Qualifying Capacity and Effective Flexible Capacity Calculation Methodologies for Energy Storage and Supply-Side Demand Response Resources

Draft Staff Proposal
Resource Adequacy Proceeding R.11-10-023
California Public Utilities Commission – Energy Division

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Introduction

This document provides a draft staff proposal (Proposal) for the California Public Utilities Commission's efforts to develop Qualifying Capacity (QC) and Effective Flexible Capacity (EFC) methodologies for energy storage (ES) and supply-side demand response (DR) resources. A resource's Qualifying Capacity (QC) is the number of Megawatts eligible to be counted towards meeting a load serving entity's (LSE's) System and Local Resource Adequacy (RA) requirements, subject to deliverability constraints.[1] A resource's Effective Flexible Capacity (EFC) is the number of Megawatts eligible to be counted towards meeting an LSE's Flexible Resource Adequacy (RA) requirements.

Energy Division (ED) staff issues this Proposal to seek informal comments for an October 15 staff workshop in the RA rulemaking (R.11-10-023). This Proposal outlines various methodologies for calculating the QC of multiple types of storage and supply-side demand response resources. Informal party comments on the proposal will help staff in the development of a formal proposal, but will not become part of the rulemaking's record. Official party comments on the formal proposal and associated workshop will be solicited later and will become part of the rulemaking's record for the Commission decision(s) on QC and EFC for ES and DR.

It is noted that only ES and DR resources that bid into California Independent System Operator (CAISO) markets and are subject to a Must-Offer Obligation (MOO) are within the scope of this Proposal. These resources are: transmission-level energy storage, some distribution-level and behind-the-meter storage (depending on whether it is operated in accordance with the above requirements), and supply-side demand response.

Supply-side demand response, which is eligible for RA credit, is distinguished here from customer-focused programs and rates. Customer-focused programs and rates count towards reliability needs as load modifiers rather than as supply-side resources, and are included in load forecasting rather than receiving a QC or EFC. The Commission will be considering bifurcating current DR programs into supply-

[1] The revised QC that incorporates deliverability constraints is called the Net Qualifying Capacity (NQC).

side and demand-side (customer-focused programs and rates) in a new DR Order Instituting Rulemaking (OIR), and ED staff will coordinate across both that rulemaking and the RA rulemaking to ensure consistency.[2]

In accordance with the RA proceeding Scoping Memo, in this Proposal the Energy Division (ED) explores how QC and EFC can be calculated for ES and supply-side DR. Staff is particularly interested in hearing feedback from parties on its recommended approach for conducting these calculations through extension of the Effective Load Carrying Capability (ELCC) modeling[3] currently under development (ELCC-ERC Study) for wind and solar resources in compliance with the Senate Bill (SB) 1x2. This type of modeling is probabilistic, rather than deterministic, and incorporates the usefulness of resources towards meeting reliability needs, as described in greater detail below. ED staff also seeks parties' opinions on the proposed similarities and differences between QC and EFC calculation methodologies, the potential for ELCC modeling to be extended to Effective Ramping Capability (ERC) modeling,[4] the role of dispatchable load, the impact of ES and supply-side DR use limitations, potential aggregation approaches and the appropriate level of CPUC involvement in specifying aggregation rules, assessment and use of performance data, and important considerations in the application of RA eligibility rules to ES and DR resources. In addition, the informal comments submitted in response to this Proposal may inform staff efforts in the ES and DR as well as other related proceedings, for example in the development of performance testing protocols.[5]

ED staff has considered a variety of approaches to capacity calculations. While this Proposal recommends one particular approach, the primary purpose of this Proposal is not only to solicit stakeholder feedback regarding the validity and desirability of this approach, but also to prompt alternative suggestions from stakeholders for further consideration.

The Proposal includes the following key components and accompanying recommendations:

1. RA eligibility requirements for ES and DR
    - ES resources may be aggregated to form a single, RA-eligible resource. DR resources may also be similarly aggregated. However, to be eligible for Local RA, the applicable ES

[2] The draft Order Instituting Rulemaking (OIR) for DR can be found at http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M076/K440/76440646.docx.

[3] ELCC refers to the ability of a MW of generation from a particular facility to contribute towards preventing loss of load due to insufficient capacity, relative to a perfect generator. For additional reading on ELCC methodologies, see http://www.science.smith.edu/~jcardell/Courses/EGR325/Readings/ieee-capacity-value.pdf.

[4] ERC is similar to ELCC, but indicates contributions toward meeting ramping needs rather than overall capacity needs.

[5] Information on the energy storage proceeding can be found at http://www.cpuc.ca.gov/PUC/energy/electric/storage.htm.

and DR assets must be located at the same transmission node and be locally dispatchable.

- To the extent possible, RA eligibility requirements should remain consistent across all resource types, including ES and DR. These requirements include the ability to operate for at least four hours at maximum energy output (P_{max}) and minimum energy production ($P_{min,}$ which in the case of storage or dispatchable load may be a negative value). Resources wishing to qualify for RA must also have the capability to operate for four consecutive hours on three consecutive days; make economic bids into CAISO markets; and commit to a must-offer obligation (MOO)[6]. Co-located ES operating in conjunction with another, larger RA-eligible resource need only meet the MOO requirements separately; in all other respects, the RA qualification of the primary generating facility is sufficient.

- Future modeling of reliability may indicate ways in which some of the above requirements could be altered; future RA proceedings will be informed by that analysis. For example, the ED's ongoing ELCC-ERC Study may suggest that resources that are currently RA-ineligible can nevertheless contribute to reliability. Once this study is complete, the Commission may revisit the RA eligibility rules for all resources.

2. CPUC testing and verification requirements

    - The Energy Division would like party comment on the extent to which QC and EFC should be based on historical performance data. To the extent that historical performance data is not available or appropriate, program design and/or test data may be used.

    - DR must be tested and/or dispatched at least once annually, to demonstrate continued performance. Testing should attempt to simulate expected dispatch conditions, and two-hour testing is required to ensure performance does not degrade over the course of operation.

[6] A must-offer obligation, or MOO, is a commitment to be available for economic dispatch by the CAISO during standard hours that are set by the CAISO. In the case of storage and demand response, resources wishing to qualify for Flexible RA must agree to be subject to a MOO during a set time window on non-holiday weekdays in either the morning (6:00-11:00 am) or the evening (4:00-9:00 pm), in order to ensure that they will be available to contribute to the times of greatest system ramping. The MOO, which sets a window of availability for dispatch, is distinct from the three hour requirement for continuous operation upon dispatch. System and Local RA resources may either bid into the CAISO markets or self-schedule.

- DR performance should be measured based on ex-post (after-the-fact) analysis using the load impact protocols (LIPs), as is already the case for the utilities' current DR programs (Retail DR).[7]
- In the energy storage and demand response proceedings, the Commission may consider testing and assessment protocols that can measure the performance of those resources.

3. Approach recommended for QC and EFC calculations

    - The QC and EFC for ES and DR should be based on probabilistic modeling, which assesses likely system needs, rather than on deterministic modeling, which is based on a single assumed case (e.g., a 1-in-2 weather condition for DR ex-ante forecasting). This probabilistic modeling should yield:
        - an Effective Load Carrying Capability (ELCC), which expresses how well the resource is able to meet reliability conditions and reduce expected reliability problems or outage events (considering availability and use limitations) as compared to a "perfect" generator,[8] and
        - an Effective Ramping Capability (ERC), which expresses how well the resource is able to meet upward ramping and intra-hour operational needs (considering availability and use limitations) as compared to a perfect generator.
    - QC and EFC should reflect the maximum capacity available from a resource, derated by its ELCC and ERC respectively, in order to capture resource availability, use limitations, and the usefulness of the resource's operating characteristics towards meeting system needs. For example, if modeling indicates that reliability needs are greatest in the afternoon, then a resource that only operates in the morning would be derated more than an otherwise-identical resource that only operates during the afternoon.
    - EFC should incorporate dispatchable load/ES charging, because these operational modes can address ramping needs. QC, because it solely aims to address capacity shortfalls, should not incorporate these operational modes.
    - In the event that ES is co-located with and operating as a supplement to a larger generating facility, the ES should modify the QC and EFC of the primary facility and not receive its own unique QC or EFC. Such an ES facility need not independently meet RA eligibility requirements; however, the ES facility remains subject to the RA MOO (to schedule or bid into CAISO markets) or the FRACMOO (for facilities wishing to qualify as

[7] LIPs were specified by Decision 08-04-050, and modified by Decision 10-04-006.

[8] A perfect generator has ideal operating characteristics: immediate start-up, infinite ramping capability, no use limitations, and no outages. This generator has positive output only (no charging or dispatchable load).

Flexible RA), as previously described. In the event that the storage facility is larger than the co-located energy generator, the ES device will be viewed as an independently operating resource and be separately evaluated for QC and EFC.

4. Proposed calculation methodology

   - QC = ELCC*P_{max}

   - EFC = ERC*(P_{max}-P_{min}), for $P_{min} < 0$;

   - EFC = ERC*P_{max} for all other resources

5. Alternative approaches that may be considered

   - In the event that the Commission elects to postpone or forgo adoption of the proposed probabilistic methodology, staff recommends that dispatchable ES receive QC and EFC in the same manner as other dispatchable resources, including testing and verification in CAISO operations. DR would receive QC and EFC in the same manner as existing Retail DR.

Informal comments on this Proposal should be emailed to the service list for the RA proceeding, R.11-10-023, on or before October 22, 2013. These comments are not to be filed, just served.

RA Eligibility

Currently, System and Local RA rules require that facilities be capable of operating for four hours at a time and for three consecutive days in order to be eligible to receive a QC. To receive an EFC and be eligible to count as Flexible RA, facilities must be capable of ramping up or sustaining output for three hours. These rules already apply to ES and DR resources. While the above durational requirements may be revisited in light of the ELCC-ERC Study results, we do not intend to address them as part of the ES and DR QC and EFC calculation methodologies.

According to CAISO tariffs, a Must-Offer Obligation (MOO) also applies for ES and DR resources to count towards RA obligations. System and Local RA resources must either schedule their output or bid it into CAISO markets. Flexible RA resources are not permitted to self-schedule their output, and must instead submit economic bids for their output into CAISO markets during at least one of two intervals specified by the CAISO (6:00-11:00 am and 4:00-9:00 pm). These intervals are intended to correspond to the morning and evening ramp periods.

Staff proposes that any ES or DR located in the same LSE service territory may be aggregated. To be eligible for Local RA, however, the resources to be aggregated must be located at the same transmission node and locally dispatchable. Aggregated resources will receive an aggregate Resource ID with a single QC and EFC. ED seeks input on how the QC of a particular aggregated resource can be quantified, e.g. by summing the P_{max} (and P_{min}) values or by summing shorter individual charge/discharge/call durations to create longer combined durations. This aggregation should take into account use limitations such as non-availability of individual units during certain hours and likelihood of availability during typical operating hours; these use limitations can then be included in modeling. Aggregated units must be viewed as a single resource at all times. In other words, if one resource includes a storage unit that is outputting 2 MW at a given time and another unit that is simultaneously consuming 1 MW, the aggregated resource has a net generation of 1 MW.

As in the case of gas-fired generation (GFG), ES and DR should be subject to testing to verify its operating characteristics, including P_{max}, P_{min}, and the duration over which they can be sustained; this testing should be submitted to the CAISO.

Supply-Side Demand Response (DR)

RA Eligibility, Operating Characteristics, and Compliance

Supply-side Demand Response (DR), consistent with other supply-side resources, should comply with standard RA eligibility criteria; namely, it must be capable of operating at its QC for at least four consecutive hours, and over at least three consecutive days. In the case of Flexible RA, the requirement to operate is reduced to only three continuous hours, but the resource is also subject to the Flexible RA Capacity Must-Offer Obligation (FRACMOO), a CAISO requirement to submit economic energy bids into the ISO's day-ahead and real-time markets for the period of either 6-11 am or 4-9 pm.

DR is not currently subject to the CAISO Standard Capacity Product (SCP) rules, as the CAISO has not yet developed an SCP for DR, but it is anticipated that the CAISO will address that issue in time for the 2016 RA year, as DR begins to bid into CAISO markets.

Aggregation is permitted, provided that the DR program operates economically in CAISO markets and is subject to the applicable MOO. DR load must all be located in the same service territory; to be eligible for Local RA, ED staff proposes that DR load must be located at the same transmission node and be locally dispatchable by individual Local Capacity Areas (LCAs). A DR program that covers multiple transmission nodes and wishes to be eligible for Local RA would have to schedule into CAISO markets separately for each node (operating as multiple, separate resources with independent telemetry, Scheduling ID, and other operating arrangements).

DR that is not RA eligible, including customer-focused programs and rates or other DR programs, will be treated as a load modifier and will be included in the load forecast, thereby reducing RA requirements. It will not receive a QC or EFC or contribute toward meeting RA requirements on the supply side. The distinctions between supply-side DR and customer-focused programs and rates will be addressed in the forthcoming DR Order Instituting Rulemaking (OIR).

QC and EFC Calculation Approach

ED staff proposes that the QC for a DR resource be equal to its ELCC*P_{max}. Its EFC would be equal to its ERC*(P_{max}-P_{min}).[9]

P_{max} and P_{min} refer to the maximum and minimum power levels of the DR facility. P_{min} may be negative in the case of dispatchable load; otherwise, it is excluded from the above equation.

The effective load carrying capability (ELCC) and effective ramping capability (ERC) are outputs of probabilistic modeling, which assesses likely system needs and the potential of the DR to contribute to these needs. The ELCC expresses how well the DR is able to meet reliability conditions and reduce expected reliability problems or outage events caused by capacity shortfalls as compared to a perfect generator (considering availability and use limitations). The ERC expresses how well the DR is able to meet upward ramping and intra-hour operational needs, as compared to a perfect generator (considering availability and use limitations).

The ELCC and ERC can be viewed as matching the usefulness of a resource's operating characteristics to reliability conditions; for example, if modeling indicates that reliability needs are greatest in the afternoon, then a DR resource that only operates in the morning would be derated more than an otherwise-identical resource that only operates during the afternoon, because its contribution to reliability needs would be smaller. Similarly, a facility with a high outage (or underperformance) rate at times of system stress would also be derated more than an otherwise-identical, more reliable resource.

Maximum and Minimum Power Determination

Maximum output (P_{max}) and minimum output (P_{min}, which may be negative for dispatchable load) should be determined via testing, which would be submitted to the CAISO and to the CPUC.[10] The testing must call on a representative sample of participants (or all participants, if the number of participants is too small or variable to be reliably sampled). A two-hour test event duration requirement is proposed for RA eligibility, in order to ensure sustained performance. DR performance would be assessed by the DR provider (DRP) via a simplified load impact protocol (LIP) model (as is already done for the non-IOU LSEs, in accordance with D.10-06-036) and then adjusted for temperature and other relevant factors (such as time of year) to yield a calculated maximum P_{min} and P_{max}. This calculation will be verified and approved by the CPUC.

The P_{min} and P_{max} determinations must be completed and submitted to the CAISO prior to initial qualification as an RA resource. If the DR resource's contracted MW later changes (due to a change in

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[9] P_{min} is only included in the equation if it is negative (i.e., if the DR resource can increase consumption); P_{max} may be either positive (reflecting demand reduction capability) or zero (indicating a dispatchable load without dispatchable demand reduction capability). Regardless of the ES P_{max} and P_{min} values, the EFC will always be calculated based on a perfect generator that goes from P_{min} of zero to positive P_{max}.

[10] This is analogous to initial testing of gas peaker plants.

the number of participants or a change in an individual participant's MW commitment), the DRP must inform the CAISO, and P_{min} and P_{max} values will be scaled accordingly. If a DR resource is not called for an entire year, it is proposed that the resource be retested for P_{max} and P_{min}. Specific implementation details for the P_{min} and P_{max} testing, LIPs, and other adjustments can be addressed as part of the DR proceeding.[11]

Modeling Resource Performance

Because DR resources can differ greatly from one another, DR poses unique challenges to ELCC and EFC calculation. To address the lack of data in the initial year, all new DR programs are required to conduct testing-based performance estimates using a simplified LIP and submit the results to the CAISO and the CPUC for review and input into the QC and EFC calculations. The QC and EFC will be calculated based on ELCC and ERC modeling that incorporates program design parameters (such as daily hours of availability, total energy availability over a given season, and dispatch triggers), performance test results, and the performance of any similar RA-qualified utility or supply-side demand response programs over the prior five years, to account for variations in program performance.

Once the DR resource is operational, performance upon dispatch will continue to be assessed via ex-post analysis using the LIPs. The ex-post results submitted by the DRP to the CPUC will be compared to the CAISO-dispatched capacity and settlement data to create resource-specific performance data. After each summer of operation, or a minimum of ten dispatches after the initial ELCC/ERC modeling (whichever comes later), the ELCC/ERC calculation will be redone using actual, resource-specific historical performance data (stretching back up to three years).

QC and EFC Calculations

The QC and EFC calculations require modeling with a reliability calculator. As discussed above, this modeling will incorporate the specific operating characteristics of the DR where possible (performance, advance notice required, use limitations, P_{max} and P_{min}, etc.). For initial resource operation, aggregated statewide demand response data should be utilized as a proxy for performance, as described in the calculation approach section above.

ELCC and QC Calculation

1. Use a reliability calculator to model California's regional electrical system with the DR and determine the loss of load expectancy (LOLE)

2. Model the system again without the DR; this will increase the LOLE

[11] A draft of the DR Order Instituting Rulemaking (OIR) can be found at http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M076/K440/76440646.docx.

3. Add a small amount of perfect generation[12] capacity to the model, and recalculate the LOLE

4. Repeat step three, stopping when the LOLE is equal to that found in step one

5. Define the ELCC of the DR to be equal to the total amount of perfect capacity added upon completion of step four, divided by P_{max}

6. Define the QC of the DR as to be equal to its ELCC*P_{max}

ERC and EFC Calculation

1. Use a reliability calculator to model California's regional electrical system with the DR and determine the lack of ramping expectancy (LORE)

2. Model the system again without the DR; this will increase the LORE

3. Add a small amount of perfect generation capacity to the model, and recalculate the LORE

4. Repeat step three, stopping when the LORE is equal to that found in step one

5. Define the ERC of the DR to be equal to the total amount of perfect capacity added upon completion of step four, divided by (P_{max}-P_{min})[13]

6. Define EFC of the DR to be equal to its ERC*(P_{max}-P_{min})[14]

Non-ELCC/ERC RA Methodology

In the event that ongoing ELCC modeling is not complete in time for the 2015 RA compliance year, or that this type of probabilistic modeling requires more time to be phased in, the RA counting rules for DR shall be identical to those for existing Retail DR, which is based on ex-ante forecasting and does not use probabilistic modeling. However, the testing requirements outlined above for the ELCC- and ERC-based methodologies will be required as an interim step.

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[12] Generation with ideal operating characteristics: immediate start-up, infinite ramping capability, no use limitations, and no outages. Perfect generation has a P_{min} of zero.

[13] P_{min} is either a negative number (indicating ability to shift load to increase consumption), or zero.

[14] Because the perfect generation has a P_{min} of zero, while the DR may have a negative P_{min}, if the ability to shift load to increase consumption contributes more to reliability than the ability to decrease load, then it is possible that the amount of perfect capacity added in step four will be greater than P_{max}-P_{min}, yielding an ERC of greater than one. This would in turn yield an EFC that is greater than P_{max}-P_{min} (where P_{min} is negative). Regardless of its exact value, the EFC is quite likely to be greater than the QC for facilities with a negative P_{min}, because the EFC includes the negative generation range and the QC does not.

Energy Storage (ES)

RA Eligibility Assumptions

For RA eligibility purposes, and to ensure consistency across resource types, it is assumed that ES charging can be scheduled in advance so as not to increase the loss of load expectation (LOLE)[15] or the lack of ramping expectation (LORE)[16] and that it is capable of fully discharging once and only once per day. It is further assumed that any ES with under 12 hours of discharge (or charge) duration is able to recharge (or discharge) over the course of that same day to return to zero mileage,[17] enabling all ES to fulfill the RA eligibility requirement of the ability to operate over three consecutive days. This is consistent with the general rule that system and local RA resources must be available for four hour events three days in a row. However, this recharging must be subject to CAISO dispatch or control, in order to avoid contributing to system stress.

Additionally, dispatchable charging (negative P_{min}) is included in the determination of EFC for energy storage, as it contributes to softening the beginning of an upward ramping period by making the net load trough shallower; it is not included in the QC, as that value is a reflection of contributions to meeting peak (positive) load only. In the event that this leads to EFC greater than QC, a situation that has been prohibited in the past, that result may need to be permitted in a decision.

Energy Storage Use Cases

In D. 12-08-016 of the CPUC Energy Storage Proceeding (R.10-12-007), the Commission approved an approach to storage that is focused on "end uses". As part of the justification for this approach, it noted that the "*[i]dentification of relevant situations will facilitate the inclusion of energy storage as needs are identified in other proceedings, such as RA, RPS and LTPP."* In keeping with that Decision, the treatment of energy storage in this document is structured based on the storage grid domains, regulatory functions, and use case examples identified in the proposed decision recently released in the Energy Storage Proceeding:[18]

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[15] Expected amount of time during the year when the load cannot be met based on available capacity. Does not include ramping considerations.

[16] Expected amount of time during the year when ramping needs cannot be met, based on the operational constraints of the available capacity.

[17] Mileage refers to the overall change in ES charge, regardless of path taken. Positive mileage indicates that the ES has discharged, and negative mileage indicates that the ES has charged. Zero mileage indicates that the ES has either remained at or returned to its initial state.

[18] R.10-12-007. Table 1, page 14 of the Proposed Decision: http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M076/K386/76386796.PDF.

Storage Grid Domains (Grid Interconnection Point)	**Regulatory Function**	**Use-Case Examples**
Transmission-Connected	Generation/Market	**(Co-Located Energy Storage)** Concentrated Solar Power, Wind + Energy Storage, Gas Fired Generation + Thermal Energy Storage
		(Stand-Alone Energy Storage) Flywheel/Ancillary Services, Battery/Peaker, Pumped Hydro/Load Following
	Transmission Reliability (FERC)	Voltage Support
Distribution-Connected	Distribution Reliability	Substation Energy Storage (Deferral), Community Energy Storage
	Generation/Market	Distributed Generation + Energy Storage
	Dual-Use (Reliability & Market)	Distributed Peaker
Behind-the-Meter	Customer-Sited Storage	Bill Management/Permanent Load Shifting, Power Quality, Electric Vehicle Charging

Only energy storage that is economically dispatched by the CAISO is within the scope of this document; customer-oriented, demand-side use cases may be addressed in future proceedings.

For transmission-connected energy storage, the qualifying capacity concept applies to both stand-alone and co-located energy storage use cases. However, only stand-alone storage receives its own QC; co-located energy storage instead modifies the QC of the associated generation.

For distribution-level energy storage, distributed ES "peakers" and distributed generation with energy storage are addressed in this proposal at this time. Both must participate in CAISO markets and be subject to must-offer obligations.

As in the case of demand response, customer-sited storage may be viewed as either a load modifier or as a supply-side resource. To be viewed as a supply-side resource and qualify for RA, behind-the-meter energy storage must comply with all RA eligibility requirements, including a minimum operating duration of four hours for three days consecutively (at both P_{max} and P_{min}), and compliance with the applicable must -offer obligation.

Stand-Alone Energy Storage, Distributed ES Peakers, and Customer-Sited Storage

In the Draft CPUC Energy Storage Use Case Analysis,[19] stand-alone energy storage (referred to as "Bulk Storage Systems") is defined as:

> Energy storage that is controlled independently of other generation sources. It accomplishes charging and discharging functions through market participation in energy and ancillary services. These systems typically have multiple hours of energy storage capability and also can provide resource adequacy to the system (subject to meeting duration requirements).

Distributed ES peakers, meanwhile, are defined as follows:

> [A] network of distributed energy storage systems functioning effectively as both a solution for local substation specific problems and a distributed peaking plant that connects to and charges off the distribution system to deliver local capacity, ancillary services, and energy to congested nodes in the distribution network.

This use case example is more specifically described in the Distributed Storage Peaker Use Case Analysis[20] as:

> [A] network of individual Distributed Energy Storage Systems (DESS), each with capacities ranging from 20 kW up to a few MW, which in aggregate provides tens of megawatts of capacity for a duration of 2-4 hours. This energy storage solution would function effectively to address local substation specific problems, provide peaking capacity, and deliver ancillary services by connecting to and charging off the distribution system. It is assumed that the resource has successfully connected to the distribution grid under California ISO interconnection rules and processes and includes CAISO-approved telemetry that allows for remote monitoring of the resource and related factors.

On the customer side, the Staff Phase Two Interim Report defines storage for customer bill management with market participation as follows:[21]

> The storage device optimizes operation to provide maximum benefit to the grid and the utility customer by reducing peak load, firming renewable output, and selling ancillary services into the CAISO market when possible. Optimal operation will depend upon the storage device, the utility,

[19] http://www.cpuc.ca.gov/NR/rdonlyres/3E556FDB-400D-4B24-84BC-CD91E8F77CDA/0/TransmissionConnectedStorageUseCase.pdf

[20] http://www.cpuc.ca.gov/NR/rdonlyres/06E4C603-300A-4B77-85A7-F0400DAB21A0/0/DistributedUseCasePeaker.pdf

[21] http://www.cpuc.ca.gov/NR/rdonlyres/4E519F6F-82CE-4428-86F2-5F8791DA248B/0/StaffPhase2InterimReport.pdf

the customer, and the location of the system. When selling into ancillary services markets, the storage device will generally participate in only one market at a time.

Other customer-sited applications with CAISO market participation are also possible, such as electric vehicle charging.

All of the above system types participate in CAISO markets and may aggregate multiple smaller storage units. The primary difference is whether the interconnection point is at the transmission level, the distribution level, or behind the meter. This difference may be relevant in the CAISO calculation of net qualifying capacity (NQC) values, which are based on QC. However, the interconnection point does not impact the QC or EFC calculations. Therefore, these use case examples are treated identically in this document.

Consistent with other RA resources, energy storage systems must be capable of sustaining P_{max} and P_{min} for a minimum of four hours (after any aggregation) in order to be eligible for System or Local RA. To be eligible for Flexible RA, systems must be capable of ramping or sustaining output over three hours continuously. To demonstrate compliance with this rule, test data for P_{max} and P_{min} must include the duration over which these values were sustained. In order to be RA-eligible, ES resources must also be subject to a must-offer obligation. Additionally, all resources, including behind-the-meter storage, must include the telemetry necessary to demonstrate performance upon dispatch.

The calculation approach and methodology described below applies to any stand-alone, distributed peaker, or behind-the-meter storage that is determined to be RA eligible.

QC and EFC Calculation Approach

Similar to DR resources, the QC is calculated as ELCC*P_{max}, and the EFC is calculated as ERC*(P_{max} - P_{min}).

P_{max} and P_{min} refer to the maximum and minimum power levels of the ES facility. P_{min} may be negative in the case of dispatchable load; otherwise, it is excluded from the above equation.

The effective load carrying capability (ELCC) and effective ramping capability (ERC) are outputs of probabilistic modeling, which assesses likely system needs and the potential of the ES to contribute to these needs. This modeling incorporates ES characteristics such as forced outage rate, ramp rate, start-up time, charge and discharge durations, available energy, and advance notice time requirements (measured in minutes).

The ELCC expresses how well the ES is able to meet reliability conditions and reduce expected reliability problems or outage events as compared to a perfect generator (considering availability and use limitations). The ERC expresses how well the ES is able to meet upward ramping and intra-hour operational needs, as compared to a perfect generator (considering availability and use limitations).

The ELCC and ERC can be viewed as deratings that capture ES availability, use limitations, and the usefulness of the resource’s operating characteristics towards meeting system needs. For example, if modeling indicates that reliability needs are greatest in the afternoon, then an ES facility that only operates in the morning would be derated more than an otherwise-identical facility that only operates during the afternoon, because its contribution to reliability needs would be smaller. Similarly, a facility with a high outage rate at times of system stress would also be derated more than an otherwise-identical, more reliable facility.

Note that because P_{max} and P_{min} are defined for a minimum duration of four hours, instantaneous power levels may be beyond P_{max} or P_{min} for short durations.[22] The ELCC and ERC calculations will account for this via an available energy constraint, which may result in a QC greater than P_{max} or EFC greater than P_{max}-P_{min}, if the duration of operation anticipated by the ELCC-ERC model is found to often be much shorter than the four hours used in testing.

The ELCC and ERC are calculated similarly to those of DR facilities, as follows.

ELCC and QC Calculations for Stand-Alone, Distributed Peaker, and Behind-the-Meter Storage Systems

1. Use a reliability calculator to model California's regional electrical system with the ES and determine the loss of load expectancy (LOLE)[23]

2. Model the system again without the ES; this will increase the LOLE

3. Add a small amount of *perfect generation*[24] capacity to the model, and recalculate the LOLE

4. Repeat step three, stopping when the LOLE is equal to that found in step one

5. Define the ELCC of the ES to be equal to the total amount of perfect capacity added upon completion of step four, divided by P_{max}

6. Define the QC of the ES to be equal to its ELCC*P_{max}

ERC and EFC Calculations for Stand-Alone, Distributed Peaker, and Behind-the-Meter Storage Systems

1. Use a reliability calculator to model California's regional electrical system with the ES and determine the lack of ramping expectancy (LORE)[25]

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[22] This may be specified in practice via CAISO emergency ratings.

[23] The model includes all ES operating characteristics, including use limitations and forced outage rate (FOR). Characteristics to be determined based on historical data when possible, or based on manufacturer test data submitted to the CAISO (for initial operation).

[24] Generation with ideal operating characteristics: immediate start-up, infinite ramping capability, no use limitations, and no outages. Perfect generation has a P_{min} of zero.

2. Model the system again without the ES; this will increase the LORE

3. Add a small amount of perfect generation capacity to the model, and recalculate the LORE

4. Repeat step three, stopping when the LORE is equal to that found in step one

5. Define the ERC of the ES to be equal to the total amount of perfect capacity added upon completion of step four, divided by (P_{max}-P_{min})[26]

6. Define EFC of the ES to be equal to its ERC*(P_{max}-P_{min})[27]

Co-Located Energy Storage

Use Case Definition and Description

In the Draft CPUC Energy Storage Use Case Analysis,[28] two examples of co-located energy storage are described: on-site VER storage, and on-site generation storage. On-Site VER Storage is defined as:

> Energy storage that is located on-site of an intermittent resource such as wind and solar. These storage deployments are used to enhance the capacity, energy, or ancillary services revenues of that generator. Some technologies, such as batteries, may choose to operate a part of the battery independently of the on-site generation source. That participation would be counted in either the bulk storage system or ancillary services storage.

On-Site Generation Storage, meanwhile, is defined as:

> Energy storage that is located on-site of a non-intermittent resource, mostly base load or flexible resource. Energy storage is used to enhance the ability of the on-site generator to participate. If controls systems develop to allow AGC controls for the on-site generation storage systems themselves, independent of the host generator, that participation would be counted in the bulk storage system or ancillary services storage.

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[25] The model includes all ES operating characteristics, including use limitations and forced outage rate (FOR). Characteristics to be determined based on historical data when possible, or based on manufacturer test data.

[26] P_{min} is a negative number (representing charging capacity).

[27] Because the perfect generation has a P_{min} of zero, while the ES has a negative P_{min}, if charging capability contributes more to reliability than discharging capability then it is possible that the amount of perfect capacity added in step four will be greater than P_{max}-P_{min}, yielding an ERC of greater than one. This would in turn yield an EFC that is greater than P_{max}-P_{min} (where P_{min} is negative). Regardless of its exact value, the EFC is quite likely to be greater than the QC, because the EFC includes the negative generation range and the QC does not.

[28] http://www.cpuc.ca.gov/NR/rdonlyres/3E556FDB-400D-4B24-84BC-CD91E8F77CDA/0/TransmissionConnectedStorageUseCase.pdf

Energy storage may also be co-located with distributed generation facilities. For RA purposes, the QC and EFC calculation methodologies are identical to those for energy storage co-located with transmission-level generation facilities. Distribution-level resources are also still subject to all RA eligibility requirements, including minimum durations for operation and being subject to the applicable must-offer obligation. However, the net qualifying capacity (NQC) determination conducted by the CAISO may follow a different methodology.

ES may also be co-located with DR. This use case will be treated separately, as it is conceptually an aggregation of two similar, use-limited resources rather than a supplement to a primary generating facility.

For ES co-located with conventional generation, application of the methodology described here is optional. The conventional facility may instead choose to follow pre-existing QC and EFC regulations rather than applying the proposed ELCC- and ERC-based methodologies; however, in this case the facility would not receive RA credit for co-located storage.

For the purposes of Local RA eligibility, co-located is defined as being located at the same transmission node as a larger, primary generating facility or DR resource.[29] For System RA and Flexible RA, the facilities must be located in the same LSE service territory. The primary facility must have a P_{max} greater than or equal to that of the storage component. A co-located storage unit can only be associated with one generating resource or DR resource. The QC and EFC are assigned to a combined facility Resource ID; both the ES and the associated generating or DR resource also receive individual Resource IDs for modeling and reporting purposes.

Primary generating facilities must independently meet applicable RA eligibility requirements and continue to follow existing RA rules. For example, dispatchable hydropower facilities must revise their available energy estimates each year to account for changes in rainwater levels. The ES component, because it operates as a supplement to the primary facility, need not independently meet RA eligibility requirements for P_{max} and P_{min}[30] duration and may report any whole-minute duration length over which it is able to generate its P_{max} and P_{min}. However, it is still subject to a must-offer obligation.

When ES is co-located with DR, the combined, aggregated resource must meet applicable RA eligibility requirements, such as ability to sustain P_{min} and P_{max} over four consecutive hours for three consecutive days and commitment to the applicable must-offer obligation. Individual components must report whole-minute durations for P_{max} and P_{min}, which can be aggregated (in duration and/or in P_{max} and P_{min}) to create a combined resource. DR eligibility and testing requirements remain otherwise unchanged from stand-alone DR.

[29] If the ES facility is larger than the generating facility or DR resource, then it shall be treated separately, as a stand-alone storage facility.

[30] P_{min} is relevant for EFC, not QC, as discussed previously.

Conceptually, maximum output from co-located storage facilities occurs during simultaneous conventional/VER/DR generation and ES discharge, for example on a windy day when the ES associated with a wind farm is already fully charged and net load is high. Minimum output occurs when the ES is charging from the grid (i.e., a negative P_{min}) and the primary generator is not generating any power (or an DR resource has increased its consumption to also create a negative P_{min}). For example, solar PV with ES may charge overnight to enable contribution to winter morning loads. Another example could be ES associated with a wind farm, charging on a calm day in order to serve early evening load. Storage can also be used to supplement a known lack of resource availability, such as a DR resource that is only available during business hours, or solar that is not available after dark. These examples illustrate that co-located storage enables significantly greater availability for VER and DR resources, including during times that would otherwise be physically impossible. At the same time, however, on-site ES may significantly change how "clean" renewable energy plants are, as the ES may frequently be charged from the grid and not from its associated renewable generation facility.[31]

QC and EFC Calculation Approach

Because storage co-located with a primary generating facility is not stand-alone but rather used to enhance the performance of the primary resource, this storage should not have its own QC, but rather increase the combined plant's QC. The calculation methodology is similar to that for stand-alone storage systems:

- $QC = ELCC*P_{max,primary}$, and
- $EFC = ERC*P_{max,primary}$,

where $P_{max,primary}$ is the P_{max} of the primary facility (excluding storage), and all other terms refer to the combined plant.

For storage that is aggregated with DR to create a combined resource, the aggregate P_{max} and P_{min} are used. Energy Division seeks stakeholder input on the details of how aggregation would be quantified. For example, if an aggregated ES can supply a P_{max} of 1 MW and a P_{min} of -1 MW over a duration of three hours, it could be combined with an aggregated DR resource that can supply the same P_{max} and P_{min} over a duration of only one hour to create a combined resource that meets the minimum duration requirement of four hours and is RA-eligible for a P_{max} of 1 MW and a P_{min} of -1 MW. The calculation methodology is then almost identical to that of the other storage use cases:

- $QC = ELCC*P_{max}$, and
- $EFC = ERC*(P_{max} - P_{min})$,

where P_{max} and P_{min} are properties of the aggregated ES-DR resource as described above.

[31] This may be a particular issue for RPS compliance. Separate Resource IDs for components may aid in reporting and compliance. This and other issues can be addressed in the appropriate proceedings.

ELCC and QC Calculations for Co-Located Storage

The ELCC for ES-supplemented resources can be calculated as follows:

1. Use a reliability calculator to model California's regional electrical system with the primary generating facility (or DR) and ES, and determine the loss of load expectancy (LOLE)[32]
2. Model the system again without the primary/DR resource and ES; this will increase the LOLE
3. Add a small amount of perfect generation capacity to the model, and recalculate the LOLE
4. Repeat step three, stopping when the LOLE is equal to that found in step one
5. Define the ELCC of the combined system to be equal to the total amount of perfect capacity added upon completion of step four, divided by either:
    a. $P_{max,primary}$, the P_{max} of the primary generating facility, excluding the ES, or
    b. P_{max}, the aggregate P_{max} of co-located DR and ES resources
6. Define QC of the combined system to be either ELCC*$P_{max,primary}$ or ELCC*P_{max}, for ES systems co-located with primary generating facilities or aggregated with DR resources, respectively

ERC and EFC Calculations for Co-Located Storage

The ERC for ES-supplemented resources can be calculated as follows:

1. Use a reliability calculator to model California's regional electrical system with the primary generating facility (or DR) and ES, and determine the lack of ramping expectancy (LORE)[33]
2. Model the system again without the primary/DR resource and ES; this will increase the LORE
3. Add a small amount of perfect generation capacity to the model, and recalculate the LORE
4. Repeat step three, stopping when the LORE is equal to that found in step one
5. Define the ERC of the combined system to be equal to the total amount of perfect capacity added in step four, divided by either:

[32] The model includes all resource operating characteristics, including use limitations and forced outage rate (FOR). Characteristics to be determined based on historical data when possible, or based on manufacturer test data submitted to the CAISO (for initial operation). The ES is permitted to charge from the grid, as well as from the primary generating facility.

[33] The model includes all resource operating characteristics, including use limitations and forced outage rate (FOR). Characteristics to be determined based on historical data when possible, or based on manufacturer test data submitted to the CAISO (for initial operation). The ES is permitted to charge from the grid, as well as from the primary generating facility.

a. $P_{max,primary}$, the P_{max} of the primary generating facility, excluding the ES, or

b. P_{max}-P_{min} (using the aggregate P_{max} and P_{min} of co-located DR and ES resources)

6. Define EFC of the combined system to be either ERC*$P_{max,primary}$ or ERC*(P_{max}-P_{min}) , for ES systems co-located with primary generating facilities or aggregated with DR resources, respectively

Non-ELCC, Alternative QC Methodology

In the event that ongoing ELCC modeling is incomplete or requires more time to be phased in, the sections below propose an alternate methodology for calculating QC and EFC for storage. The ES must still meet all standard RA eligibility rules, as previously described. ES must also bid into the CAISO market, making it economically dispatchable. ES that is customer-oriented and non-dispatchable will not be RA eligible. Facilities may be aggregated to increase P_{max} and P_{min} and/or discharge duration, as discussed previously.

Stand-Alone, Distributed ES Peaker, and Behind-the-Meter Storage Systems

Similar to gas-fired generation facilities, ES facilities must submit P_{max} testing to the CAISO; this number would be used as the basis for the QC. For the time being, as few ES facilities exist, proxy values must be found and verified until actual historical production data is available. As soon as possible, ES facilities would be analyzed to create proxy performance data for facilities yet to become commercial. Historical data must be submitted where possible; if less than one year of historical data is available, manufacturer test data may be substituted. Over time, performance data (going back up to three years) would be used to modify the QC of ES facilities to reflect actual operational capabilities.

The effective flexible capacity would be calculated according to the same methodology as for other resource types. However, it may include the full operational range of the ES, from a negative P_{min} to a positive P_{max}.

Co-Located Storage

If an ES is capable of independently qualifying as an RA resource, then it would be permitted to submit testing and receive QC and EFC values in exactly the same manner as stand-alone, distributed ES peaker, and behind-the-meter storage systems. The associated generating or DR resource would receive its own QC and EFC values as well, according to the standard methodology for that resource (excluding storage). Co-located resources would not receive combined QC and EFC values, nor would they receive an aggregate Resource ID.

If an ES is not capable of independently qualifying as an RA resource, then it would not receive a QC or EFC according under this alternative proposal. However, it would still enhance the performance of the co-located facility, which would be reflected in the performance data used to calculate the QC (and EFC) of the co-located generator.