Deliverability Assessment Methodology

Issue Paper

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Regional Transmission

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Deliverability Assessment Methodology
Issue Paper

1 Introduction

The deliverability assessment methodology is a CAISO methodology developed for generation interconnection study purposes pursuant to the CAISO tariff, and is used in support of resource adequacy assessments. The CAISO last modified the existing methodology in 2009, and it has largely remained unchanged since its initial development in 2004. Given the significant changes in the composition of the existing generation fleet and the further changes anticipated over the forecast horizon, the CAISO is considering revisions to the existing methodology.

The focus of the CAISO's deliverability study methodology considerations is to adapt the study assumptions in the On-Peak Deliverability Assessment methodology to changing system conditions when resource adequacy resources are needed the most. The CAISO initially proposed revisions in its 2018-2019 transmission planning cycle, and based on stakeholder feedback, the CAISO has undertaken this separate stakeholder initiative to review the issue more comprehensively and address stakeholder concerns with the potential impacts of the proposed revisions. The purpose of this issue paper is to provide a summary of the changing system conditions driving the need for revisions to the methodology, a summary of the proposed revisions, a summary of the comments provided by stakeholders in the 2018-2019 transmission planning process, and options for addressing these comments.

2 Stakeholder Process

The CAISO held a stakeholder call on December 18, 2018 to offer a more in-depth review of the proposed revisions to the on-peak generation deliverability assessment methodology originally discussed in the 2018-2019 transmission planning process meeting on November 16, 2018. Stakeholders' written comments were generally supportive of the proposed changes, but raised various concerns regarding impacts to other processes and existing generation and recommended that the CAISO take more time to address these concerns. The CAISO considered those comments and decided to reconsider the proposed revisions through a broader stakeholder initiative and continue to apply the current methodology in studies required by the Generation Interconnection and Deliverability Allocation Procedures for Cluster 11 phase 2 and Cluster 12 phase 1 efforts. The purpose of this issue paper is to garner additional stakeholder input needed to develop a straw proposal that addresses the comments provided on the proposed on-peak generation deliverability methodology revisions. The CAISO has reviewed those suggestions and categorized them below. After the publication of the issue paper, the CAISO will hold a stakeholder call as set out in section 9, and after reviewing comments, will develop a more comprehensive stakeholder process for additional papers, stakeholder calls or workshops as necessary to finalize the revisions.

3 The Role of Deliverability in Resource Adequacy

The CAISO developed an on-peak deliverability study methodology for resource adequacy purposes in 2004. The methodology was generally adopted in the CPUC's Resource Adequacy (RA) proceeding in 2004. The deliverability requirement is a critical component in the consideration of the role a resource can play and the benefit attributed to a resource in contributing to system and local requirements in the state's overall resource adequacy framework administered by the CPUC. The CPUC initially assesses the contribution in MW that various resources can provide towards meeting resource adequacy capacity needs based on the attributes of various types of generation. This results in a Qualifying Capacity level being assigned to the individual resources focusing on load and generation parameters and looking at peak load hours in particular, but not taking into account potential transmission system limitations that could impede relying on these resources.

A generating resource must pass the CAISO's deliverability test under system summer peak load conditions for its Qualifying Capacity (QC) as determined by the CPUC, and the amount that meets the test requirements, which may be less than the full Qualifying Capacity initially assigned by the CPUC, is the Net Qualifying Capacity (NQC) that can be counted to meet RA requirements. The generating resource passes the deliverability test if it is able to deliver its output to system load under these conditions. When the original methodology was established, generating resources predominantly were non-intermittent, such as thermal plants and hydro plants. The QC values used in the deliverability assessment were the respective maximum output for the resource. When the 20% and 33% RPS targets were adopted, they 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 needed to recognize the differences in the nature of the resources, and the CAISO similarly needed to adjust its deliverability methodology to properly address these new resources and new circumstances.

The methodology has been applied in the CAISO generation interconnection studies and transmission planning studies. In addition to delivery network upgrades identified in generator interconnection studies, several policy driven transmission upgrades were identified and approved to support deliverability of 33% RPS portfolios through the transmission planning process. In other words, the CAISO transmission planning process approved those upgrades necessary for a system fleet including 33% renewable resources to be able to deliver their output to meet system demand during the peak conditions described above.

The previous changes made to accommodate the renewable resources provided reasonable overall results as long as the hourly load profiles of the load served by the transmission grid remained consistent with traditional norms upon which the CPUC's Qualifying Capacity metrics were based.

However, as the resource portfolio keeps evolving toward more renewable resources, energy efficiency solutions, demand response resources, and behind-the-meter distributed generation, the characteristics of the load profile and the resource portfolio impact the utility of the current methodologies including both the QC approach and corresponding deliverability methodology.

Starting in 2018, the CPUC replaced the exceedance based QC calculation with an Effective Load Carrying Capability ("ELCC") calculation. ELCC is a statistical modeling calculation that determines effective capacity values of different resources to serve incremental load over a period of time, usually an entire year. The ELCC of a generator is generally defined as the capacity amount by which the system's loads can increase when the generator is added to the system while maintaining the same system reliability as a probability over a period of time. (It is important to note that a new resource may make a marginal contribution to overall load serving capability while maintaining the same overall level of reliability by being available only in lower load level hours, even if not generally available at times of peak load.) It therefore becomes necessary to consider the ability of the transmission system to deliver generation to load during a broader range of conditions as opposed to focusing exclusively on an examination of peak load conditions.

To consider the changes taking place in the system and in the CPUC's approach to determining Qualifying Capacity levels, the CAISO performed an informational study in the 2016-2017 transmission planning process (TPP) 50% RPS deliverability assessment that evaluated the deliverability methodology and experimented with modifications to the study assumptions in the deliverability assessment. This issue paper summarizes the evolution of the CPUC's Qualifying Capacity approaches and previous CAISO work, and also reviews the deliverability assessment from a broader framework that involves the study methodology, the study process, and how upgrades would be identified to meet deliverability needs.

4 Qualifying Capacity Calculation for Wind and Solar Resources

4.1 Exceedance Methodology

Until 2017, the QC of wind and solar resources was based on an exceedance methodology adopted in CPUC ruling D.09-06-028. The exceedance approach measured the minimum amount of generation produced by the resource in a certain percentage of selected hours. The selected hours for the wind and solar QC calculations were 1 p.m. to 6 p.m. from April to October, and 4 p.m. to 9 p.m. for the remaining months. These times were selected to represent general peak load conditions. The exceedance level used to calculate the QC of wind and solar resources was a 70% exceedance level. Another way to describe the exceedance level is that the 70% exceedance level of a resource is the generation amount that it produces at least 70% of the time. For example, a 70% exceedance value of 10 MW for a 20 MW generator means that a resource is producing 10 MW or more 70% of the time. First, an initial QC value was calculated for each resource. Then, a diversity benefit was added to the Initial QC to recognize the diversity benefit of a diverse fleet of resources. (The exceedance value of the sum of a diverse group of resources is always greater than or equal to the sum of the exceedance values of the individual resources. The difference between the exceedance value of the overall fleet of wind and solar resources and the mathematical sum of the exceedance value for each individual resources was the “diversity benefit” that was allocated to each of the wind and solar generators and added to the initial QC to produce a final QC value for each resource).

4.2 Effective Load Carrying Capacity Methodology

The CPUC Energy Division developed a proposal for measuring the Effective Load Carrying Capacity (ELCC) of wind and solar resources for use in the RA program, and began relying on this methodology for QC calculations in 2018. As mentioned above, ELCC is a statistical modeling approach to determine the effective capacity value of different resources by comparing the resource’s effectiveness relative to “perfect capacity.” that had 100% availability. The ELCC values are expressed as a percentage of the resources’ capacity and are calculated using the following steps:

1) Create the capacity portfolio that brings the CAISO area as a whole to a target Loss of Load Expectation (LOLE) of 0.1 given the loads and resources expected to exist.
2) Remove all wind and solar resources in the CAISO.
3) Add the needed amount of “perfect capacity” to bring the CAISO back to the target LOLE of 0.1.
4) The ELCC value – as a percentage of the resources’ installed capacity – is calculated as { perfect capacity/removed capacity*100%}.

4.3 2019 ELCC Values and Technology Factors

The 2019 ELCC Values and Technology Factors provided to the CAISO for purposes of determining the qualifying capacity of solar and wind resources are shown in Table 1.

Table 1: 2019 ELCC Values and Technology Factors

2019 ELCC Values and Technology Factors

Non-Dispatchable Solar, Wind, Biomass, Cogeneration, Geothermal, and Hydro Technology Factors for Compliance Year 2019

Solar PV and Solar Thermal

Month	CY 2019 Solar ELCC
1	0.0%
2	2.4%
3	10.4%
4	33.2%
5	30.5%
6	44.8%
7	41.7%
8	41.0%
9	33.4%
10	29.4%
11	4.1%
12	0.0%

Wind

Month	CY 2019 Wind ELCC
1	11.3%
2	17.3%
3	18.3%
4	31.4%
5	30.6%
6	47.5%
7	29.7%
8	26.5%
9	26.5%
10	8.8%
11	8.4%
12	15.2%

5 Existing Deliverability Assessment Methodology

5.1 On-Peak Deliverability Assessment Methodology[1]

As noted earlier, the CAISO's on-peak 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. 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.[2]

From the perspective of individual generator resources, deliverability 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 dispatched to produce energy at any given system load condition. The CAISO does not offer "firm" network or point-to-point transmission service. Rather, the test's purpose is to demonstrate that the installed capacity in any electrical area can be run and delivered simultaneously, at peak load, and that the excess energy above load in that electrical area can be exported to the remainder of the Balancing Authority Area.[3] In short, the test ensures that bottled capacity conditions will not exist at peak load, limiting the availability and usefulness of resource adequacy capacity resources for meeting resource adequacy requirements. In actual operating conditions, energy-only resources may displace resource adequacy resources in the market's economic dispatch that serves load.

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. Failure of the generator deliverability test when evaluating a new resource in the generator interconnection study impacts the ability of the resource to be included in meeting resource adequacy needs. If the addition of the resource will cause a deliverability deficiency, then the resource should not be fully counted

[1] http://www.caiso.com/Documents/On-PeakDeliverabilityAssessmentMethodology.pdf

[2] 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.

[3] Subject to contingency testing.

towards resource adequacy reserve requirements until transmission system upgrades are completed to correct the deficiency.

In summary, the goal of the On-Peak 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 CAISO Balancing Authority Area during resource shortage conditions. Any generators requesting Full or Partial Capacity Deliverability Status[4] in their interconnection request to the CAISO Controlled Grid will be analyzed for "deliverability" in order to identify the Delivery Network Upgrades necessary to obtain this status.

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

5.2 Off-Peak Deliverability Assessment Methodology[5]

The CAISO Tariff requires the CAISO to perform both an on-peak deliverability study as described above, and also requires an informational off-peak deliverability study. The Tariff states that the Off-Peak Deliverability Assessment will be performed to identify transmission upgrades in addition to those Delivery Network Upgrades identified in the On-Peak Deliverability Assessment, if any, for resources where the fuel source or source of energy for the resource substantially occurs during off-peak conditions.[6] The resources included in this study are those that (a) use a primary fuel source or source of energy that is in a fixed location and cannot practicably be transported from that location; and (b) are located in an Energy Resource Area.[7] Generating Units meeting this criterion include, but are not be limited to, wind, solar, geothermal, hydroelectric, digester gas, landfill gas, ocean wave and ocean thermal tidal current generating units. The CAISO tariff defines an Energy Resource Area as a geographic region certified by the California Public Utilities Commission and the California Energy Commission for renewable resource adequacy resources.

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[4] Full Capacity Deliverability Status ("FCDS") means that the generator is requesting that its entire output be deliverable. Partial means something less than its entire output. Generating units comprising a single generating facility/interconnection customer/generator interconnection agreement may have separate meters and resource IDs such that the individual generating units may be FCDS even if the entire facility at the point of interconnection is not deliverable.

[5] http://www.caiso.com/Documents/Off-PeakDeliverabilityAssessmentMethodology.pdf

[6] In the past, only resource areas that had wind generation were considered to meet this criteria.

[7] A geographic region certified by the California Public Utilities Commission and the California Energy Commission as an area in which multiple LCRIGs could be located, provided that, for the interim period before those agencies certify such areas and for LCRIFs that are proposed to connect LCRIGs located outside the State of California, an Energy Resource Area shall mean a geographic region that would be connected to the CAISO Controlled Grid by an LCRIF with respect to which the CAISO Governing Board determines that all of the requirements of Section 24.1.3 are satisfied, except for the requirement that the LCRIGs to which the LCRIF would connect are located in an area certified as an ERA by those agencies.

During the off-peak load period, CAISO system load is between 40% to 60% of summer peak load. As a result, minimum required conventional generation is kept online at minimum output levels in order to be available later in the day. The off-peak deliverability studies should reflect this reality. In addition, because replacement generation is practically always available during the off-peak, even low cost generation that has a controllable fuel source is reduced in the study, without regard to marginal economic cost in order to mitigate transmission constraints found during the analysis. However, generation that does not have a controllable fuel source (e.g., wind and solar) is assumed to be running at its expected output during the study. Additionally:

- A review of wind production data has indicated that wind generation can produce at its maximum nameplate capacity for a large number of hours during the off-peak load period.
- Saturday, Sunday, and holidays are typically considered to be within the off-peak load period.
- A review of solar generation production data has indicated that solar generation can produce near its nameplate capacity for a large number of hours during the weekend portion of the off-peak load period.

However, in the past, solar generation, hydro, geothermal, digester gas, and landfill gas have produced a significant amount of energy during the peak load hour as well as in the off-peak conditions. In the past, only wind generation has had a fuel source or source of energy for the resource that substantially occurs during off-peak conditions.

5.2.1 Off-Peak Deliverability Base Case Modeling Assumptions:

The current Off-Peak deliverability study assumptions are described as follows:

- Basic scenario: Spring weekend approximately 12:00 PM with high hydro conditions. Alternate scenario: Fall off-peak import conditions from Arizona to California.
- Wind generation at its maximum nameplate output
- Solar generation at 85% of its nameplate output
- System load level at ~50% of peak
- Hydro generation at its high hydro dispatch level for the spring off-peak load period
- Gas fired combustion turbines off-line
- Gas fired combined cycle units at minimum load or off-line
- QF's at historical output for off-peak period
- Imports at average historical schedules for off-peak period
- Model Delivery and Reliability Network Upgrades identified in the On-Peak deliverability assessment and reliability assessment respectively.
- Only forced transmission outages will be considered.

5.2.2 Off-Peak Deliverability Study Procedures

- Dispatchable generation that relieves constraints should be dispatched to relieve identified constraints, unless the same generation also exacerbates other identified constraints.
- For each identified constrained facility or path, identify LCRIF IC's that have a DFAX[8] of 5% or greater on that facility or path rating or a Flow Impact of greater than 5% of the facility or path rating. These LCRIF IC's will be linked to this constraint and related upgrades for cost allocation purposes.

6 Alignment of the ELCC-based QC Calculation and the On-Peak Deliverability Assessment Methodology

As discussed above, starting in 2018, the CPUC has replaced the exceedance based QC calculation with an ELCC approach to account for the growth of intermittent resources. In response to this change, the CAISO began this initiative to revise the on-peak deliverability methodology assumptions.

An objective of this initiative is to examine the impacts of load peak shifting and ELCC-based QC calculations on the appropriateness of the current deliverability methodology. As noted previously, the ELCC methodology considers the potential contribution of the particular resources in supporting additional firm load while maintain an overall probabilistically-determined reliability level over a period of time, generally a year, so the transmission system reasonably needs to also be able to deliver that contribution over a broader range of times than a single peak load period.

Regarding the load peak shifting to later in the day, as the behind-the-meter distributed generation grows significantly in the future, the load shape seen from the transmission grid will continue to change. The load peak will continue to shift to a later hour in the day when the solar production has dropped – both grid-connected and customer behind-the-meter - and the load consumption is still high. The shifted peak "sale" hour is when the remaining generating resources are needed the most.[9]

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[8] DFAX is primarily a characteristic of the network model. Since the network model in the on-peak case and the off-peak case is identical, the DFAX's previously calculated using the summer peak case will be used for the off-peak case as well. In addition, any Delivery Network Upgrades identified in the Off-Peak Deliverability Assessment will be subsequently modeled in the on-peak case and DFAXs on the additional upgrades will be calculated.

[9] The term "sale" is defined as gross consumption minus the behind-the-meter DG production and represents the load seen from the transmission grid.

As well, a certain amount of the solar resources can be needed for system resource adequacy during the peak gross consumption hour, which occurs earlier in the day when customers' gross consumption is at its highest, but sales have been reduced by behind the meter generation. However, the incremental reliability benefit to the peak gross consumption hour of adding more solar hits a saturation point after enough capacity is installed. Additional solar resources provide a much lower incremental reliability benefit to the system than the initial solar resources, because their output profile does not align with the need during the peak sale hour that has shifted from the gross consumption period to later in the day. As a result, the need for transmission upgrades identified under the peak gross consumption condition to support deliverability of additional solar resources becomes more of an economic or policy decision focused on reducing curtailment of solar resources due to transmission limitations than a reliability decision. In other words, there may be an economic or policy benefit derived from these transmission upgrades relieving curtailment, but there is less likely to be a substantial capacity benefit because there is more likely to be sufficient capacity during the peak gross consumption hour with very high solar production both behind the meter, and in other unconstrained areas.

7 Proposed Revisions to the On-Peak Deliverability Assessment Methodology

7.1 Selection of System Conditions to Test Deliverability

The current deliverability methodology focuses on a limited set of snapshot power flow analyses – the on-peak analysis and the informational off-peak analysis. If the resource passes the deliverability test under this limited set of snapshot system conditions, in particular the on-peak analysis, the resource is likely to be deliverable during all the hours that are taken into account in deriving the exceedance-based QC. In the exceedance-based QC calculation, the correlation between the resource production and the system load within the counting window does not play a role, and all the hours in the counting window have the same weight. Transitioning into ELCC-based QC, resource production in each hour of the year contributes to the ELCC value differently depending on the load level for the hour and the availability of other resources in that hour. In other words, the ELCC value captures the hourly correlation between the resource production, the system load, and the available capacity from resources in the baseline across all hours. The limited set of snapshot analyses utilized in previous studies are unlikely to be sufficient to catch the correlation between three modeling quantities – load, generation and imports. This suggests that, at a minimum the deliverability should test multiple critical system conditions so that the contribution of resources to reliability across the year are not impeded by transmission limitations.

Fundamentally, the on-peak deliverability assessment is for Resource Adequacy purposes, that is to ensure the system has sufficient deliverable generation to maintain reliability. The on-peak deliverability assessment should be designed to minimize the identification of transmission needs during hours when there is a substantial surplus of generation, and instead focus on the need to deliver generation when there is a potential resource shortage (namely, during periods of high load). Thus, selection of scenarios might continue focusing on the high load period during summer months when a resource shortage is most likely.

An “adaptive procedure” to select study scenarios embedded in the peak deliverability assessment methodology would be desirable. The scenario selection is adaptive in that it selects the scenarios based on the resources production profile, location, distribution of the net sale, and the resource mix in the gen pocket. For example, the CAISO could study two scenarios: one is the highest system need scenario and the other is a second scenario under high gross load conditions. The highest system need scenario is tested for all generating resources in the study. The load, generation dispatch and imports are corresponding to when the system RA need is the highest during the year based on pre-selected profiles. The highest system need in the past has been the peak gross consumption condition but it is expected to transition to the peak sale condition as the behind-the-meter DG continues to grow. The study could be supplemented by a second scenario that could focus on the transition period when the gross load is still high and the solar production is dropping off. During this condition, a resource shortage is less likely but could still occur.

7.2 On-Peak Deliverability Methodology Revisions Presented in 2018

The CAISO held a stakeholder call on December 18, 2018 to offer a more in-depth review of the revisions proposed at that time to the generation deliverability assessment methodology originally discussed in the 2018-2019 transmission planning process meeting on November 16, 2018. The slides from this call are included in Appendix A. A redlined version of the On-Peak Deliverability Methodology documentation is included in Appendix B. Stakeholder comments from that call are summarized below.

7.3 On-Peak Deliverability Methodology Revisions Issues Summary

7.3.1 Increased risk of renewable generation curtailment

Because solar generation output is expected to be low during the system conditions most likely to result in a resource shortage (namely, summer evenings), the proposed revisions would reduce the amount of solar generation output assumed during the on-peak deliverability study. This change in assumptions would reduce the need for transmission network upgrades required to achieve full capacity deliverability status, and this in turn would tend to increase the risk of solar and wind generation curtailments due to transmission constraints during times of high solar production. However, the CAISO TPP would identify policy driven and economic-driven transmission upgrades and would seek approval of upgrades to alleviate curtailment that were beneficial to CAISO ratepayers. American Wind Energy Association California Caucus (ACC), Clearway Energy, EDF-Renewables, First Solar, Golden State Clean Energy, Large-Scale Solar Association (LSA), Middle River Power, PG&E, Six Cities, and Western Power Trading Forum all raised questions and concerns about this increased curtailment risk. Concerns were raised about the CAISO Transmission Economic Evaluation Assessment (TEAM) methodology,[10] and specifically about the valuation of renewable energy curtailments. Concerns were also raised about the curtailment impacts on existing resources. The timing of upgrades that would be approved in the TPP, and the potential financial harm to generation projects from delays in the development of needed transmission upgrades were also concerns.

Refinements to the TEAM methodology are beyond the scope of this initiative to revise the on-peak deliverability methodology, but will be discussed during upcoming TPP stakeholder meetings or in a separate initiative. However, the timing of approving upgrades and the identification of those upgrades in the TPP versus the deliverability assessment studies for the Generation Interconnection and Deliverability Allocation Procedures (GIDAP) will be further discussed in this issue paper.

7.3.2 The proposed solar and wind output assumptions for the revised on-peak deliverability assessment are different than the ELCC based QC values

The revised on-peak deliverability methodology would assume solar and wind generation production levels based on expected production levels when a resource shortage was expected to occur. These values were determined from a stochastic analysis performed for the CAISO 2018 summer assessment. Solar and wind production levels during hours when the unloaded capacity margin was less than 6% were analyzed. ELCC qualifying capacity values are calculated as generally described in section 4.2, and ELCC values tend to be more like the average value of the resource production during resource shortage conditions. For example, if a 100 MW resource has 0 MW of production during one hour when there is a resource shortage condition, and is fully available during a different hour when there is a

[10] The Transmission Economic Analysis Methodology (TEAM) document describes how the CAISO performs analysis to determine the need for economically driven transmission projects.

resource shortage condition, then the ELCC value for that resource would be approximately 50 MW[11]. However if the transmission system can only deliver 50 MW of that resource then it would be curtailed to 50 MW during the second hour. The true ELCC value would be more like 25 MW to account for the hour when that resource had 0 MW of production and the second hour when it was curtailed to 50 MW. As a result, to make such a resource fully deliverable, the CAISO deliverability study would need to study a value closer to the a 100 MW production value than the 50 MW ELCC value. Studying the example resources' ELCC value of 50 MW, would not result in sufficient transmission capability to actually provide 50 MW of dependable capacity. In other words, the transmission system must be capable of delivering the energy from the resource at the time it is making its contribution to increasing the amount of load that can be served reliably, which is not necessarily the time of peak system stress.

7.3.3 Hybrid Solar-Storage Facilities

Some stakeholders pointed out that storage facilities can be operated with solar facilities as stand alone projects or as hybrid projects to complement their output profile, and that the CAISO on-peak deliverability study methodology should address how these facilities would be modeled in the assessment. The CAISO agrees that storage projects can complement the output profiles of intermittent resources, and that it is reasonable to expect that storage facilities would be discharging at full output during resource shortage conditions. Therefore, hybrid solar-storage facilities and stand-alone storage facilities are modeled such that the storage is fully utilized during a resource shortage condition. For a typical hybrid project, the CAISO assumes the storage would be controlled to supplement the solar PV output and compensate for the end of day decline of solar output. For example, a project with 100 MW of installed solar capability, 100 MW of installed storage capability, and a combined total output capability of 100 MW would be modeled with 100 MW of combined total output in both the "highest system need scenario" and the "secondary system need scenario".

7.3.4 Transition Issues

Some stakeholders proposed postponing the posting of financial security for upgrades required by the generation interconnection process until after a new methodology is adopted. However, given the decision to delay the implementation of any changes to the methodology, and that it is not known which postings would be impacted until the revisions to the methodology are finalized, postponement of security postings would be imprudent at

[11] This simplified example assumes there are only two supply shortfall conditions of concern over the entire period and that the rest of the time that the risk of a supply shortfall is immaterial.

this time. Some stakeholders also asked questions about how transfers of deliverability would be impacted by the new methodology. Again, once the revisions to the methodology are finalized, then the details on how transfers of deliverability would be impacted can be addressed.

8 Increased risk of renewable generation curtailment

The CAISO acknowledged in its December 18, 2018 presentation to stakeholders that the objective of the on-peak deliverability study methodology has been to ensure that resources are deliverable during a resource shortage condition. The objective has *not* been to ensure that resources can be delivered when there is *not* a resource shortage condition (*e.g.*, in the middle of a Spring day). (However, the transition to ELCC methodologies for determining qualifying capacity levels implies that the deliverability methodology needs to consider the transmission system's capabilities to enable the resources to contribute to overall load carrying capability at the times the resource is making its contributions to reliability, not necessarily when it is needed the most). The previously proposed revisions would continue to meet this objective and would result in identifying fewer transmission delivery network upgrades. With a reduced amount of network upgrades there would be an expectation that deliverability-driven transmission costs would decrease, but renewable generation curtailments would increase. The CAISO initially proposed to address this increase in curtailments by identifying needed policy and economic driven transmission upgrades in the TPP. However, stakeholder comments clearly expressed a desire for the interconnection study process to also have an objective of ensuring excessive curtailment risks are identified and mitigated. One concern of relying on the TPP is that delivery network upgrades needed for specific generation interconnection projects may not be approved until there was a high degree of certainty that the generation project would proceed. Essentially, the generation project would need to already have a power purchase contract and be permitted for construction (or already constructed) before its delivery-related transmission costs may be identified in the TPP. The CAISO proposes to explore additional studies that can be performed as part of the interconnection study process to meet the objective of avoiding excessive curtailment. The CAISO welcomes comments on what data would be most helpful to developers in making decisions to proceed with a project, and what delivery network upgrade requirements should be placed on new generators requesting FCDS to avoid excessive transmission constraints on both the new and existing generators.

Any upgrades identified in the interconnection studies to avoid curtailment would be delivery network upgrades and not reliability network upgrades, but the interconnection process is currently designed to only require delivery network upgrades if the interconnection customer has requested FCDS. The difference for a generation project with FCDS versus Energy Only is that FCDS allows that generator to count for resource adequacy and Energy Only does not. Until now network upgrades were only identified in the interconnection studies if they were identified in the on-peak deliverability study, which is designed to ensure that resources are deliverable for resource adequacy purposes. Including additional studies to identify delivery network upgrades to avoid excessive curtailment would identify upgrades that are not necessarily needed to meet resource adequacy needs. However, there is no other mechanism available to the CAISO to require generators to fund delivery network upgrades. Another option would be to perform these additional studies for informational purposes only. However, informational studies are likely to be much less effective at protecting generation from significant curtailments, and could potentially result in excessive curtailments in some locations. Perhaps the more pressing question is whether ratepayers should ultimately finance curtailment-related network upgrades so generators can provide energy outside of the most severe shortage conditions. Because LMP is typically low during such periods, modest amounts of energy savings may not recoup the costs of such upgrades.

The primary purpose of this issue paper is to solicit feedback from stakeholders on two key questions.

1. Should additional studies be added to the interconnection study process to meet the objective of avoiding excessive curtailment?
2. If such studies are performed in the interconnection study process, then should the identified delivery network upgrades be required to be funded by the generator owner for its generation project to obtain FCDS?

9 Next Steps

In this issue paper the CAISO has summarized stakeholder’s comments and identified one topic that practically all stakeholders commented on. Stakeholders were all concerned about increased levels of curtailments. Other comments were provided by one or two stakeholders, and responses have been provided. The CAISO will hold a stakeholder call on May 2, 2019 to review this issue paper and solicit input on the approach for addressing concerns about increased levels of curtailment. After obtaining this additional feedback, the CAISO will prepare a straw proposal and host a subsequent stakeholder meeting. The CAISO encourages all stakeholders to submit comments on this issue paper.

Appendix A

December 18, 2018 Generation Deliverability Assessment Methodology Proposal stakeholder meeting presentation

Introduction and Overview

Neil Millar

Generation Deliverability Assessment Methodology Proposal Call
December 18, 2018

Generation Deliverability Methodology Revision Process

- November 16, 2018: CAISO presented proposed revisions during the third 2018-2019 Transmission Planning Process meeting.
- November 30, 2018: Stakeholder comments due
- December 12, 2018: CAISO posted revised Generation Deliverability Methodology document, along with additional presentation slides addressing stakeholder questions and comments
- December 18, 2018: CAISO hosts a call to present materials posted on the 11th.
- January 7, 2019: Stakeholder comments due
- Based on comments, the ISO will consider scheduling a further technical workshop in early February 2019

Implementation Timeline

- The 2019 Reassessment Study will begin in January 2019.
- If a technical workshop is not required:
  - the revised Generation Deliverability Methodology can be applied in the 2019 Reassessment Study commencing in January 2019, and then in the subsequent Cluster 11 Phase II study
- If a technical workshop is required:
  - the revised Generation Deliverability Methodology can be applied in the Cluster 12 Phase I study

Purpose of the Generation Deliverability Assessment

- The CAISO Generation Deliverability Assessment methodology was developed in 2004
- The methodology has been utilized since then to ensure that resource adequacy resources are deliverable to load during conditions when a resource shortage is most likely to occur
- Deliverability is not tied to market operation - a generator that meets this deliverability test may still experience congestion – even substantial congestion
- The CAISO Transmission Planning Process annually assesses the need for policy-driven and economic-driven transmission projects to ensure sufficient energy from renewable resources needed to meet the state's resource policies can be delivered to load

Why is the ISO changing the study scenarios for assessing deliverability?

- The study changes are driven by the evolving shape of the "net sales" load shape to peaking later in the day, and increasing levels of intermittent resources
- This necessitates more deliberate study of the output of intermittent resources to serve load matched with the load level at the time of output
- The same factors have essentially led the CPUC to move towards an "effective load carrying capability" or ELCC basis for considering "qualifying capacity" values in resource adequacy processes
- As a probabilistic approach is not viable for deliverability assessments, the solution for deliverability is to study specific scenarios matching load with intermittent generation output

Generation Deliverability Assessment Methodology Proposal

Songzhe Zhu

Generation Deliverability Assessment Methodology Proposal Call
December 18, 2018

Current Deliverability Methodology

- Power flow analysis tests deliverability under a system condition when the generation capacity is needed the most assuming 1-in-5 ISO peak load conditions
- Specific levels of intermittent generation output are studied: 50% exceedance values (a lower MW amount) or 20% exceedance values (a higher MW amount) from 1 PM to 6 PM during summer months.
- Deliverability is tested by:
  - Identifying potential gen pockets from which delivery of generation to the ISO grid may be constrained by transmission
  - Increasing generators in the gen pocket to 100% of the <u>study amount</u> and reducing generation outside the gen pocket
  - Conducting the power flow analysis

Changes Affecting Deliverability Assessment

- When the capacity resources are needed the most:
  - The time of highest need is moving from the peak consumption hours (Hours 16:00 to 17:00) to peak sales hours (Hour 18:00) due to increased behind-the-meter solar PV distributed generation

- The need to more properly account for the evolving contribution of growing volumes of intermittent resources on resource adequacy
  - For CPUC, moving from exceedance value to effective load carrying capacity (ELCC) approach

CPUC ELCC Based Qualifying Capacity Calculation for Wind and Solar Resources

- QC = ELCC (%) * Pmax (MW)

- Probabilistic reliability model
  - 8760-hour simulation for a study year
  - Each study consists of many separate cases representing different combinations of load shape and weather-influenced generation profiles
  - Each case is run with multiple iterations of random draws of variables such as generator outages

CPUC ELCC Based Qualifying Capacity Calculation for Wind and Solar Resources (continued)

- Reliability impacts of the wind or solar resources are compared to the reliability impacts of “perfect” capacity
  - Calibrate the CAISO system to weighted average LOLE = 0.1
  - Remove the solar or wind resources and replace with perfect capacity
  - Adjust perfect capacity until LOLE = 0.1
  - ELCC (%) = perfect capacity / removed solar or wind resources

- Aggregated by technology and region

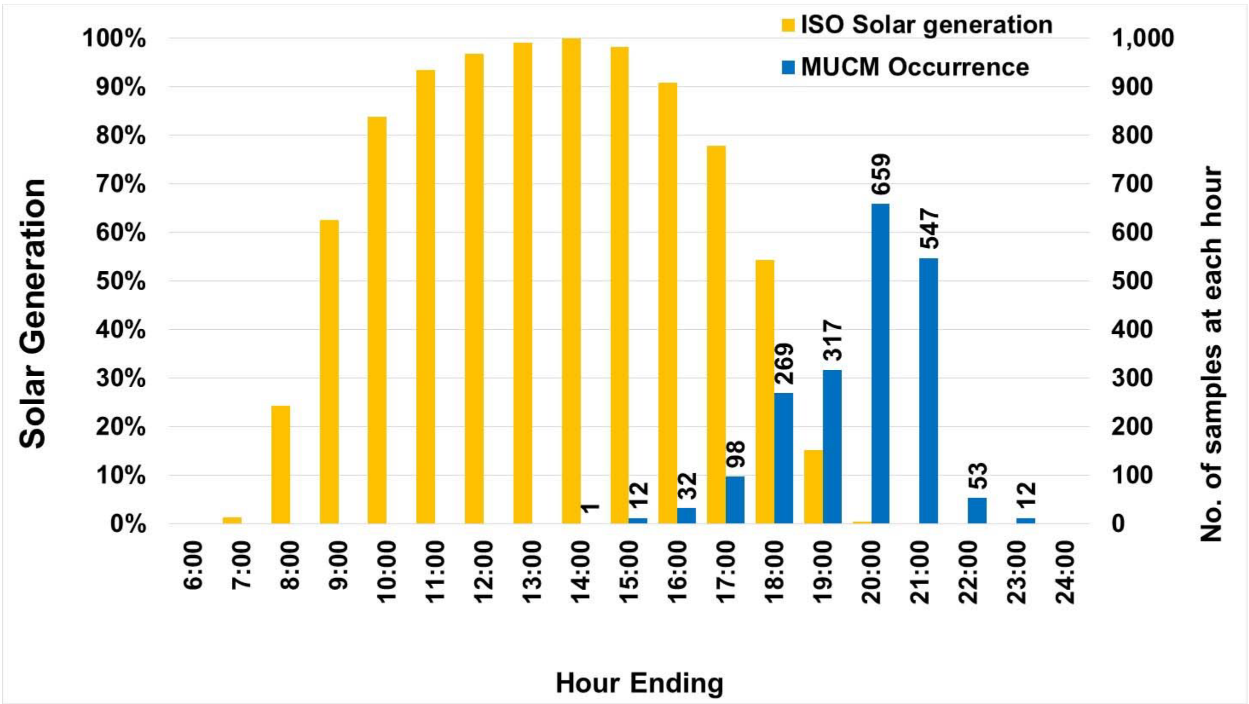
Issues identified and considered in Deliverability Methodology Review:

- Selection of system conditions to test deliverability
- Implications of “vintaging”, e.g resources receiving average or incremental results for each resource type
  - The same solar and wind resource output assumptions are made for all resources regardless of “vintage”
  - The revised methodology would be applied in the next reassessment study and subsequent cluster studies so that network upgrade requirements would be reduced
  - Changes to existing resources would need to go through the queue, as is currently required

Selection of System Conditions

- The deliverability test itself is not changing, but;
- We need to expand study scenarios to capture a broader range of combinations of modeling quantities – load, generation and imports
- At a minimum, the deliverability analysis should test multiple critical system conditions
- Data sources for identifying critical system conditions:
  - CAISO summer assessment
  - CPUC ELCC data (http://www.cpuc.ca.gov/General.aspx?id=6442451973)
    - CPUC unified RA and IRP Modeling Datasets
    - Latest CPUC output data from QC calculation for wind and solar resources

Critical Conditions per Review of Minimum Unloaded Capacity Margin Hours from 2018 Summer Assessment



Source: http://www.caiso.com/Documents/2018SummerLoadsandResourcesAssessment.pdf

Critical Conditions per Review of Loss of Load Hours from CPUC Monthly LOLE Summary

- For summer peak days, loss of load events occur in HE16 – HE21

SCE

Day/Hour	June	July	August	September
Peak Day - Hour 17	-	1.66%	0.24%	-
Peak Day - Hour 18	-	1.12%	0.26%	0.08%
Peak Day - Hour 19	0.55%	4.34%	2.56%	3.66%
Peak Day - Hour 20	4.11%	7.02%	1.86%	0.29%
Peak Day - Hour 21	1.99%	0.12%	0.03%	-

PG&E Valley

Day/Hour	June	July	August	September
Peak Day - Hour 16	0.02%	-	-	-
Peak Day - Hour 17	0.08%	1.21%	0.06%	-
Peak Day - Hour 18	0.02%	1.18%	0.04%	0.08%
Peak Day - Hour 19	0.83%	2.87%	1.02%	2.68%
Peak Day - Hour 20	3.37%	3.35%	2.09%	0.02%
Peak Day - Hour 21	1.01%	0.07%	0.04%	-

Critical System Conditions derived from these sources:

- Highest system need scenario (peak sale)
  - HE18 ~ HE22 in the summer
- Secondary system need scenario (peak consumption)
  - HE15 ~ HE17 in the summer
- These are the two critical system conditions the ISO selected in which generation will be tested for deliverability

Highest System Need (HSN) Scenario – Study Assumptions

Load	1-in-5 peak sale forecast by CEC
Non-Intermittent Generators	Pmax set to QC
Intermittent Generators	Pmax set to 20% exceedance level during the selected hours (high net sale and high likelihood of resource shortage)
Import	MIC data with expansion approved in TPP*

* The MIC is calculated from the highest imports during the summer hours when the load is above 90% of the annual peak load. In the last five years, the highest import hours are between HE18 and HE21.

HSN Scenario – Basis for Assumptions for Intermittent Generation

- Time window of high likelihood of capacity shortage
  - High net sale
  - Low solar output
  - Unloaded Capacity Margin < 6% or Loss of Load hours
- 20% exceedance level to ensure higher certainty of wind and solar being deliverable when capacity shortage risk is highest

Wind and Solar Output Percentile for HE18~22 & UCM<6% Hours

Exceedance		50%	40%	30%	20%	10%
wind	SDG&E	11.1%	16.3%	23.0%	33.7%	45.5%
	SCE	27.6%	36.9%	46.3%	55.7%	65.6%
	PG&E	29.8%	38.2%	52.5%	66.5%	78.2%
solar	SDG&E	0.0%	0.1%	1.7%	3.0%	7.6%
	SCE	1.9%	3.9%	7.0%	10.6%	14.8%
	PG&E	0.9%	4.1%	6.8%	10.0%	13.7%

Secondary System Need (SSN) Scenario – Assumptions

Load	1-in-5 peak sales forecast by CEC adjusted by the ratio of highest consumption to highest sale
Non-Intermittent Generators	Pmax set to QC
Intermittent Generators	Pmax set to 50% exceedance level during the selected hours (high gross load and likely of resource shortage)
Import	Import schedules for the selected hours

SSN Scenario – Basis for Assumptions for Intermittent Generation

- Time window of high gross load and high solar output
  - High gross load
  - High solar output
  - UCM < 6% or LOL hours
- 50% exceedance level due to mild risk of capacity shortage

Wind and Solar Output Percentile for HE15~17 & UCM<6% Hours

Exceedance		50%	40%	30%	20%	10%
wind	SDG&E	11.2%	16.6%	26.5%	40.8%	47.9%
	SCE	20.8%	24.8%	34.9%	57.4%	64.8%
	PG&E	16.3%	21.4%	44.7%	69.7%	76.8%
solar	SDG&E	35.9%	44.7%	58.0%	72.1%	75.4%
	SCE	42.7%	49.6%	51.8%	61.9%	86.3%
	PG&E	55.6%	61.6%	63.2%	74.6%	75.9%

Data Sources for Intermittent Generation Assumptions

- The exceedance values were derived from 2018 Summer Assessment data
- These values will be examined and updated with the latest available data periodically in the future
- The exceedance values apply to all intermittent generation in the study – existing or future.

Intermittent Generation Maximum Study Amount Assumptions and QC Values

Calendar Year 2018
Summer Month ELCC

Month	Wind	Solar
6	47.5%	44.8%
7	29.7%	41.7%
8	26.5%	41.0%
9	26.5%	33.4%

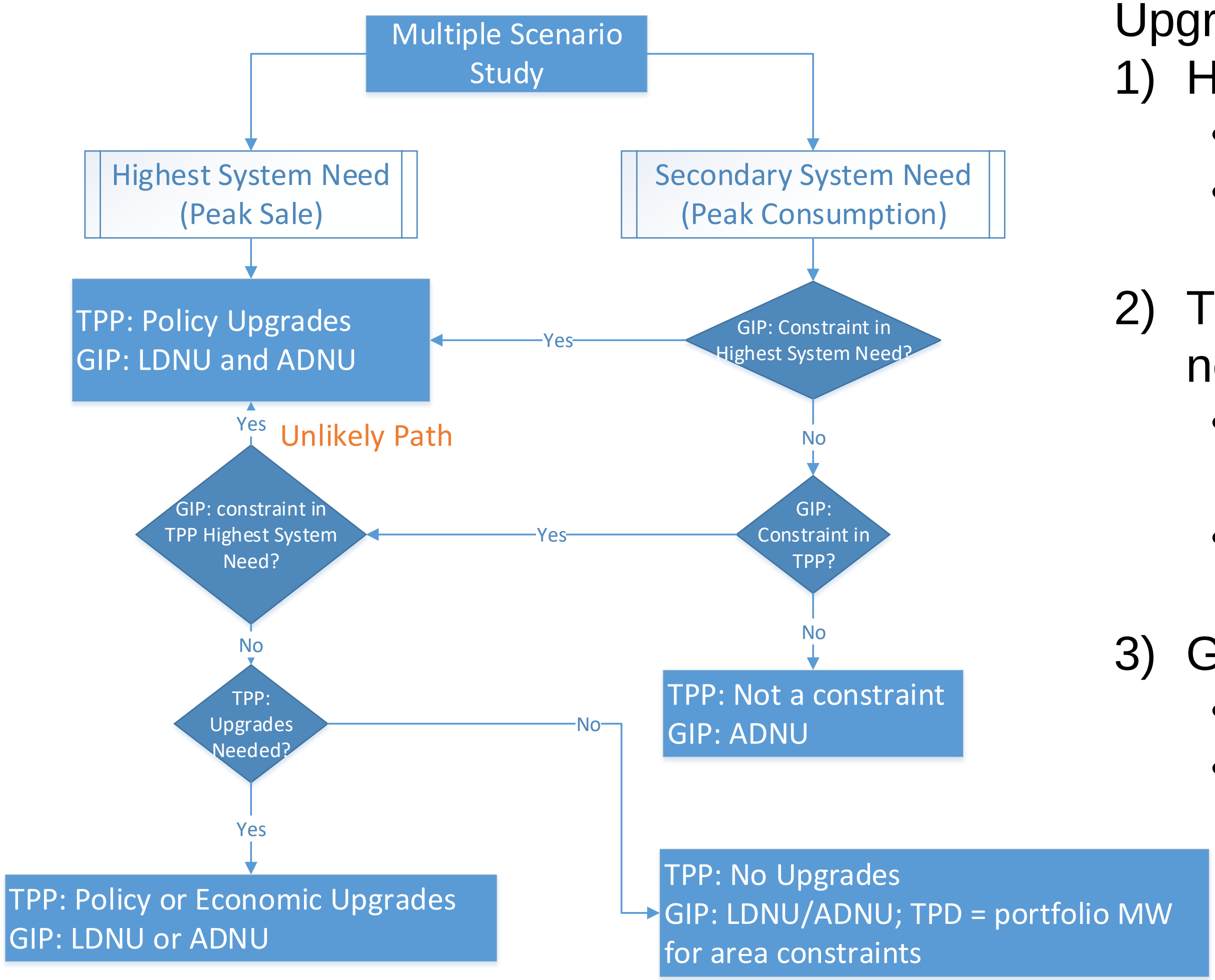
Current Modeling Assumptions

		50% Exceedance	20% Exceedance
wind	SDG&E	37%	51%
	SCE	38-47%	61-73%
	PG&E	32% - 47%	58-71%
solar	SDG&E	87%	96%
	SCE	92-93%	99-100%
	PG&E	92%	99%

Proposed Modeling Assumptions

		Highest System Need	Secondary System Need
wind	SDG&E	33.7%	11.2%
	SCE	55.7%	20.8%
	PG&E	66.5%	16.3%
solar	SDG&E	3.0%	35.9%
	SCE	10.6%	42.7%
	PG&E	10.0%	55.6%

Network Upgrade Identification in each Stage



Upgrades needed in:

1) Highest system need case
   - TPP – policy upgrades
   - GIP – LDNU/ADNU

2) TPP secondary system need
   - Policy/economic upgrades
   - No upgrade

3) GIP secondary system need
   - ADNU
   - TPD = portfolio if area constraint and TPP no upgrade

Annual Net Qualifying Capacity Determination for Full Capacity Deliverability Status Generation

- Annual process assesses if generation with FCDS is limited to a lower deliverability amount due to system conditions
- The Annual NQC study includes both the HSN and SSN scenarios
- Deliverable % is calculated from both the HSN and SSN scenarios
- For deliverability constraints in the secondary system need scenario, if the TPP identified the same constraint and determined that no upgrades are required, then that constraint would not reduce the FCDS generator's NQC level
- The lower deliverable % between the HSN and SSN scenarios is the resource's deliverable %

Two studies were performed using two different base cases to demonstrate the revised methodology

1. The 2018-2019 50% RPS 42MMT portfolio base case was studied
   – This portfolio generation is described on the next slide

2. The Cluster 10 Phase I – 2023 summer peak base case was studied and compared to the original results from the Cluster 10 GIDAP studies
   – The Cluster 10 Phase I generation list and detailed documentation of the deliverability study of this generation using the current methodology is posted on the ISO market participant portal
   – A comparison of original results developed using the current methodology and the results using the proposed revised methodology is provided in the following slides

2018-2019 50% RPS 42MMT PORTFOLIO STUDY RESULTS USING THE REVISED DELIVERABILITY METHODOLOGY

California ISO

2018-2019 50% RPS 42MMT portfolio

Renewable zones	FCDS (MW)			EODS (MW)		
	Solar	Wind	Geothermal	Solar	Wind	Geothermal
Central Valley / Los Banos	-	146	-	-	-	-
Greater Carrizo	-	-	-	-	160	-
Greater Imperial	-	-	-	-	-	-
Kramer / Inyokern	978	-	-	-	-	-
Mountain Pass / Eldorado	-	-	-	-	-	-
Northern California	-	-	210	-	-	-
Riverside East / Palm Springs	2,791	42	-	1,084	-	-
SoCal Desert	-	-	-	-	-	-
Solano	-	-	-	-	643	-
Southern NV	802	-	-	2,204	-	-
Tehachapi	1,013	153	-	-	-	-
Westlands	-	-	-	-	-	-
Grand Total	5,584	341	210	3,288	803	-

SCE-VEA-GWT Area Results – 42MMT Portfolio

- No deliverability constraints in primary system need scenario
- RAS required in second system need scenario

Contingency	Overloaded Facilities	Flow	Comments
Kramer – Victor 230 kV No. 1 & 2	Kramer – Raodway 115 kV	123.62%	North of Lugo RAS (Kramer RAS and Mohave RAS)
Kramer – Victor 230 kV No. 1 & 2	Kramer - Victor 115 kV	119.01%	
Kramer – Victor 230 kV No. 1 & 2	Kramer 230/115 kV No. 1 & 2	114.43%	

San Diego Area Results – RPS 42MMT Portfolio

- No deliverability constraints in the primary and secondary system need scenarios

PG&E Area Results – 50% RPS 42MMT

- No deliverability constraints in the primary and secondary system need scenarios

CLUSTER 10 PHASE I STUDY RESULTS USING THE REVISED DELIVERABILITY METHODOLOGY AND COMPARISON TO ORIGINAL RESULTS USING CURRENT METHODOLOGY

California ISO

SCE-VEA-GWT Area Results – Cluster 10 Phase I

- No deliverability constraints in primary system need scenario
- RAS and ADNU required in second system need scenario

<table>
<tr><th>Contingency</th><th>Overloaded Facilities</th><th>Flow</th><th>Comments</th></tr>
<tr><td>Base Case</td><td>Calcite – Lugo 230kV</td><td>107.04%</td><td>Calcite Area Deliverability Constraint</td></tr>
<tr><td>Calcite – Lugo 230kV</td><td>Lugo – Pisgah 230kV No. 2</td><td>107.73%</td><td rowspan="3">Calcite RAS</td></tr>
<tr><td>Calcite – Lugo 230kV</td><td>Calcite – Pisgah 230kV</td><td>129.63%</td></tr>
<tr><td>Calcite – Lugo 230kV & Lugo – Pisgah 230kV No. 2</td><td>Calcite – Pisgah 230kV</td><td>129.89%</td></tr>
</table>

SCE-VEA-GWT Area Results – Cluster 10 Phase I (Cont.)

Contingency	Overloaded Facilities	Flow	Comments
Base Case	Victor – Kramer 230 kV No. 1 & No. 2	101.30%	North of Lugo Area Deliverability Constraint
Kramer – Victor 230 kV No. 1	Kramer – Victor 230 kV No. 2	128.72%	NOL RAS
Kramer – Victor 230 kV No. 1 & 2	Victor – Roadway 115 kV	diverged	
Kramer – Victor 230 kV No. 1 & 2	Kramer - Roadway 115 kV	diverged	
Kramer – Victor 230 kV No. 1 & 2	Kramer - Victor 115 kV	diverged	
Kramer – Victor 230 kV No. 1 & 2	Kramer 230/115 kV No. 1 & 2	diverged	
Lugo – Victor 230 kV No. 3 & 4	Lugo – Victor 230 kV No. 1	139.65%	
Lugo 500/230 kV No. 1	Lugo 500/230 kV No. 2	113.72%	

SCE-VEA-GWT Area Results – Cluster 10 Phase I (Cont.)

Contingency	Overloaded Facilities	Flow	Comments
Base Case	Alberhill - Serrano 500 kV	100.51%	Desert Area Deliverability Constraint; West of Colorado River CRAS; Devers RAS
Base Case	Alberhill - Valley 500 kV	114.80%	
West Wing - Palo Verde 500 kV No. 1 & 2	SNVLY - Delaney 500 kV	109.11%	
Devers - Red Bluff 500 kV No. 1 & 2	Mead - Perkins 500 kV	diverged	
Devers - Red Bluff 500 kV No. 1 & 2	Mead - Market Place 500 kV	diverged	
Devers - Red Bluff 500 kV No. 1 & 2	Eldorado - Lugo 500 kV	diverged	
Devers - Red Bluff 500 kV No. 1 & 2	Eldorado – Moenkopi 500 kV	diverged	
Devers - Red Bluff 500 kV No. 1 & 2	West Wing - Perkins 500 kV	diverged	
Devers - Red Bluff 500 kV No. 1 & 2	N Gila – Q1286 – IV 500 kV	diverged	
Lugo – Vincent 500 kV No. 1 & 2	East ST – West ST 500 kV	111.09%	
Devers - Red Bluff 500 kV No. 1	Devers - Red Bluff 500 kV No. 2	134.52%	
Devers – Vista 230kV No. 2 & TOT185 – Vista 230 kV	San Bernadino – Vista 230kV No. 2	111.78%	
Devers – Vista 230kV No. 2 & Devers – TOT185 230 kV	San Bernadino – Vista 230kV No. 2	110.58%	
San Bernadino – Vista 230 kV No. 2	Etiwanda – San Bernadino 230 kV	102.84%	
Eldorado 500/230 kV No. 5	Bob – Mead 230 kV	157.24%	Ivanpah RAS

SCE-VEA-GWT Area Results – Summary

- Generators are required to participate in RAS
  - Calcite RAS, NOL RAS, Ivanpah RAS, West of Colorado River RAS, Devers RAS
- Area Deliverability Constraints
  - Calcite
  - North of Lugo
  - Desert

San Diego Area Results – Cluster 10 Phase I

- RAS required in the primary system need scenario

Contingency	Overloaded Facilities	Flow	Comments
Encina-San Luis Rey-Palomar 230 kV and Encina-San Luis Rey 230 kV	Melrose Tap-San Marcos 69 kV	120%	Encina RAS
Encina-San Luis Rey 230 kV	Encina Tap-San Luis Rey 230 kV #1	120%	
Encina-San Luis Rey-Palomar 230 kV	Encina-San Luis Rey 230 kV #1	108%	
Monserate Tap-Monserate 69 kV	Avocado Tap-Avocado 69 kV	165%	Avocado RAS
Avocado-Pendleton-Monserate 69 kV	Avocado-Monserate Tap 69 kV	131%	
Avocado Tap-Avocado 69 kV	Avocado-Monserate Tap 69 kV	134%	
San Luis Rey-San Onofre 230 kV #2 and #3	San Luis Rey-San Onofre 230 kV #1	110%	San Luis Rey - San Onofre RAS

San Diego Area Results – Cluster 10 Phase I (Cont.)

- RAS required in secondary system scenario

Contingency	Overloaded Facilities	Flow	Comments
Encina-San Luis Rey-Palomar 230 kV and Encina-San Luis Rey 230 kV	Melrose Tap-San Marcos 69 kV	140%	Encina RAS
Encina-San Luis Rey 230 kV	Encina Tap-San Luis Rey 230 kV #1	123%	
Encina-San Luis Rey-Palomar 230 kV	Encina-San Luis Rey 230 kV #1	110%	
Avocado-Monserate-Pala 69 kV	Avocado Tap-Avocado 69 kV	131%	Avocado RAS
Monserate Tap-Monserate 69 kV	Avocado Tap-Avocado 69 kV	177%	
Avacado-Monserate Tap 69 kV	Avocado Tap-Avocado 69 kV	136%	
Avocado-Pendleton-Monserate 69 kV	Avocado-Monserate Tap 69 kV	133%	
Avocado Tap-Avocado 69 kV	Avocado-Monserate Tap 69 kV	138%	
Monserate Tap-Monserate 69 kV	Avocado-Monserate Tap 69 kV	101%	

San Diego Area Results – Summary

- Generators are required to participate in RAS
  - Encina RAS
  - San Luis Rey – San Onofre RAS
  - Avocado RAS
- No LDNU/ADNU

PG&E Area Results – Cluster 10 Phase I

- LDNU and RAS required in the primary system need scenario

Contingency	Overloaded Facilities	Flow	Comments
Round Mountain-Table Mountain #2 500 kV Line or Round Mountain-Table Mountain #1 500 kV Line	Round Mountain-Table Mountain #1 500 kV Line or Round Mountain-Table Mountain #2 500 kV Line	104%	RAS (2018 Reassessment)
Delevan-Vaca Dixon # 2 & # 3 230 kV	Delevan-Cortina 230 kV overload	104%	Cluster 10 Phase 1 LDNU
Delevan-Vaca Dixon # 3 230 kV overload	Delevan-Vaca Dixon # 2 230 kV overload	103%	Cluster 10 Phase 1 RAS

PG&E Area Results – Cluster 10 Phase I (Cont.)

- LDNU/ADNU required in secondary system need scenario (Performed only for PG&E South Area)

Contingency	Overloaded Facilities	Flow	Comments
GATES-HURON-FIVEPOINTSSS 70kV	Schindler-Coalinga #2 70 kV Line (Schindler-Q526 Jct-Pleasant Valley-Coalinga #2)	134%	C10-LDNU
Los Banos 500/230 Bank	Gates 500/230 kV bank # 11 & # 12	111%	Fresno Area Deliverability Constraint
Wilson A-Q1395SS #1 115kV	Merced Falls-Exchequer 70 kV Line	112%	C10-LDNU
PANOCHE-TRANQUILLITY SW STA #1 & #2 230 KV LINES	30825 MCMULLN1 230.00 kV to 30830 KEARNEY 230.00 kV CCT 1	104%	Gates Bank Area Deliverability Constraint
Westley-Q1244SS #1 230 kV Line	Los Banos 500/230 kV Bank #1	125	C10-RAS
LOSBANOS-Q779SS #1 230 KV	Los Banos-Mercy Spring 230 kV Line (Now Dos Amigo-Mercy Spring was cancelled)	103%	Fresno Area Deliverability Constraint

Comparing to past results using Current Methodology

The new methodology results in the following upgrades identified using the current methodology in QC10 Phase I reports not be needed, and no new requirements:

PG&E South area	SCE-VEA-GWT area	SDG&E area
LDNU: Warnerville-Wilson 230 kV	RNU: Lugo – Victorville RAS expansion	RNU: Sycamore-Penasquitos 230 kV RAS
LDNU: Borden-Wilson Corridor 230 kV OLs	RNU: Bob RAS	RNU: Mission-San Luis Rey 230 kV RAS
LDNU: ElCapitan-Wilson 115 kV	RNU: Innovation RAS	
LDNU: Panoche-Mendota 115 kV Line	ADNU: Desert Area Deliverability Constraint substantially alleviated	LDNU: Silvergate-Bay Boulevard 230 kV series reactor
LDNU: GWF-Kingsburg 115 kV line	ADNU: North of Lugo Area Deliverability Constraint substantially alleviated	ADNU: East of Miguel Area Deliverability Constraint (IV – Valley 500 kV line)
LDNU: Helm-Crescent SW Station 70 kV line	ADNU: Barre-Lewis 230 kV Area Deliverability Constraint (Talega-Santiago 230 kV line)	
RNU: 4 RAS (3 in Fresno and 1 in Kern) not needed		

Summary of Proposed Deliverability Assessment Methodology Revisions – What Remains the Same

- Methodology remains fundamentally the same, but study scenarios align load levels with intermittent generation output
- What remains the same:
  - TPP policy study assesses deliverability of the renewable portfolio
  - GIP study assesses deliverability of the generation projects seeking FCDS
  - Energy-only generators are off-line in the study unless needed to balance load

Summary of Proposed Deliverability Assessment Methodology Revisions – What will Change:

- System conditions selected to test deliverability:
  - Highest system need scenario (peak sale)
  - Secondary system need scenario (peak consumption)

- Delivery network upgrades and NQC determination:
  - TPP approves upgrades to mitigate portfolio amounts for peak sale deliverability constraints;
  - TPP approves upgrades based on portfolio amounts (or not) for peak consumption constraints if the need is also identified in the policy/reliability or economic studies
  - TPP no-upgrade determination means MWs up to the portfolio amount is deemed deliverable for the peak consumption constraint in TPD allocation and annual NQC determination
  - GIP may identify LDNU/ADNUs in the primary system need scenario and ADNUs in the secondary system need scenario

Expected Impacts of the Proposed Methodology

- More deliverability available in the TPD allocation on the basis of installed MW.
- Fewer transmission upgrades required for the generators to achieve FCDS
- Fewer transmission upgrades identified from the deliverability assessment in both the generation interconnection study process and TPP process
- Transmission congestion may increase, which would need to be addressed in the transmission planning process as policy-driven or economic-driven upgrades (aligned with TEAM)

Next Steps Pertaining to Deliverability Assessment Methodology

- Seek feedback from the stakeholders on the proposal
- If necessary, schedule a technical workshop in early February 2019
- Finalize the methodology
- Implement the methodology in the generation interconnection studies and the transmission planning studies
  - If no technical workshop, begin with 2019 reassessment and Queue Cluster 11 Phase II study
  - If technical workshop, begin with later Queue Cluster 12 Phase I study and 2019-2020 TPP deliverability study

Appendix B

December 18, 2018 draft edits to the On-Peak Deliverability Assessment Methodology

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 12)	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 23)	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 34)	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 12: 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 23: 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 34: 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.