On-Peak Deliverability Assessment Methodology (for Resource Adequacy Purposes)

Background

The CAISO's deliverability study methodology for resource adequacy purposes was discussed extensively in the CPUC's Resource Adequacy Proceeding in 2004, and was generally adopted in that proceeding. It was also accepted by FERC as a reasonable implementation of LGIP Section 3.3.3, during the FERC Order 2003 compliance filing process. At that time, the generating resources were predominantly non-intermittent, such as thermal plants and hydro plants. The Qualifying Capacity (QC) values used in the deliverability assessment were the respective maximum output for the resource. When the 20% and 33% RPS targets were adopted, that drove a high volume of renewable generation interconnection requests to the grid; hence the methodology was expanded to account for intermittent resources. The QC values for wind and solar resources were calculated based on resource production exceedance values. Aligned with the QC calculation, the CAISO developed the capacity assumptions for intermittent resources in the deliverability assessment based on the exceedance values during the same QC counting window in the summer months. The methodology for selecting capacity assumptions for use in the deliverability assessment has been applied in the CAISO generation interconnection studies and transmission planning studies since that time. Further, policy driven transmission upgrades have been identified and approved to support deliverability of the 33% RPS portfolio relying on the capacity assumption methodology and deliverability assessment methodology.

As the resource portfolio keeps evolving toward a higher RPS target, energy efficiency, demand response and behind-the-meter distributed generation, both the characteristics of the load profile and the resource portfolio are going through a drastic transformation which are driving the need to revise the capacity assumptions used in the deliverability methodology. Starting in 2018, the CPUC replaced the exceedance based QC calculation with an interim Effective Load Carry Capacity (ELCC) approach. ELCC is a statistical modeling approach to determine the capacity value of different resources relative to "perfect capacity". In response to these changes, the CAISO proposed modifications to the methodology for selecting capacity assumptions and vetted with the stakeholders during the fourth quarter of 2018.

1.0 Introduction

A generator deliverability test is applied to ensure that capacity is not "bottled" from a resource adequacy perspective. This would require that each electrical area be able to accommodate the full output of all of its capacity resources and export, at a minimum, whatever power is not consumed by local loads during periods of peak system load.

Export capabilities at lower load levels can affect the economics of both the system and area generation, but generally they do not affect resource adequacy. Therefore, export capabilities at lower system load levels are not assessed in this deliverability test procedure.

Deliverability, from the perspective of individual generator resources, ensures that, under normal transmission system conditions, if capacity resources are available and called on, their ability to provide energy to the system at peak load will not be limited by the dispatch of other capacity resources in the vicinity. This test does not guarantee that a given resource will be chosen to produce energy at any given system load condition. Rather, its purpose is to demonstrate that the installed capacity in any electrical area can be run simultaneously, at peak load, and that the excess energy above load in that electrical area can be exported to the remainder of the control area, subject to contingency testing. Due to the increasing installation of behind-of-the-meter solar PV generation, the peak net load observed from the transmission grid, i.e. peak sales, shifts to later hours when the solar PV output is down and the gross load consumption is still high, which becomes the most critical system condition for non-solar resources to deliver their energy to the aggregated load. For grid connected solar resources, the most critical time period is the peak consumption hours coincident with substantial solar output. The deliverability test assesses both peak load conditions – peak sale and peak consumption.

In short, the test ensures that bottled capacity conditions will not exist at peak load, limiting the availability and usefulness of capacity resources for meeting resource adequacy requirements.

In actual operating conditions energy-only resources may displace capacity resources in the economic dispatch that serves load. This test would demonstrate that the existing and proposed capacity units in any given electrical area could simultaneously deliver full energy output to the control area.

The electrical regions, from which generation must be deliverable, range from individual buses to all of the generation in the vicinity of the generator under study. The premise of the test is that all capacity in the vicinity of the generator under study is required, hence the remainder of the system is experiencing a significant reduction in available capacity. However, since localized capacity deficiencies should be tested when evaluating deliverability from the load perspective, the dispatch pattern in the remainder of the system is appropriately distributed as proposed in Table 1.

Failure of the generator deliverability test when evaluating a new resource in the ~~System Impact Study~~ generation interconnection studies brings about the following possible consequences. If the addition of the resource will cause a deliverability deficiency, then the resource should not be fully counted towards resource adequacy reserve requirements until transmission system upgrades are completed to correct the deficiency.

A generator that meets this deliverability test may still experience substantial congestion in the local area. To adequately analyze the potential for congestion, various stressed conditions (i.e., besides the system peak load conditions) will be studied as part of the overall interconnection study for the new generation project. Depending on the results of these other studies, a new generator may wish to fund transmission reinforcements beyond those needed to pass the deliverability test to further mitigate potential congestion—or relocate to a less congested location.

The procedure proposed for testing generator deliverability follows.

2.0 Study Objectives

The goal of the proposed ISO Generator deliverability study methodology is to determine if the aggregate of generation output in a given area can be simultaneously transferred to the remainder of ISO Control Area. Any generators requesting Full Capacity Deliverability Status in their interconnection request to the ISO Controlled Grid will be analyzed for "deliverability" in order to identify the Delivery Network Upgrades necessary to obtain this status.

The ISO deliverability test methodology is designed to ensure that facility enhancements and cost responsibilities can be identified in a fair and nondiscriminatory manner.

~~3.0 Baseline analysis~~

~~In order to ensure that existing resources could pass this deliverability assessment, a Phase I Generation and Import Deliverability Study was completed that established the deliverability of all existing generation connected to the ISO Controlled Grid. This study included generation projects expected to be commercially operating during summer 2006. The study also established the deliverability of a specified level of imports that were tested during the generation deliverability test. All generation projects higher in the interconnection queue have been tested either prior to, or simultaneously with, generation projects which are undergoing deliverability analysis. This tends to ensure that all new deliverability problems identified can be legitimately assigned to the generation projects currently undergoing analysis.~~

3.0 Modeling Assumptions

The deliverability assessment is performed under two distinct system conditions – the highest system need scenario and the secondary system need scenario.

3.1 Highest System Need Scenario

The highest system need scenario represents when the capacity shortage is most likely to occur. In this scenario, the system reaches peak sale with low solar output. The highest system need hours are hours ending 18 to 22 in the summer months with an unloaded capacity margin less than 6% in the CAISO annual summer assessment or identified as loss of load hour in the CPUC ELCC study for wind and solar resources.

The CEC 1-in-5 peak sale forecast for each planning area is distributed to all the load buses in study.

The net scheduled imports at all branch groups as determined in the latest annual Maximum Import Capability (MIC) assessment set the imports in the study. Approved MIC expansions, if not yet implemented, are added to the import levels.

The intermittent resources are modeled based on the output profiles during the highest system need hours. A 20% exceedance production level for wind and solar resources during these hours sets the Pmax tested in the deliverability assessment. The CAISO will review the latest available CPUC ELCC study data and CAISO annual summer assessment data to annually update the modeling assumptions, as needed.

Pmax for the non-intermittent resources are set to the highest summer month Qualifying Capacity in the last three years. For proposed new non-intermittent generators that do not have Qualifying Capacity value, the Pmax is set according to the interconnection request. For energy storage generation, the Pmax is set to the 4-hour discharging capacity limited by the requested maximum output from the generator.

Table 3.1: Modeling Assumptions for Highest System Need Scenario

Selected Hours	HE18 ~ 22 in summer month and (loss of load event in ELCC simulation by CPUC or UCM < 6% in CAISO summer assessment)
Load	1-in-5 peak sale forecast by CEC
Non-Intermittent Generators	Pmax set to highest summer month Qualifying Capacity in last three years
Intermittent Generators	Pmax set to 20% exceedance level during the selected hours
Import	MIC data with expansion approved in TPP

3.2 Secondary System Need Scenario

The secondary system need scenario represents when the capacity shortage risk will increase if the intermittent generation while producing at a significant output level is not deliverable. In this scenario, the system load is modeled to represent the peak consumption level and solar output is modeled at a significantly high output. The secondary system need hours are hours ending 15 to 17 in the summer months with an unloaded capacity margin less than 6% in the CAISO annual summer assessment or identified as loss of load hour in the CPUC ELCC study for wind and solar resources.

The hour with the highest total net imports among all secondary system need hours from the latest MIC assessment data is selected. Net scheduled imports for the hour set the imports in the study. Approved MIC expansions, if not yet implemented, are added to the import levels.

The intermittent resources are modeled based on the output profiles during the secondary system need hours. 50% exceedance production level for wind and solar resources during the hours sets the Pmax tested in the deliverability assessment. The CAISO will review the latest available CPUC ELCC study data and CAISO annual summer assessment data to annually update the modeling assumptions, as needed.

Pmax for the non-intermittent resources are set to the highest summer month Qualifying Capacity in the last three years. For proposed new non-intermittent generators that do not have Qualifying Capacity value, the Pmax is set according to the interconnection request. For energy storage generation, the Pmax is set to the 4-hour discharging capacity limited by the requested maximum output from the generator.

Table 3.2: Modeling Assumptions for Secondary System Need Scenario

Select Hours	HE15 ~ 17 in summer month and (loss of load event in ELCC simulation by CPUC or UCM < 6% in CAISO summer assessment)
Load	1-in-5 peak sale forecast by CEC adjusted to peak consumption hour
Non-Intermittent Generators	Pmax set to highest summer month Qualifying Capacity in last three years
Intermittent Generators	Pmax set to 50% exceedance level during the selected hours
Import	Highest import schedules for the selected hours

4.0 General Procedures and Assumptions

Step 1: Electrically group the proposed new generation units that are to be tested for deliverability. These electrical groups will be based on engineering knowledge of the transmission system constraints on existing and new generation dispatch. Generating units will be grouped by transmission limitations that will be expected to constrain the generation. Base cases will be built that focus on each group. Because the total MW of proposed generation usually exceeds the amount that is needed to balance loads and resources, several base cases may need to be created, each of which will focus on at least one of the groups. If a group is not the focus, then generation in that group will be dispatched at zero, but will be available to be turned on during the analysis.

Step 2: For each base case created in step 1, dispatch ISO resources and imports as shown in Table 1. This base case will be used for two purposes: (1) it will be analyzed using a DC transfer capability/contingency analysis tool to screen for potential deliverability problems, (2) it will be used to verify the problems identified during the screening test, using an AC power flow analysis tool.

Step 3: Using the screening tool, the ISO transmission system is essentially analyzed facility by facility to determine if normal or contingency overloads can occur. For each analyzed facility, an electrical circle is drawn which includes all units (including unused Existing Transmission Contract (ETC) injections) that have a 5% or greater distribution factor (DFAX) or Flow Impact[1] on the facility being analyzed. Then load flow simulations are performed, which study the worst-case combination of generator output within each 5% Circle. The 5% Circle can also be referred to as the Study Area for the particular facility being analyzed.

Step 4: Using an AC power flow analysis tool and post processing software, verify and refine the analysis of the overload scenarios identified in the screening analysis.

The outputs of capacity units in the 5% Circle are increased starting with units with the largest impact on the transmission facility. No more than twenty[2] units are increased to their maximum output. In addition, no more than 1500 MW of generation is increased. All remaining generation within the Control Area is proportionally displaced, to maintain a load and resource balance. The number of units to be increased within a local area is limited because the likelihood of all of the units within a local area being available at the same time becomes smaller as the number of units in the local area increases. The amount of generation increased also needs to be limited because decreasing the remaining generation can cause problems that are more closely related to a deficiency in local generation rather than a generation deliverability problem.

[1] See note on Flow Impact in Section 4.1 Specific Assumptions. The electrical circle drawn which includes all generators that have a 5% or greater distribution factor (DFAX) or Flow Impact on the facility being analyzed is referred to as the 5% Circle.

[2] The cumulative availability of twenty units with a 7.5% forced outage rate would be 21%--the ISO proposes that this is a reasonable cutoff that should be consistently applied in the analysis of large study areas with more than 20 units. Hydro units that are operated on a coordinated basis because of the hydrological dependencies should be moved together, even if some of the units are outside the study area, and could result in moving more than 20 units.

For Study Areas where the 20 units with the highest impact on the facility can be increased more than 1500 MW, the impact of the remaining amount of generation to be increased will be considered using a Facility Loading Adder. The Facility Loading Adder is calculated by taking the remaining MW amount available from the 20 units with the highest impact times the DFAX for each unit. An equivalent MW amount of generation with negative DFAXs will also be included in the Facility Loading Adder, up to 20 units. Negative Facility Loading Adders should be set to zero.

Step 5: Once the initially identified overloaded facilities are verified, all new generators inside the 5% Circle are responsible for mitigating the overload. Once a mitigation plan has been identified it will be modeled and the deliverability assessment will be repeated to demonstrate that all of the new generation is deliverable with the mitigation plan modeled. If additional overloaded facilities are found, then the mitigation plan will be modified or expanded, as needed, to ensure the deliverability of the new generation.

Table 4.1: Resource Dispatch Assumptions

Resource Type	**Base Case Dispatch**	**Available to Selectively Increase Output for Worst-Case Dispatch?**	**Available to Scale Down Output Proportionally with all Control Area Capacity Resources?**
Existing Capacity Resources (Note ~~1~~2)	80% to 95% of ~~Summer Peak Net Qualified Capacity (NQC)~~ PMAX (Note 1)	Y Up to 100% of ~~NQC~~ PMAX	Y
Proposed Full Capacity Resources (Note ~~2~~3)	80% to 95% of ~~Summer Peak Qualified Capacity (QC)~~ PMAX (Note 1)	Y Up to 100% of ~~QC~~ PMAX	N
Energy-Only Resources	Minimum commitment and dispatch to balance load and maintain expected imports	N	Y
Imports (Note ~~3~~4)	Maximum summer peak simultaneous historical net imports by branch group during selected hours		
Load			
• Non-pump load	~~1 in 5 simultaneous peak load level for CAISO. (Diversity factor of 96% applied to Northern and Southern California 1 in 5 peak loads.)~~ 1 in 5 peak sale level for CAISO in the highest system need scenario and net sale for the peak consumption hours in the secondary system need scenario	N	N
• Pump load	Within expected range for ~~Summer peak load hours (Note 4).~~ the scenario hours	N	N

Note 1: Refer to Section 3 for Pmax for different types of resources in the highest system need scenario and the secondary system need scenario.
Note ~~1~~2: All existing units should be dispatched at the same percentage of their ~~Net Dependable Capacity~~ Pmax, but this level may fluctuate to account for differing expectations of system-wide forced outages, retirements, and spinning reserve levels. Some large units with a high likelihood of retirement within the near future may be dispatched at zero to balance loads and resources, but will be available to be turned on during the analysis. ~~See discussion on Wind and other Intermittent Generation in Section 4.1 Specific Assumptions.~~
Note ~~2~~3: Proposed capacity resources will be grouped electrically. Base cases will be developed that focus on each of the groups. If a group is not the focus, it will be dispatched at zero in that case.
Note ~~3~~4: Refer to Section 3 for imports in the highest system need scenario and the secondary system need scenario. Maximum summer peak simultaneous historical net imports by branch group in the highest system need scenario are the basis for determining the maximum import capability that can be allocated for resource adequacy purposes. Historically unused ETCs will be considered during the analysis, but will not be simultaneously represented in the base case. Historically unused Existing Transmission Contracts (ETC's) crossing control area boundaries will be modeled as zero MW injections at the tie point, but available to be turned on at remaining contract amounts for screening analysis. For historically congested import paths expected to be increased by upgrades with all regulatory approvals in place, the portion of the

incremental upgrade expected to be utilized immediately during summer peak can also be represented in the analysis similar to unused Existing Transmission Contracts. During the base case development, import flows on Branch Groups electrically remote from the generation group, that is the focus of the base case being created in Steps 1 and 2, can be moderately reduced to balance loads and resources.

~~**Note 4**: Summer peak load hours are the 50 to 100 hours in the months of August and September when Control Area load is between 90% and 100% of maximum annual load.~~

4.1 Specific Assumptions

Distribution Factor (DFAX)
Percentage of a particular generation unit's incremental increase in output that flows on a particular transmission line or transformer when the displaced generation is spread proportionally, across all dispatched resources "available to scale down output proportionally with all control area capacity resources in the Control Area", shown in Table 1. Generation units are scaled down in proportion to the dispatch level of the unit.

~~**G-1 Sensitivity**~~
~~A single generator may be modeled off-line entirely to represent a forced outage of that unit. This is consistent with the ISO Grid Planning Standards that analyze a single transmission circuit outage with one generator already out of service and system adjusted as a NERC level B contingency. System adjustments could include increasing generation outside the study area. The number of generators increased outside the study area should limited to 20.~~

Municipal Units
Treat like all other Capacity Resources unless existing system analysis identifies problems.

Energy-Only Resources
If it is necessary to dispatch Energy Resources to balance load and maintain expected import levels, these units should not contribute to any facility overloads with a DFAX of greater than 5%. Energy Resource units should also not mitigate any overloads with a DFAX of greater than 5%.

WECC Path Ratings
All WECC Path ratings (e.g. Path 15 and Path 26) must be observed during the deliverability test.

Flow Impact
Generators that have a Flow Impact (DFAX*Generation Capacity) > 5% of applicable facility rating or OTC will also be included in the Study Area.

~~**Wind and other Intermittent Generation**~~
~~The Qualified Capacity of wind generation is calculated as the average production between the hours of 12PM-6PM, during the months of May through September (QC period). In order to ensure the deliverability of this generation during this entire QC period this generation will be dispatched at the minimum level during this QC period in the base case but can be increased to its maximum value within that QC period during the analysis. If the intermittent generation is electrically clustered with other types of generation, then the cumulative availability of this generation will determine how much the intermittent generation can be increased during the deliverability analysis. For example, if only wind generation is in the group (scenario 1) then it will be increased to the production level expected to be exceeded less than 20% of the time for that group~~

~~during the QC period. If 20 or more non-wind generation units are in the group (scenario 2) then the wind generation would not be increased above its average output during the QC period. The maximum wind generation output level would be interpolated for groups in between the two scenarios above. If both wind and intermittent solar generation are in the group, then a scenario with average production during the QC period, for both types will be assessed.~~

5.0 Application of Highest System Need Scenario and the Secondary System Need Scenario study results

The highest system need scenario (HSN) represents when a capacity shortage is most likely to occur. As a result, If the addition of a resource will cause a deliverability deficiency determined based on a deliverability test under the HSN scenario, then the constraint will be classified as either a Local Deliverability Constraint or an Area Deliverability Constraint.

The secondary system need scenario (SSN) represents when the capacity shortage risk will increase if the intermittent generation while producing at a significant output level is not deliverable. If the addition of a resource will cause a deliverability deficiency determined based on a deliverability test under the SSN scenario, and is not identified in the HSN scenario, then the constraint can be classified as an Area Deliverability Constraint following the classification guidelines in the BPM for the Generator Interconnection and Deliverability Allocation Procedures.