California ISO

Aggregate Capability Constraint - Implementation

May 27, 2021

1. Summary and Timeline

The ISO recognizes that developers build large projects and often disaggregate those projects among off-takers. The ISO also recognizes that developers are co-locating renewable and energy storage resources at single generating facility sites. Currently, the ISO tariff permits an interconnection customer to utilize one aggregate capability constraint (ACC) at such a generating facility. This functionality allows the ISO to model the aggregate capabilities of separate resources co-located at a single generating facility as part of its day-ahead and real-time markets. By using this constraint the combined maximum operating level of the co-located resources may not exceed the generating facility's interconnection service capacity.

In the context of this initiative, the ISO proposes a framework under which interconnection customers may use multiple aggregate capability constraints for portions of the co-located resources at a single generating facility. This framework will also allow the ISO to relax subordinate aggregate capability constraints when the market is having difficulty balancing supply and demand. This will ensure that multiple aggregate capability constraints at a single generating facility do not inadvertently strand generating capacity behind a constraint that may otherwise be available to serve demand when there are reliability concerns on the grid.

The ISO proposes the following:

- The ISO will allow multiple ACCs at the same generating facility
- All co-located resources at the generating facility utilizing an ACC will be subject to the studied POI limits
    - The ISO will manage these with a "master ACC" constraint
- Co-located resources may utilize additional "subordinate ACCs"
    - The ISO will recognize multiple constraints in parallel
    - One resource ID can be only in one sub ACCs
    - If the market software relaxes a subdue ACC for a reliability constraint, underlying resources are still required to follow dispatch instructions
    - The ISO will have no liability if co-located resources do not comply with dispatch instructions and infringe on interconnection capacity for use by other co-located resources at a generating facility
- The master ACC constraint may be re-evaluated by the ISO operations team in extreme (i.e. emergency) circumstances during processes when other POI limits are adjusted
    - The market will not relax the master ACC
- The ISO market optimization may relax sub-ACC constraints while trying to resolve reliability issues and to help mitigate the risk of violating the power balance constraint

The ISO proposes the expedited timeline, outlined in Table 1, to complete this effort. This timeline includes approval from the ISO Board of Governors during its July 2021 meeting. Following the Board of Governors Meeting, the ISO plans to file necessary tariff changes with the Federal Energy Regulatory Commission.

Table 1: Timeline

Date	Milestone
March 15, 2021	ISO Published Informational Paper on ACC
March 22, 2021	ISO Presented Informational Paper
May 27,2021	ISO Published ACC Proposal and draft tariff language
June 3, 2021	ISO Presented ACC Proposal and draft tariff language
June 14, 2021	Comments Due
June 30, 2021	EIM Governing Body Meeting
July 14-15, 2021	BOG Meeting to discuss changes to ACC
Fall 2021	Target ACC Implementation

2. Background

2.1. Policy Development

The ISO developed the aggregate capability constraint as a component of the hybrid resource initiative.[1] Phase 1 of the hybrid resource initiative introduced the aggregate capability constraint, which provides the ISO with greater flexibility to model co-located resources. The constraint allows the ISO to model the aggregate capabilities of separate resources co-located at a single generating facility as part of its day-ahead and real-time markets. By using this constraint the combined maximum operating level of the co-located resource may exceed the generating facility's interconnection service capacity. Prior to developing this constraint, the ISO required that the sum of maximum generation levels (Pmax) for various resource IDs at a single point of interconnection to not exceed the interconnection service capacity limit. This rule was in place to ensure that market software did not issue infeasible dispatch instructions to resources behind a single point of interconnection because they would otherwise exceed the generating facility's studied interconnection service capacity limit. The ISO Board of Governors approved phase 1 of the hybrid resource initiative at the July 2020 meeting.[2] The ISO implemented the software to implement the aggregate capability constraint in the fall of 2020.

Phase 2 of the hybrid resource initiative contemplates allowing co-located resources with an aggregate capability constraint to provide ancillary services in addition to energy. The ISO Board of Governors approved phase 2 of the hybrid resources initiative at the November 2020

[1] Hybrid resource initiative: https://stakeholdercenter.caiso.com/StakeholderInitiatives/Hybrid-resources.
[2] Board of Governors Meetings: http://www.caiso.com/informed/Pages/BoardCommittees/BoardGovernorsMeetings.aspx.

meeting. The ISO anticipates activating functionality to allow co-located resources using an aggregate capability constraint to provide ancillary services in the fall of 2021.

In late 2020, stakeholders approached the ISO about using the aggregate capability constraint to represent contractual limits for underlying portions of resources at a single point of interconnection. This paper offers a methodology for enforcing established and future contractual operating limits for co-located resources and continuing to enforce interconnection service capacity limits at a generating facility's point of interconnection.

2.2. Aggregate Capability Constraint

In the hybrid resource initiative, the ISO recognized an issue where co-located and hybrid resources could build generating capability in excess of approved interconnection limits, which can happen when resources are paired at a generating facility behind a single point of interconnection. For example, solar and storage pair well and may be 'oversized' compared to the interconnection limit, as storage is incentivized to charge while solar is generating and solar is usually partially or completely unavailable when storage is economic to discharge. These resource arrangements are a result of various commercial considerations and resource synergies that can better leverage and respond to market prices on the ISO grid.

The ISO has experience with multiple resources at the same generating facility behind a single point of interconnection. Traditionally, the ISO modeled these resources so that the aggregate maximum generating value, Pmax in Master File, reflected the interconnection service capacity of the entire generating facility. For example, a 100 MW resource and a 50 MW resource operating behind a single 100 MW interconnection service capacity limit might register as two resources – one resource with a 67 MW maximum generating capability (Pmax) and a second resource with a 33 MW maximum generating capability. Modeling resources this way ensures that aggregate dispatch instructions to both resources never exceeds the 100 MW interconnection limit. However, this modelling approach limits the total amount of dispatch available from each individual resource and the ISO would like the ability to receive bids from and issue awards to all of the capacity of these resources in order to enhance reliability and market efficiency. The aggregate capability constraint is the market functionality that allows for this outcome.

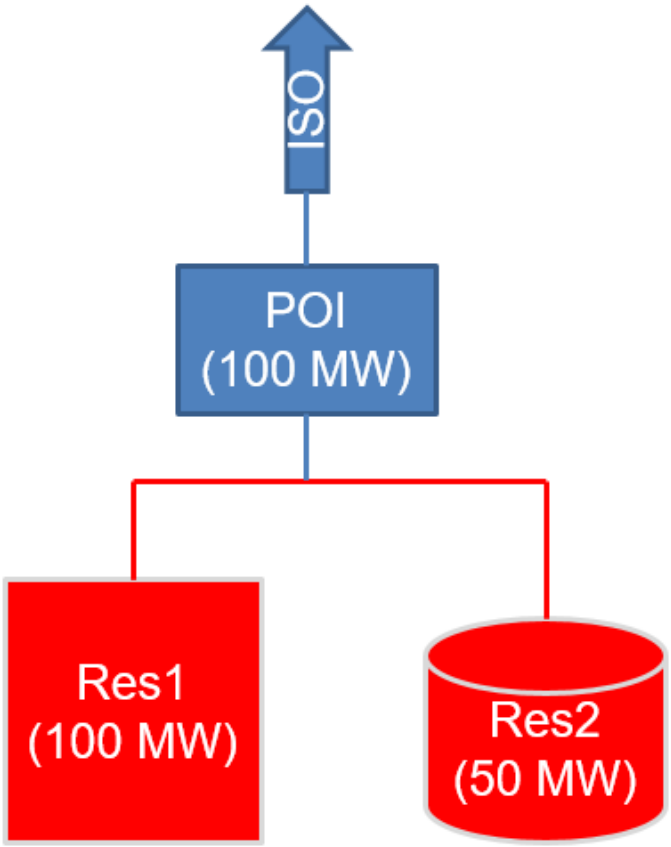
By using the aggregate capability constraint, the ISO can manage the interconnection limit when co-located resources have aggregate maximum generating capabilities greater than the interconnection limit. It serves as a limit to the total aggregate quantity of energy that may be dispatched from an underlying set of co-located resources. The ISO can apply the aggregate capability constraint to multiple resources (i.e. more than two) at the same generating facility. The current aggregate capability constraint functionality does not allow for sub-constraints at a single generating facility such that co-located resources at a single generating facility are subject to different aggregate capability constraints.

Simple Example: Aggregate Capability Constraint

This is a relatively straightforward example with two underlying co-located resources with a single aggregate capability constraint applied to enforce a single point of interconnection limit.

In Figure 1**Error! Reference source not found.**, there are 2 co-located resources: resource 1 and resource 2. We assume that resource 1 is a 100 MW resource and resource 2 is a 50 MW resource. Both resources are part of the same generating facility and are limited to injecting no more than 100 MW into the ISO at their point of interconnection at any time. In this example, there is a physical limit reflected in the interconnection agreement preventing injection onto the grid above 100 MW.

Figure 1: Simple ACC application with 2 co-located resources



In this example, resource 1 and resource 2 are co-located. Further, because the aggregate value of the maximum generation from these two resources exceeds the limit at the point of interconnection, the ISO will require application of the aggregate capability constraint to prevent the combined dispatch from these resources from ever exceeding the 100 MW interconnection limit.

The ISO is agnostic about the underlying technology for resource 1 and resource 2. In this example, resource 1 could be a solar resource and resource 2 could be a storage resource, which could reflect many of the resources that the ISO anticipates implementing in the market

during the next few years. However, these resources could be any combination of hybrid, gas, renewable, hydro or storage generation.

3. ACC Implementation Proposal

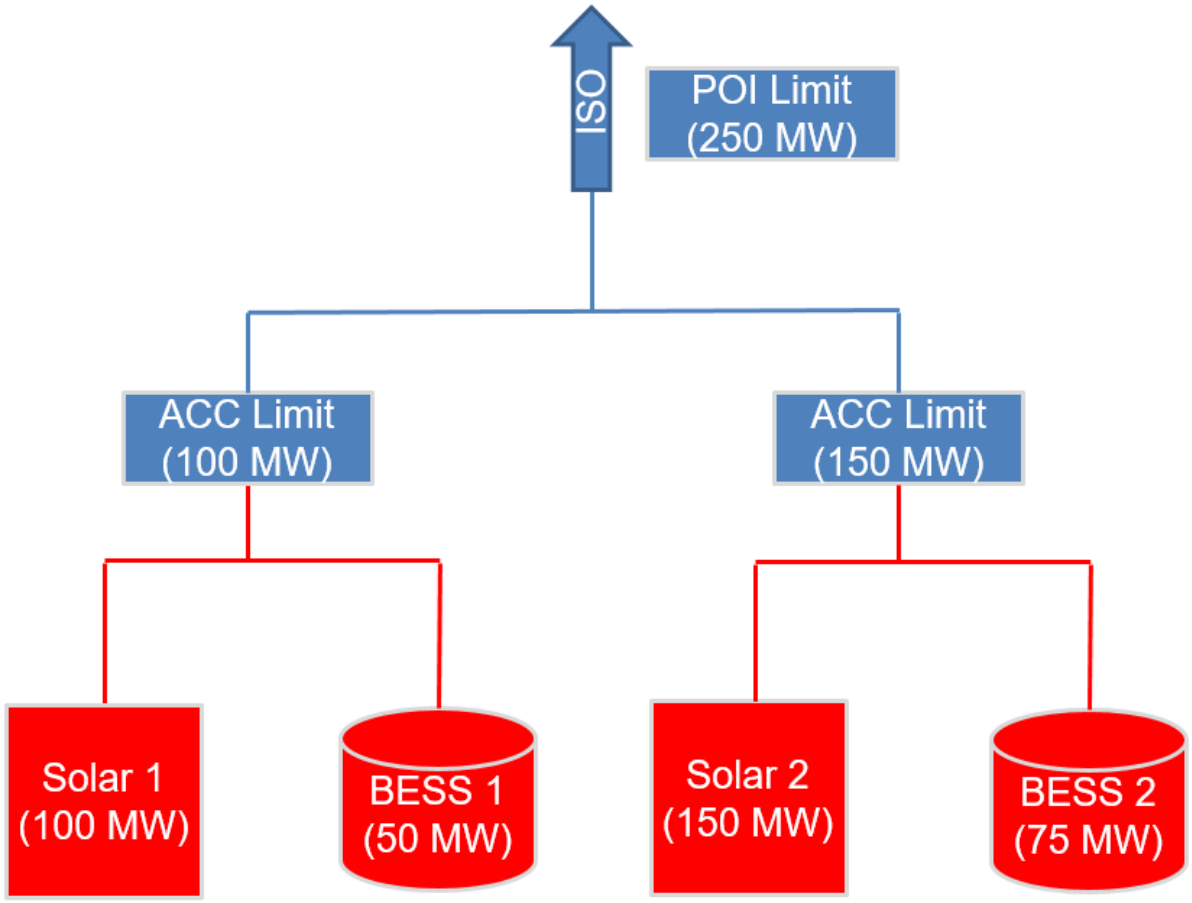
The ISO proposes a framework to allow for the use of multiple aggregate capability constraints at a single generating facility to groups of co-located resources. The ISO refers to these constraints as subordinate aggregate capability constraints because they nest and are subordinate to the aggregate capability constraint that observes the generating facility's total interconnection service capacity limit. This framework would allow multiple resources and off-takers at a generating facility comprised of co-located resources. The use of subordinate constraints will allow the ISO to model each set of co-located resources to their maximum operating levels but limit the awards and dispatch instructions to the portion of the interconnection service capacity represented by the subordinate aggregate capability constraint. Using these market constraints could prevent any off-taker from exceeding specified contractual limits under normal operating conditions. The example below illustrates this proposal.

Example: Multiple Sub-ACC Constraints

Figure 2, shows a scenario with four co-located resources at a single generating facility and two subordinate aggregate capability constraints. This example reflects a scenario where two physical resources, a 250 MW solar and a 125 MW storage resource are constructed and the developer enters into contracts with two off-takers.[3] The first off-taker, represented on the left, receives contractual rights to 100 MW of the solar resource and 50 MW of the storage resource. That resource is also contractually obligated to never generate more than 100 MW from a combination of the two underlying resource shares at any time. Similarly, a second off-taker, represented on the right, contracts for a 150 MW share of the solar facility and a 75 MW share of the storage resource. The second off-taker is also contractually obligated to never generate more than 150 MW from a combination of the two underlying resource shares at any time.

[3] For simplicity assume that the storage resource is a 4-hour duration battery with a physical generating capability between -125 MW and 125 MW, and a total charging capability of 500 MWh.

Figure 2: One facility with two off-takers and two aggregate capability constraints



In this example, the first off-taker represents their share of the physical solar resource as an independent resource with its own resource ID, modeled as Solar1 and their share of the physical storage resource as BESS1.[4] Similarly, the second off-taker represented their share of the solar resource as Solar2 and their share of the storage resource as BESS2. To accommodate this scenario, the ISO will model four resources: Solar1, BESS1, Solar2 and BESS2 as independent resources with attributes, including maximum generating capabilities and maximum state of charge values, located at the same point of interconnection.[5]

The ISO's modeling approach recognizes the contractual limits for the combined output of the Solar1 and BESS1 resources and for the combined output of the Solar2 and BESS2 resources.

[4] The off-taker may represent any of the resources with one or more resource IDs, and is not limited to a single resource ID for a given fuel type.

[5] This is consistent with current ISO practice within the interconnection process today. Each resource is subject to the typical ISO interconnection process, and is required to submit telemetered information to the ISO for market modeling of each resource. All variable energy resources continue to be subject to Appendix Q requirements and must have specific meteorological stations for forecasting purposes for each resource. This process also requires that the physical resources (turbines/panels…) related to each specific resource be specified.

The ISO enforces these limits in the market using two subordinate aggregate capability constraints. The first subordinate aggregate capability constraint ensures that output from Solar1 and BESS1 does not exceed 100 MW and the second ensures that Solar2 and BESS2 do not exceed 150 MW. Further, all four resources would continue to be subject to the interconnection service capability limit of 250 MW, imposed by the master aggregate capability constraint.

Additional Implementation Details

During normal operations, when the power balance constraint and reliability is not threatened, the ISO will not dispatch resources above subordinate aggregate capability constraints. During periods when reliability is threatened and the market is considering relaxation of the aggregate capability constraint, the market may relax subordinate aggregate capability constraints to ensure that supply can satisfy demand. Relaxing these constraints may result in dispatch instructions above contractual limits specified between the off-taker and project developer.

The ISO requires that resources follow issued dispatch instructions during all intervals, including those when instructions may exceed contractual limits to maintain reliable grid operations.[6] This implies that a project off-taker may receive market awards in excess of contractual output limits from the co-located project during periods when these constraints are relaxed. Previously, during the initial discussion of the aggregate capability constraint, the ISO noted a similar situation could arise due to how the aggregate capability constraint would be priced:

> *Further, if the ISO finds that co-located resources are broadly not following dispatch instructions because of this inconsistency, where the ISO may determine that this approach is not achieving its objective of balancing efficient use of the interconnection capability while maintaining and ensuring reliable operation, this component of the policy may be revisited. Specifically, the ISO may reconsider how co-located resources are priced so that these resources receive prices behind the point of interconnection, rather than in front of it. This would imply that when prices are high and co-located resources are collectively capable of producing above the interconnection limit, then the price signal would equal the marginal cost of one of the co-located resources, rather than the prevailing price at the point of interconnection.*[7]

At that time the ISO committed to reviewing the behavior of co-located resources and reviewing allowable functionality from those resources. This commitment would extend to reviewing market participant behavior for resources that are subject to master and subordinate aggregate capability constraints. At this time, the ISO is not proposing specific criteria for flagging market participants or specific criteria that would result in ineligibility for either of the constraints.

Failure to follow dispatch for a single resource could result in reduced ability for other off-takers to use their full interconnection capability or revoking the ability for particular resources to use the subordinate aggregate capability constraints. The ISO is not proposing any compensation for other off-takers nor accepting liability during these situations, should they arise. This is

[6] Requirements to follow dispatch instructions are included in Section 7.7(c) of the ISO tariff.
[7] Hybrid Resources Second Revised Straw Proposal, April 29, 2020: http://www.caiso.com/InitiativeDocuments/SecondRevisedStrawProposal-HybridResources.pdf.

similar to treatment of other generating facilities split into multiple resources. In the event that these situations arise, off-takers and counterparties may devise some contractual methodology for compensation. Relaxations will occur similar to other typical market dispatch awards from the ISO, and the ISO will not flag these intervals or alert other scheduling coordinators at the co-located project.

This proposal does not allow for functionality of 'overlapping' subordinate aggregate capability constraints. For example, the ISO is not proposing to allow a subordinate aggregate capability constraint for Solar1, BESS1 and Solar2 and a second subordinate aggregate capability constraint for BESS1, Solar2 and BESS2. In this example BESS1 and Solar2 are included in both constraints and the thus the constraint overlaps these two resources.

4. Constraint Prioritization

Today the ISO sets a priority for all of the constraints that are enforced in the market. During typical operation, constraints may not bind or have any impact on market solutions. As conditions change on the grid and constraints bind, the market software may elect to relax certain constraints to arrive at an optimal solution. Doing so requires that the cost minimization solved by the market incur the penalty price for the constraint it relaxes. Setting appropriate penalty parameters is therefore important to determine the priority among constraints for the market optimization to relax under challenging operational conditions.

The ISO studies impose point of interconnection constraints and line ratings as fixed inputs to the market model. The ISO will impose master aggregate capability constraints in a similar manner, so that the market will not relax them. Consistent with the ISO's interconnection agreements and tariff, the ISO has the right to dispatch any resource at a generating facility to resolve a threatened or imminent system emergency. These situations can include abnormal system operations, including local constraints and can result in temporary increases to interconnection limits.[8] Interconnection limits for co-located resources and master aggregate capability constraints may be temporarily increased during these situations.

As stated in the previous sections, the ISO will enforce two types of aggregate capability constraints, the master and the subordinate aggregate capability constraint. Each constraint will have an associated penalty price to signal the market the relative priority for relaxation. The master aggregate capability constraint is not expected to be relaxed, except in extreme system emergency circumstances as directed by the ISO, and this constraint will have higher priority than the power balance constraint and transmission constraints.[9]

During periods when reliability is threatened, or times when the market is challenged to find supply to satisfy demand, the subordinate aggregate capability constraints can be relaxed. This constraint will have a priority greater than economic bids and just below the priority of the power balance constraint.

[8] These situations are outlined in Section 7.7(c) of the ISO tariff.
[9] This is similar to the priority of the aggregate capability constraints in the market today.