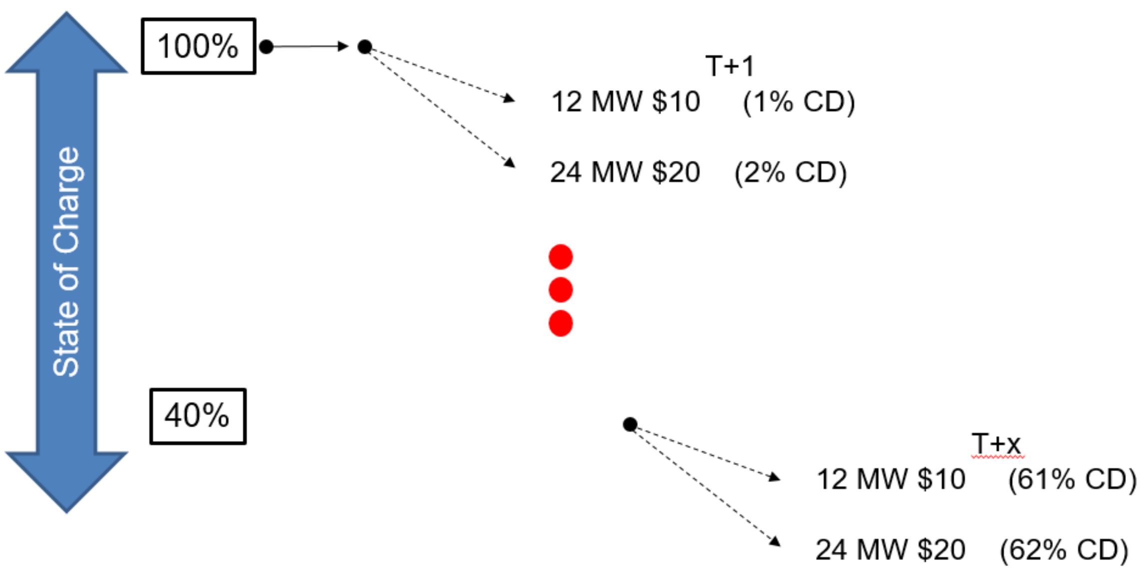
where:

v:	Value equal to 1 when the state of charge is decreasing
ρ:	Cell degradation cost (constant)
SOC:	State of charge
P:	Dispatch instruction (Market decision variable)
Δt:	Fraction of an hour (1/12 in RTD market)
i:	Resource
t:	Interval

Equation 4 can be simplified to a function that does not depend on state-of-charge, but only on dispatch instruction. The CAISO updates values for state-of-charge in the real-time market based on the average of the previous two dispatch instructions. This matches the assumption that any resource will reach a dispatch instruction in the middle of the 5-minute interval and will be ramping linearly from the previous dispatch instruction. The actual dispatch instruction from the

Also, Equation 4 is expressed as a function of ρ, the resource specific value representing the cost of cell degradation related to dispatch. Although the parameter is used in Equation 3, the values take on two different meanings in each of the equations. In Equation 3 the value of ρ represents the cost of discharge that the resource would incur if the resource were to be dispatched down to 0% state of charge. This value would remain the same in the day-ahead and real-time markets. However, the ρ value in Equation 4 represents a multiple of the same cost, so that the values were related to the specific MW dispatch received by the resource. These values do differ between the day-ahead and real-time markets. In this case the value of ρ used in Equation 3 is divided by the maximum output of the resource (24 MW) then multiplied by the number of intervals in an hour (12 intervals each hour in the real-time market). In the example illustrated below the value of ρ is $10.

Figure 7: Example of individual depth of discharge model



In the case of the hypothetical resource used to describe the first function for cycle depth, we continue to assume that the resource may be dispatched in the range between -24 MW to +24 MW, and that the resource has 100 MWh of energy storage capability. As discussed, the pricing for the resource is agnostic to the state-of-charge, and the only factor impacting how the cost for cycling is the dispatch of the resource. Figure 7 shows that if the resource is fully charged at 100% or is only charged at 40%, the cost to discharge the hypothetical resource is linear with dispatch instructions. It also shows that the cost to discharge is equal to $20/MWh when the resource is dispatched at its maximum capability (24 MW) and is arbitrarily small when minimally dispatched.

One potential pitfall with the second model for cycling costs, is that the storage resource could be dispatched frequently at low levels of output, since the market will view these dispatches as relatively inexpensive. But the actual costs may be significantly higher if the resource is at a low state of charge. Similarly, the resource may not be dispatched at full output, because the model will associate this with a relatively high cost. However, it may be efficient for these resources to be dispatched close to their maximum capability if the resource is at an operation point where the cycle depth would be relatively shallow.

The first model captures costs based on total depth of discharge, while the second model captures costs that are independent of total depth of discharge. At this time, the CAISO is not proposing a specific model but continues to assess both options. Stakeholder feedback and data analysis will be used to inform future iterations for modelling costs for storage resources to discharge.

3.1.4 Opportunity Costs

The market power mitigation tool can replace submitted bids with CAISO calculated default energy bids. In the event that these bids are lower than the true cost to operate a resource, the tool may force an inefficient dispatch. Storage resources can only generate until its stored energy is depleted, before it needs to recharge from the grid. To avoid being discharged before the optimal time, a resource with limited availability should have an opportunity cost included in their default energy bid. These opportunity costs include the value to the resource owner from not running during a particular interval and saving stored energy until a later time when prices are higher.

This proposal includes a construct where the default energy bid may change with the state-of-charge of the resource. Generally, when the state of charge for the resource is high, the default cost to discharge the resource will be low, and when the state-of-charge is low, the cost to discharge the resource will be high. A scenario may exist when the resource is charged at full or nearly full state-of-charge, and that portion of the default energy bid will be particularly low. If the resource is fully charged and the resulting default energy bid is $10/MWh and the current price is $20/MWh, it will indeed be profitable for the resource to discharge and receive this revenue. However, this may not be optimal behavior, as prices for the successive four hours may be $100/MWh. In this example, the resource would optimally wait to discharge stored energy, until the later hours when prices are higher.

This example is highly simplified, but it illustrates the need for inclusion of an opportunity cost adder in the default energy bid for storage resources. In this simple example, an opportunity cost increasing the total default energy bid to $100/MWh is appropriate for this resource. The inclusion of opportunity costs in the default energy bid is further complicated when a resource is capable of buying and selling energy for multiple hours, and buys or sells energy in the real-time market and experiences economic losses.

The CAISO proposes including the highest price, corresponding to the storage duration of the resource in the default energy bids for storage resources. For example, if a specific storage resource is capable of storing 4 hours of energy, the opportunity cost included in the default energy bid will be equal to estimated prices in the 4^{th} highest hours of the day.[14] The process used to estimate these costs will be the same outlined to estimate energy costs in the section above. This methodology will include looking at expected prices in the future, based on previous known prices and expected futures prices.

Equation 5: Opportunity Costs

$$OC_t^{\delta} = OC_{t-1}^{\delta} * Max\left(\frac{DAB_t}{DAB_{t-1}}, 1\right)$$

where:

OC: Opportunity cost
DAB: Day-ahead bilateral hub
t: Interval (day)
δ: Storage duration for the resource (i.e. 4 hours)

Equation 5 is formulated in a similar manner to Equation 2, which expresses the expected costs for energy, outlined above.

Using a value less than the total duration of the resource could lead to potential issues with the dispatch of the resource. Suppose that the four highest priced hours have energy priced at $100/MWh and these hours occurred in one four hour block. Setting the opportunity cost at a lower value, such as $90/MWh could lead to inefficient outcomes. This would be the case if actual prices were $95/MWh in the hour directly preceding the four hour block when prices are $100/MWh may have the resource discharge energy when prices are less than the maximum for the day.

If the derivation for the opportunity cost is dynamic, it may be possible to apply enhanced logic as to what the opportunity cost would be. A dynamic approach is not currently being considered.

3.2 Input parameters

There are several equations in this section of the proposal outlining the calculation for a default energy bid for storage resources. Some of these equations include variables that characterize costs that are specific to individual resources. The CAISO contends that these values are relatively stable over time, but also are generally unknown to the CAISO. Similar to existing gas resources today, the CAISO plans to collect this data for all storage resources in the future. This data will be collected via the CAISO master file process that is already in place for many other resource specific data.

Master File variables that will be collected for storage resources:

[14] For example, if prices are $45, $35, $32, $30, $27, $31, $40; the fourth highest hour would be $32.

λ: Round-trip efficiency losses
δ: Storage duration for the resource (i.e. 4 hours)
$\boldsymbol{\rho}$: Cell degradation cost

Like other variables that are collected and stored in master file, scheduling coordinators for these resources will have requirements for submitting these variables to the CAISO. As with other master file data, CAISO will have descriptions of what this data should represent, how the data should be submitted and what, if any, documentation should accompany this data when it is submitted to master file. Finally, as with all data submitted to the CAISO, there will be an obligation on scheduling coordinators to ensure that this data is up to date and accurate for all resources.

3.3 Alignment of Default Energy Bid with Market Bids

The CAISO believes that there should be alignment between the default energy bid values and the bids a resource is able to submit to the market. As noted above, this default energy bid should reflect marginal costs for storage resources. The market will mitigate bids to these costs if local market power mitigation is triggered. Each of the suggested approaches outlined above includes costs that change dynamically with the resource's state-of-charge value or dispatch instruction. Today, all scheduling coordinators are required to submit bids into the CAISO markets prior to each operational hour, and may submit bids for multiple hours at a time. Once the hour begins, these bids are fixed for the duration of the hour and will not be changed. Further, these bids are expressed in $/MW and are currently not set up to vary based on any resource parameter such as a state-of-charge. This causes an inconsistency between values that a storage resource may bid and the formulation the CAISO will use to calculate a default energy bid.

Because of the need to align bidding capability with the default energy bid, the CAISO proposes to allow bids for storage resources to vary based on state-of-charge or dispatch instruction, so that it is possible for a resource owner to submit bids that mirror values that CAISO could use for mitigation.

3.4 Alternative Default Energy Bids

Although the CAISO is striving to develop a functional default energy bid that will reasonably approximate costs for most storage resources, it may not be feasible to develop a methodology that will work for all storage resources and technology types. Therefore, resources always have the ability to apply for a negotiated default energy bid if the proposed methodology outlined is insufficient. Additionally, the CAISO has started a stakeholder initiative to update allowable operations and maintenance values for all resource types, including storage. These values will apply to variable cost default energy bids and may also be sufficient for some storage resources. Further, the operations and maintenance adders can be negotiated with the CAISO at a resource specific level, at a justifiable cost.

4 Establishing Parameters to Reflect Demand Response 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 operational challenges for certain demand response resources. Today, long-start resources (equivalent of day-ahead only DR) committed in the residual unit commitment (RUC) process are started and instructed 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.[15]

The scenario above can result in a rational and economic dispatch where a demand response resource receives multiple and subsequent instructions to curtail load in one interval and return to Pmin of 0 MW in another interval. While the CAISO market systems are acting rationally and see the demand response resource as economic and capable of moving between its Pmin and Pmax in any interval, certain demand response resources are inflexible and can only provide a limited number of sustained responses from their Pmin.

The CAISO continues to highlight a combination of market parameters and bidding options as proposed methods for demand response resources to effectively reflect operational limitations. The CAISO has received positive feedback on ability for many demand response resource to benefit from these options. However, comments received from stakeholders have identified specific demand response program designs that may not be effectively characterized utilizing these available and emerging options. Program designs, when characterized as a resource, are constrained with a limited number of starts and a set number of hours available for dispatch within a day. To optimize demand response resources with these programmatic constraints, the CAISO is proposing a maximum daily run time parameter so that the market can optimize demand response resources with daily hourly limitations that may not be manageable utilizing the current maximum daily energy limitation parameter.

4.1 Scenarios utilizing current market parameters

Option 1: Pmin = 0 MW and resource registers startup costs

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. This will allow for effective real time dispatching of PDRs with a Pmin = 0 MW. Additionally, with the implementation of the Commitment Cost and Default Energy Bid

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

Enhancements[16] and Commitment Cost Enhancements[17] initiatives, non-gas resources have ability to submit a minimum load cost and enhanced capability to have a resources start-up cost be independent of Pmin, allowing for non-zero start-up with Pmin = 0MW.

If a proxy demand resource (PDR) were to elect an hourly bid option and define a non-zero dollar commitment cost at a Pmin of 0 MW, the resource would no longer be a zero cost option in the CAISO's residual unit commitment optimization. Additionally, once committed in the residual unit commitment process, the proxy demand resource would only be dispatched off its Pmin in hourly blocks per its elected bidding option.

Even with these additional PDR resource parameter options, challenges remain. These include a demand response resource's inability to respond to multiple and variable dispatches from Pmin based on program limitations on the number of curtailments available within a day. Additionally, scheduling coordinators for demand response resources have hesitated to submit commitment costs and have asked the CAISO to provide guidance.

The benefit of this option 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.[18]

Option 2: 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.[19] 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.

This proposed option requires the scheduling coordinators to determine and provide a minimum load cost.

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

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

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

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

[19] 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."

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.

4.2 Maximum Daily Run Time Parameter

Based on stakeholder feedback, the CAISO is no longer proposing a “maximum run time” but instead is proposing a maximum daily run time parameter to optimally resolve the issue of demand response resources being dispatched beyond program limitations. The issue occurs when the market observes a Pmin of zero as an “on” state and moves dispatches between its Pmin of zero and a non-zero value. Introducing a maximum daily run time parameter would allow a demand response resource to identify the maximum number of hours the resource could be “on” over the course of a day. This parameter, in combination with the currently available start-up constraint, provides for ability to characterize program constraints along with flexibilities that can be considered in their optimization.

The parameter will be captured in master file and represent the maximum number of hours a demand response resource can be committed and/or dispatched on a daily basis. The parameter components and requirements are summarized below:

- Master file parameter representing a daily maximum number of hours the resource can be committed and/or dispatched.
- Parameter is an option under master file and not a requirement.
- Applicable for both proxy demand response and reliability demand response resources.
- Resources must register a maximum value that is equal to or greater than 1 MW.

The CAISO is establishing the 1 MW threshold due to concerns with overloading its market systems. As the number of participants in the market has expanded, the CAISO is concerned with maintaining the performance of its market systems. In general, implementing discrete constraints in addition to binary variables, have a large impact on market performance. On most days, the day-ahead market is evaluating bids for over 800 proxy demand resources. If the CAISO allowed a maximum daily run time parameter for all demand response resources regardless of size, the resulting impact on performance could put the 1 PM day-ahead market publishing deadline in jeopardy. The CAISO is looking to continue develop these requirements to align with market performance concerns.

The examples below illustrate how the proposed parameter will be utilized in the market’s optimization of demand response resources.

Example 1: Maximum Daily Run Time Constraint with Day Ahead Commitments

Figure and Figure 8 represent a demand response resource with a Pmin of 0 MW, start-up >= 1, a minimum run time of 1 hour, and a maximum daily run time of 5 hours.

Figure 9 illustrates the resources commitment in the day-ahead market to a Pmin= 0 MW to its maximum daily run time limitation and receiving contiguous dispatches in real-time.

In this example, the resource is committed for its maximum daily run time of 5 hours with its initial start-up to Pmin.

In real time the resource is dispatched contiguously in the hours in which it was committed, from HE17 to HE 21. This example illustrates how a resource with a start-up = 1 would receive a contiguous real time dispatch at its maximum daily run time. The characteristics of this resource will always result in a contiguous real time dispatch of the resource for a number of hours up to its maximum daily run time.

The CAISO has previously expressed concern with demand resources maintaining a Pmin of zero with a maximum daily run time parameter resulting in instructions to a Pmin of 0 MW leading to limited or no provision of curtailment. Therefore, the CAISO will work with stakeholders on addressing the inefficiencies and market concerns as it develops the proposal.

Figure 8: Contiguous dispatch in real-time market

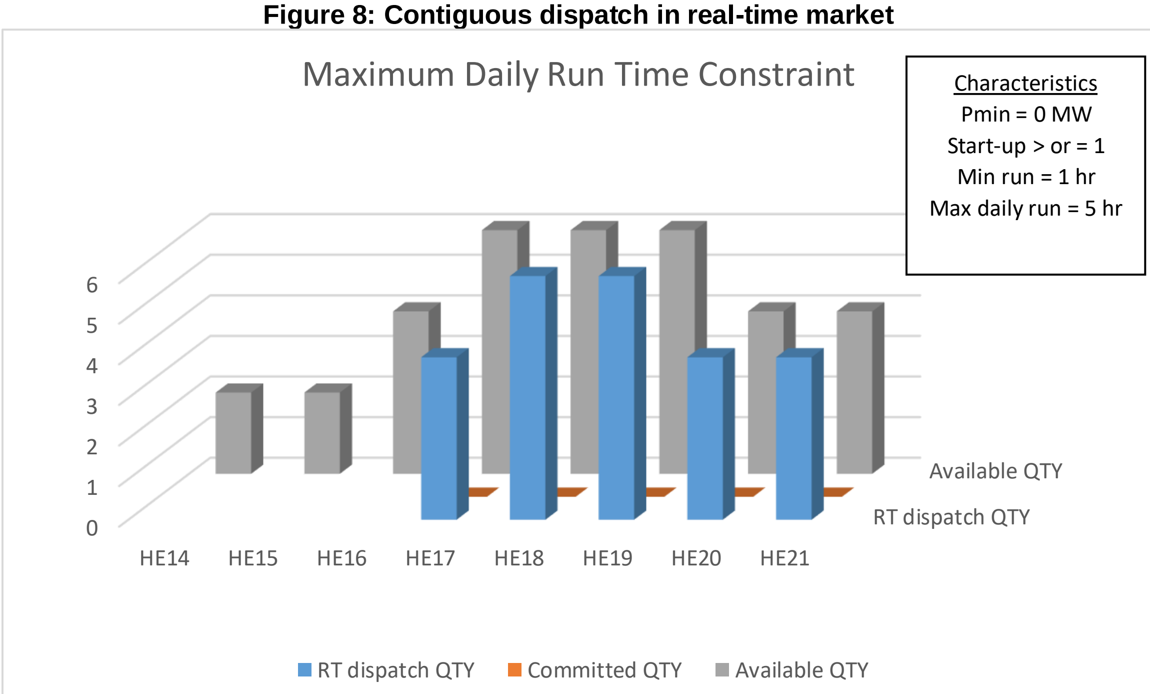
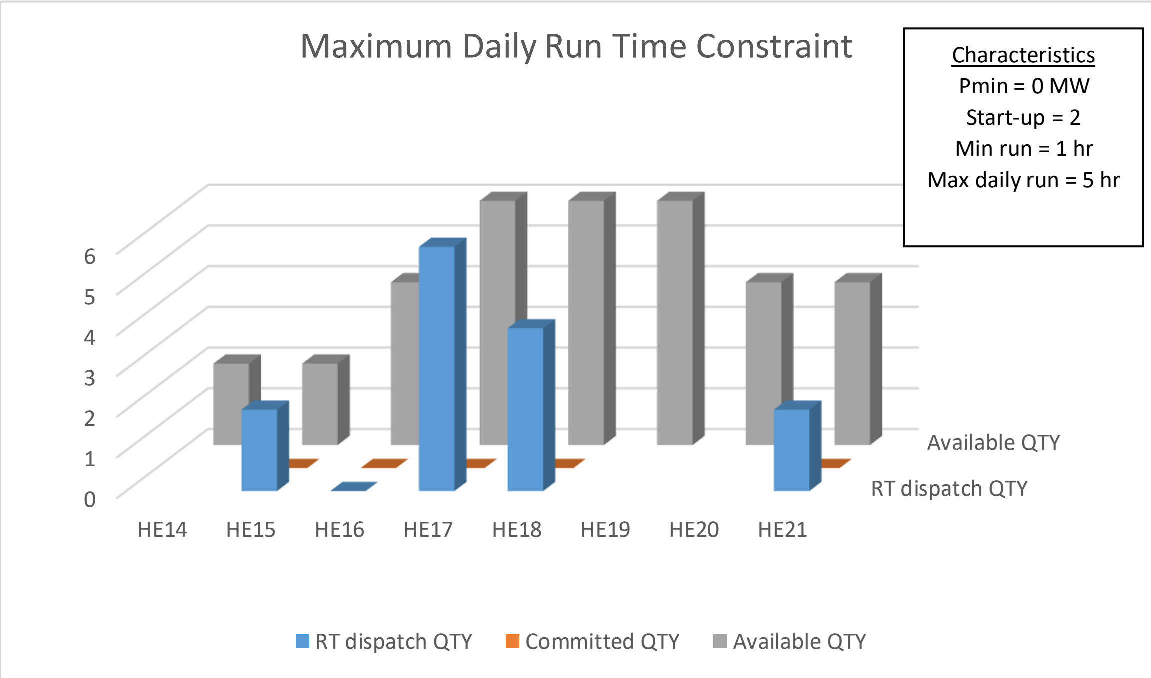


Figure 10 illustrates the resources commitment in the day-ahead market to a Pmin= 0 MW to its maximum daily run time limitation while receiving non-contiguous dispatches in real-time.

In this example, the first start up committed the resource for 4 hours with a subsequent start-up to Pmin for 1 hour, honoring both the start-up and maximum daily run time constraints.

In real time the resource is dispatched in HE15 and again in HE17-18 after being instructed back to its Pmin of 0 MW. The resource is again called in HE 21. This example illustrates how a real time dispatch respecting the resources start-up and maximum daily run time is respected for a resource with Pmin = 0 MW. The CAISO recognizes this as a shortcoming of demand response resource choosing to register with a Pmin of 0 MW while utilizing a maximum daily run time and start-up > 1.

Figure 10: Noncontiguous dispatch in real-time market



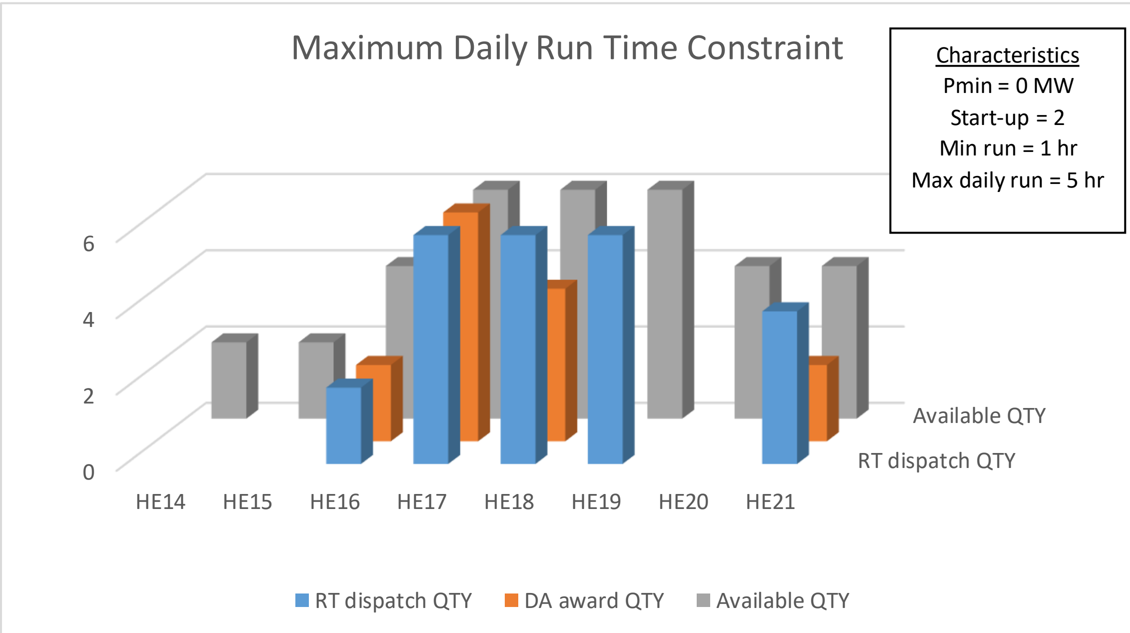
Example 2: Interaction between day-ahead and real-time market awards

Figure 11 represent a demand response resource with a Pmin of 0 MW, start-up = 2, a minimum run time of 1 hour, and a maximum daily run time of 5 hours and demonstrates how the CAISO optimization will consider the maximum daily run time constraint across both the day-ahead and real-time markets.

In this example, the resource is awarded in the day-ahead market for 3 hours with its first start up with a subsequent award for 1 hour with its second start-up, honoring both the start-up and maximum daily run time constraints.

Figure 9 illustrates the resource day-ahead market awards in for HE16-18 and HE21. In real time, the resource is not only dispatched for hours awarded in the day ahead but also for an additional hour contiguous to its day ahead award in HE19. In real-time, the optimization has feasibly dispatched the resource considering and respecting both start up and maximum daily run time constraints.

Figure 9: Resource receives awards in day-ahead and real-time market



5 Vetting Qualification and Operational Processes for Variable-Output Demand Response

The CAISO defines variable-output demand response resources as those demand response resources whose maximum output can vary over the course of a day, month, or season due to production schedules, duty cycles, availability, seasonality, temperature, occupancy, etc. For instance, certain demand response resources' output may vary with weather, like an AC cycling demand response program that 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 capacity into the market, depending on certain conditions, the resource may be unable to deliver its full stated resource adequacy capacity.

Many demand response resources also have availability limitations that affect a resource's ability to provide the energy associated with the RA capacity they provide. Availability limitations are significant dispatch limitations such as limited duration hours (e.g., per year, season, month, or day) or event calls (e.g., per year, season, month or consecutive days). As California transitions to a decarbonized grid, CAISO will likely rely more heavily on both variable and availability-limited resources. As such, it is critical to assess the ability of the new resource fleet, including preferred resources, to displace carbon-emitting generation while maintaining system reliability and serving energy needs every hour of the year.

The central tenet of the resource adequacy program is to ensure sufficient energy is available and deliverable when and where needed. As CPUC Commissioner Randolph stated, "*A successful Resource Adequacy program ensures that every part of California has instantaneous power to serve their customers every hour of the year. It is invisible to the public when it is functioning as it should, because power flows without curtailment or outages even when the grid is stressed*."[20] Thus, the inability to deliver energy associated with resource adequacy capacity because of certain known dependencies is a "visibly" significant issue. Currently, if a resource cannot bid its full qualifying capacity and deliver it under its must offer obligation, it jeopardizes the central tenet of the resource adequacy program. Additionally, resources incapable of meeting their net qualifying capacity value will be assessed penalties through the Resource Adequacy Availability Incentive Mechanism (RAAIM).[21]

A majority of demand response resources have dependencies that result in having a variable output (curtailment capability) even though they are treated under CPUC resource adequacy rules as capable of delivering their full qualifying capacity value whenever dispatched. This overstates their resource adequacy qualifying capacity capability and jeopardizes the CPUC's resource adequacy program and reliability.

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, and
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 to wind and solar resources because maximum output is dependent on some variable

[20] CPUC News Blog; Commissioner Blog: Keeping the Lights On, by Commissioner Randolph, 2/22/2019, found here: https://www.cpuc.ca.gov/cpucblog.aspx?id=6442460494&blogid=1551

[21] Application of RAAIM is currently being reviewed in the RA Enhancements initiative: http://www.caiso.com/informed/Pages/StakeholderProcesses/ResourceAdequacyEnhancements.aspx

condition like weather, availability, temperature, 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 when they are needed. For wind and solar resources, this assessment is done by determining the resources' Effective Load Carrying Capability (ELCC).[22] 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 and availability-limited demand response.[23]

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.

5.1 Stakeholder Comments

The CAISO summarizes the stakeholder comments received on the Straw Proposal and working groups held on the Straw Proposal here.

Stakeholders encourage more definition around what classifies a DR resource as variable-output. The CAISO believes it is not yet necessary to develop a strict definition used to classify programs as either variable output or not. Saying this, if a resource cannot consistently deliver its net qualifying capacity amount during its must offer obligation hours because of dependencies as described previously in this paper, then it is presumably a variable output demand resource. The CAISO believes the results of an ELCC study will further inform such a classification.

Similarly, some stakeholders suggest clarity on the applicability of the proposal considering different DR programs have differing degrees of variability. The CAISO believes an ELCC methodology should apply to all demand response that is variable, availability limited, or both. Such a methodology should consider both availability (i.e., duration, maximum calls, program hours) and variability to inform the qualifying capacity value. The CAISO recognizes that not all DR has the same degree of availability or variability, just as it is not the same for other variable energy resources such as wind and solar. The extent of a resources availability and variability are factors that impact a resource's ability to maintain system reliability. An ELCC study is an appropriate and

[22] ELCC is explained in detail below.

[23] It may not be necessary to apply an ELCC value or provide alternative market participation options for demand response resources that are neither variable nor availability limited if they can provide a fixed load reduction value over the course of the RA month.

industry-accepted way to assess and compare the capacity value of resources that exhibit variability and or have limited availability to support the system.

Several stakeholders, including CLECA and PG&E, question the CAISO's proposal to evaluate DR under a loss of load study, rather than under the CPUC defined RA Measurement hours of 4pm-9pm.[24] The CAISO believes the loss of load expectation study offers multiple benefits. For example, results of such a study can inform the saturation rate of variable or availability-limited resources. It can also compare the reliability contribution of different variable resources (i.e., other DR programs or other variable technology types), as well as account for diversity effects. Additionally, it can help inform the ability of the transforming resource mix and preferred resources to displace carbon-emitting resources while maintaining reliability. Assessing resources based on their ability to meet a summer day coincident peak is less relevant today given the challenges meeting the "net load peak" late in the day, the grid's growing dependence on variable energy resources, and the goal to displace fuel-backed resources in an effort to decarbonize California's grid. It is essential to understand how demand response, as a variable and availability-limited resource, meets new and emerging challenges and supports system reliability under a decarbonized grid paradigm.

Stakeholders are generally supportive of the CAISO's proposal to allow variable output DR resources to bid their capability to fulfill their must-offer obligation. Some stakeholders believe the CAISO should adopt this proposal independent of the adoption of a new QC valuation methodology. The CAISO believes the proposed changes to the bidding rules should only be adopted if the LRA adopts an ELCC methodology for determining the QC. The QC and bidding rules must align to assure the energy associated with RA capacity is available to CAISO when the resource is needed. Adopting an ELCC methodology in tandem with the bidding rules changes is the best way to assure alignment between QC values and real-time availability.

The CAISO received several comments regarding the feasibility of real-time data submission of resource capability. Stakeholders are generally concerned that providing real-time data could be cost prohibitive if the requirements for doing so are overly intensive. Stakeholders including the Joint Parties, OhmConnect, and PG&E suggest the day-ahead forecast of a resource's capability is likely sufficient to reflect changes between the QC value and daily operations. OhmConnect recommends resources submit one forecast in the day-ahead and another, if needed, the day-of. Similarly, SCE cited an ISO-NE practice that allows demand response resources to submit changes to their maximum or minimum reductions to reflect the physical operability or availability of the resource.[25] Olivine suggests it could be feasible to submit hourly updates of availability, given the requirements are not too onerous.

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[24] RA Measurement Hours are defined by the CPUC for establishing the qualifying capacity value of demand response. They are aligned with the CAISO's availability assessment hours and defined in CPUC Decision D.18-06-030:
http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M216/K634/216634123.PDF

[25] ISO New England Market Rule 1, Section III.1.10.

5.2 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 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 (DRAM) 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.

Through this initiative, the CAISO, with the input of stakeholders, will explore how ELCC values can be established for demand response. The CAISO intends to use the outcome of this initiative to inform the CPUC and other LRAs on how demand response could be valued considering its variable and availability-limited nature, and establish in the CAISO tariff default qualifying capacity provisions for LRAs who do not adopt their own qualifying capacity counting methodology.

ELCC background

ELCC is a probabilistic approach used to quantify the reliability contribution of a resources or class of resources. The CPUC currently uses this approach to determine the qualifying capacity of wind and solar resources. 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 resources or group of resources 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 resource 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 resource with an ELCC of 50% would be half as effective at reducing LOLE as a perfect generator. If a solar resource had a nameplate capacity of 100 MW and a 50% ELCC, the resource adequacy qualifying capacity would equal 50 MW.

Using ELCC to assess the capacity value of variable-output demand response

The CAISO believes the ELCC method can and should be applied to variable-output and availability-limited demand response resources. This type of assessment is appropriately applied to resources whose output is variable or potentially limited based on its use. Its application to variable-output and availability-limited 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 are too limiting and only considers a resource's load reduction capability in the RA measurement hours of the monthly peak day. This does not necessarily align with when the resource is needed to avoid a loss of load event when considering the availability of other resources on the system, especially as the system grows more dependent on variable energy resources and retires fuel-backed resources. The load impact protocols assess the load impact of an individual resource rather than the reliability contribution of a portfolio of variable and availability-limited resources (including DR, wind, solar, etc.). 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 believes variable-output and availability-limited demand responses should be considered under an ELCC methodology to determine their qualifying capacity values since the ELCC can capture the incremental benefit of a demand response resource to system reliability across multiple hours while considering the impact of the entire demand response and variable energy resource portfolio.

Once an ELCC methodology is adopted for demand response, the CAISO believes resource bids could be used as the data set for the ELCC calculation to reflect resource availability. As outlined in the section below, the CAISO proposes to allow variable-output demand response resources to bid their expected capability. Once demand response resources bid the amount they are physically capable of providing, the bids should accurately reflect the capability of the resource. For example, resources could forecast their capability by using a variation of the load impact protocols 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.

ELCC Study

Stakeholders have requested and the CAISO has committed to providing ELCC numbers for California demand response resources in the ESDER 4 initiative. In parallel with this initiative, the CAISO has contracted with Energy and Environmental Economics, Inc. (E3) to develop an analytical framework to evaluate the resource adequacy value of demand response using an ELCC. Through this effort, E3 will simulate the capacity contribution of demand response in their Renewable Energy Capacity Planning (RECAP) model. Results of this work will be presented to stakeholders through the ESDER 4 stakeholder process for stakeholder consideration.

The CAISO will continue to work with stakeholders to establish program parameters to account for differences in availability between program types. In the August 21, 2019 working group, the CAISO presented potential program parameters to use in an ELCC study, including duration, hours per month, program hours, consecutive days, and hourly load profiles that reflect the variability of resources in the program. When defining the program parameters to use in the model, the CAISO and E3 will consult with stakeholders to ensure the parameters are reflective of program capabilities and availability.

The CAISO expects the results of the study to be presented to stakeholders in early 2020.

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

Resource adequacy resources have must offer obligations to bid into the CAISO market the amount of net qualifying capacity the resource has shown in their supply plan. Demand response resources on supply plans are required to bid in the hours specified within their program, typically aligned with the CPUC's RA measurement hours and 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.

The CAISO proposes to address this issue by allowing variable-output demand response resources to bid the amount they are physically capable of providing, rather than the net qualifying capacity, in order to meet their must offer obligation. Today, VERs receive this treatment. Scheduling coordinators for VERs must either use a forecast provided by the CAISO or submit their own CAISO-approved forecast. Bids are submitted every hour, and the forecast is used to reflect intra-hour variability and set the upper economic limit on these bids, such that the resource is not dispatched above its forecasted capability in any interval. Therefore, the maximum MWs dispatched by the CAISO for a VER could be at, above, or below the net 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 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 capability. 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 capability 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 could be appropriate for developing these load curtailment forecasts. As suggested in CLECA's comments to the issue paper working group meeting,[26] 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 CAISO is considering two options on the type of real-time data submission required to enable these resources to bid to their capability. The first option would be for resources that do not have intra-hour variability. For these resources, their capability can be reflected through their bids into the day-ahead and real-time markets. The CAISO has received feedback from stakeholders that implies many demand response resources do not have intra-hour variability. In this case, it may not be necessary for resources to provide real-time data to reflect their capability. Instead, resources could reflect their capability through their bids, which are submitted on an hourly basis 75 minutes prior to the operating interval for the real-time market.

If demand response resources do experience intra-hour variability, the second option would require resources to submit their forecasted capability in real-time. The real-time forecast should be submitted on a 15- or 5-minute basis to reflect any updates to real-time capability. This way, resources could still submit bids 75-minutes prior to the operating interval, as is done today. Then, if their capability changes between when they submit their bids and the operating interval, the most recent forecast would set the limit on the amount the resource could be dispatched. This option would be required if resources experience intra-hour variability in order to ensure feasible dispatches that do not exceed the resource's capability. The CAISO asks for stakeholder feedback on these two options and if demand response resources experience intra-hour variability.

The must offer obligation for variable-output demand response would not require the resource to bid up to the shown capacity value but rather to the forecasted capability. The forecasted value could be at, above, or below the shown 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.

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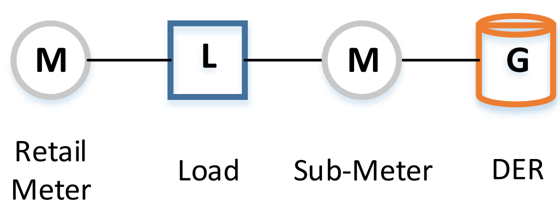
[26] Comments by CLECA to the ESDER 4 Issue Paper Working Group, April 1, 2019. http://www.caiso.com/Documents/CLECAComments-EnergyStorage-DistributedEnergyResourcesPhase4WorkingGroup-Mar18-2019.pdf

Because the CAISO proposes the scheduling coordinator for the resource would submit its forecasted capability that would set the resources must offer obligation, it is important to establish adequate controls to limit opportunities to submit inaccurate forecasts for strategic purposes. 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.

6 Discussion of Non-24x7 Settlement of Distributed Energy Resources

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.[27] In examining the application of these multiple-use application rules in the CAISO market, stakeholders have questioned whether behind-the-meter resources participating under the DER aggregation model should be able to choose in which market intervals to participate and be settled at a wholesale rate. Currently, a behind-the-meter resource participating as a DER aggregation is a 24x7 wholesale market resource (comparable to all other supply resources). They are financially settled for charge or discharge in a given interval, regardless of whether the resource received a CAISO dispatch instruction. Certain stakeholders have suggested this rule to change so that behind-the-meter resources could participate in other markets without 24x7 wholesale settlement because their point of interconnection allows them to provide retail and distribution services most easily.

Figure 10: Metering construct for behind-the-meter DER participation



For the purpose of this section, Figure 10 will define a DER as a supply resource that is physically located behind the retail meter to provide services to the retail load represented by "L." Today, the DER is able to participate in the CAISO wholesale market but due to its metering configuration, the CAISO will settle all energy from the "sub-meter" regardless of if there was a CAISO market award or not. Throughout this section, Figure 10 will serve as the use case for illustrative purposes.

The CAISO led several discussions and collected stakeholder comments on the implications of a non-24x7 settlement for behind-the-meter DERs. Generally, the CAISO understands that a solution must go beyond just implementation in the wholesale market but a coordinated effort across jurisdictional entities. After

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

consideration of comments from stakeholders, the CAISO lists the following observations.

1. There is no definitive solution with how LSEs will forecast and bid load with behind-the-meter DER participation.
2. There are several solutions presented by stakeholders to account for both retail and wholesale settlement but will still require clarification from the local regulatory authority.

6.1 LSE Load Forecast Uncertainty

As shown in Figure 10, because the DER is physically located behind a retail load meter, LSEs will need to understand the operational configuration (wholesale vs. retail participation) of DERs to accurately forecast and serve load. Although the CAISO developed a DER Provider participation model as a pathway to the wholesale market, utility stakeholders raised several concerns.

If the DER were participating in the wholesale market, the UDC or distribution operator would need to coordinate with the resource operator and the CAISO. Similar to understanding when a resource should be financially settled in retail versus wholesale, PG&E commented on needing to understand the operational configuration of the DER whether it be a daily or seasonal notification to properly forecast its load. SCE also stated that not only are communication and data collection protocols necessary, but forecasting load would become much more complex since the behind-the-meter device would choose when to serve the retail customer, distribution system, or transmission system. The CAISO agrees with PG&E and SCE that the introduction of behind-the-meter resources that are not fully retail or wholesale requires greater clarification from the local regulatory authority.

Stakeholders like CESA and Electrify America point to past efforts made for demand response programs and believes that similar communication protocols and solutions could be used. They also stated that LSEs currently have these issues with demand response programs today. The CAISO does not believe similar treatment such as baselines or communication protocols can be used for behind-the-meter resources because there needs to be a differentiation between load and generation resources. Demand response resources do not provide a net export into the wholesale market, are not deemed a “sale for resale” by FERC, and are simply a reduction of load. In contrast, a behind-the-meter resource can both simultaneously export energy into the bulk electric system, like a generator, while reducing load like a demand response resource. A simple extension of the demand response model to net-exporting behind the meter resources is not feasible or realistic for technical, operational, and jurisdictional reasons.

6.2 Retail versus Wholesale Settlement

Under the current construct, behind-the-meter resources would receive double compensation and/or double payment for wholesale activity. Majority of stakeholders agree that cross-jurisdictional coordination is needed to correctly account for wholesale and retail activities.

Listed below were questions raised by SCE and PG&E:[28] [29]

1. Should there be a demarcation of hours when behind-the-meter resources can provide either a wholesale or retail level service?
2. With regards to metering standards, which entity owns and controls the meter and meter data to account for separation of retail and wholesale transactions and settlement?
3. Does there need to be a new retail rate for resources participating partially in the wholesale market?
4. How should UDCs separate retail charges or payments when the resource is settled in the wholesale market?

Electrify America and Olivine provided thoughts on how settlement of retail versus wholesale could be approached:[30] [31]

1. LRAs would set standards for UDCs to net out any wholesale activity from a customer's bill while DER owners would be responsible to communicate load or generation for correct accounting.
2. All export of energy from the behind-the-meter resource would be settled as wholesale while all load is charged as retail. For example, a behind-the-meter battery would be settled for all discharge that provides a net export into the wholesale market, while the UDC or LSE would assess retail rates for all load including when the battery is charging (even if it is for wholesale discharging purposes).
3. Allow for the settlement of net export under proxy demand resource model.

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[28] SCE Comments (pg. 1-3) http://www.caiso.com/Documents/SCEComments-EnergyStorage-DistributedEnergyResources-Phase4-Aug21WorkingGroup.pdf

[29] PG&E Comments (pg. 1-3) http://www.caiso.com/Documents/PG_EComments-EnergyStorage-DistributedEnergyResources-Phase4-Aug21WorkingGroup.pdf

[30] Olivine Comments (pg.1-3) http://www.caiso.com/Documents/OlivineComments-EnergyStorage-DistributedEnergyResources-Phase4-Aug21WorkingGroup.pdf

[31] Electrify America Comments (pg. 1-3) http://www.caiso.com/Documents/ElectrifyAmericaComments-EnergyStorage-DistributedEnergyResources-Phase4-Aug21WorkingGroup.pdf

4. Create a similar construct to the load shift resource model with no symmetric dispatchability requirements along with bidding rules to bid above the net benefits test price threshold to provide energy and bid below $0 for charging.

The CAISO agrees with stakeholders that clarification is needed from the LRA on settlement of retail versus wholesale activities. Because the resource is not only physically located on the distribution system and it resides behind a retail meter managed by a UDC/LSE, the CAISO does not have the jurisdictional authority nor the visibility to establish methods to account for wholesale versus retail activity and transactions.

In response to stakeholder suggestions, options 1 and 2 reflect concerns that LRA clarification on retail rate accounting is necessary. Option 3 does not address accounting for retail versus wholesale activity, but rather focuses on settlement of net exports to the wholesale market under the proxy demand resource model. In addition, as Olivine states, the CAISO does not believe the settlement of net export is allowed due to a “sale for resale” provision under the Federal Power Act. Lastly, option 4, similar to option 3, merely transfers proxy demand resource attributes and ignores the discrepancy of retail versus wholesale settlement.

6.3 Conclusion

The CAISO cannot move forward in the ESDER initiative to develop a non-24x7 settlement for behind-the-meter resources participating as a DER aggregation. The CAISO believes that because these resources are physically located in the distribution system, it is imperative that the local regulatory authority first provide jurisdictional clarity on retail versus wholesale activities, and also vet and resolve energy accounting and settlement issues, metering and visibility requirements, distribution system impacts and planning, and operational and forecasting concerns. The CAISO has developed models for open participation of DERs in its wholesale market, but it cannot overlook the many critical technical, operational, and regulatory decisions that first must be vetted by state and local regulatory authorities and utility distribution companies. Additionally, the CAISO is concerned that without clear accounting of retail versus wholesale activity, there would be a violation of the “sale for resale” provision under the Federal Power Act. As discussed above, review of stakeholder suggestions concluded that further vetting is needed within the jurisdiction of the local regulatory authority followed by coordination with the CAISO.

Next Steps

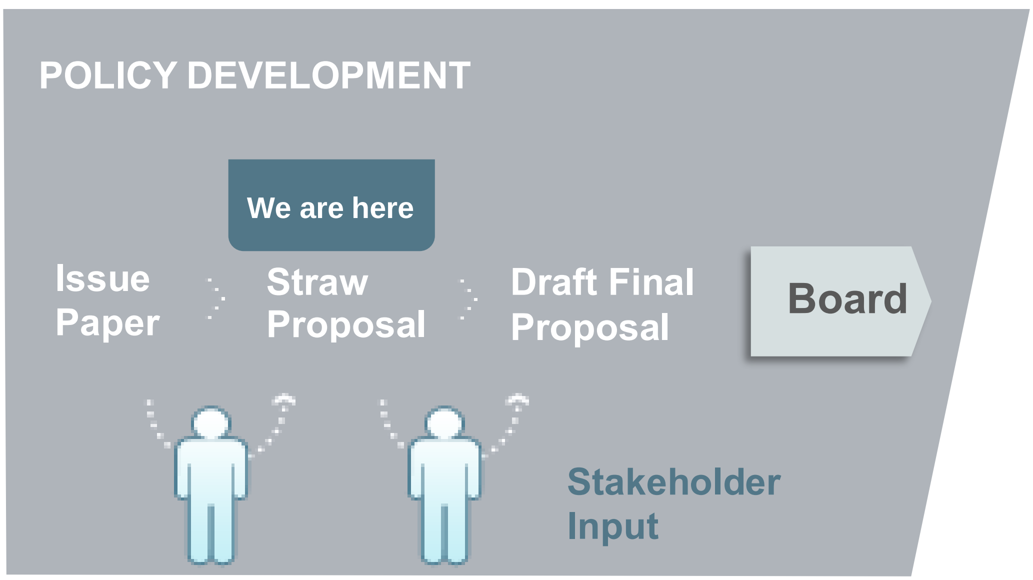
The CAISO will hold a stakeholder web conference on October 28, 2019 to review the revised straw proposal and encourages stakeholders to submit comments by November 12, 2019. The CAISO will hold an additional working group meeting (will be announced via market notice) to refine proposals before the second revised straw proposal is published.

Stakeholder Process

The CAISO is at the "Straw Proposal" stage in the ESDER 4 stakeholder process. Figure 11 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 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 11: Stakeholder Process for ESDER 4 Stakeholder Initiative



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.