California ISO

Transmission Capability Estimates for use in the CPUC's Resource Planning Process

White Paper

Version 2024

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Transmission Infrastructure Planning

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1 Introduction

As part of its Integrated Resource Planning (IRP) process, the California Public Utilities Commission (CPUC) develops resource plans to meet the state's renewable policy targets and resource adequacy requirements. The CPUC currently uses the RESOLVE resource optimization model for developing resource portfolios. RESOLVE co-optimizes investment and dispatch in order to identify least-cost resource portfolios that meet the policy and reliability targets. The portfolios are comprised of resources with Full Capacity Deliverability Status (FCDS), which count towards resource adequacy needs, and resources with Energy-Only Deliverability Status (EODS), which contribute to meeting renewable energy targets but do not count towards resource adequacy. The CPUC, in collaboration with the California Energy Commission (CEC) and the ISO, maps the geographically coarse RESOLVE resource selections to substations using a documented bus bar mapping process.

One of the key inputs to the resource optimization model and the bus bar mapping process is transmission capability information supplied by the ISO. For this purpose, the ISO develops FCDS and EODS transmission capability estimates that limit the amount and deliverability status of candidate resources that can be selected or mapped in transmission-constrained areas. The information includes previously identified conceptual transmission upgrades along with an estimate of the associated incremental increase in transmission capability.

The ISO uses the resource portfolios developed by the CPUC in its annual Transmission Planning Process (TPP). The CPUC typically transmits to the ISO a base portfolio and one or more sensitivity portfolios. The ISO utilizes the base portfolio in its reliability, policy-driven and economic assessments to identify the need for transmission development. The sensitivity portfolios are mainly used in policy-driven assessment for informational purposes.

The purpose of this white paper is to provide updated transmission capability estimate information for use by the CPUC in developing future resource portfolios based on the latest available information. The paper describes the information, methodology and the primary sources of information that are used to produce it and how the information may be implemented by the CPUC in its resource planning process. This white paper and accompanying documentation replaces the version the ISO released in 2023.[1]

The 2024 transmission capability estimate package is comprised of:

- This white paper
- Attachment A, an Excel worksheet containing the transmission capability information described herein

[1] https://www.caiso.com/library/transmission-capability-estimate-inputes-for-cpuc-integrated-resource-plan-jul-05-2023

- Attachment B, a PowerPoint file containing diagrams showing the substations or buses that are behind each constraint. In addition, substation bus lists are provided for each constraint in PG&E area because the diagrams may not show all relevant buses behind the constraint due to the complexity of the PG&E system[2].

As the name suggests, transmission capability estimates are just estimates. They are developed primarily based on the location, mix and size of resources in the ISO generation interconnection queue and certain other assumptions described in this white paper. The accuracy of these estimates will be impacted depending, among other things, on the deviation of the resource portfolios selected from the commercial interest that these estimates are primarily based on. The final determination of the transmission upgrades needed by the resource portfolios is made during the policy-driven assessment the ISO conducts as part of the TPP.

2 Changes from previous transmission capability estimate

The previous (2023) version of the transmission capability estimates were used by the CPUC to develop resource portfolios for the 2024-2025 TPP cycles. The 2023 estimate was developed primarily based on Interconnection Queue Cluster 14 Phase I study. Resources that were operational before January 1, 2022 were considered as the baseline. This means the transmission plan capability values for the existing system including approved transmission planning projects known at the commencement of the study were over and above those baseline resource amounts. Cost estimates for deliverability network upgrades were escalated to the year of commercial operation.

The current estimates are based primarily on 2024 TPD study. Resources that were operational before January 1, 2024 were considered as the baseline. As such, the transmission plan capability values are over and above the transmission headroom taken up by those resources. Approved transmission planning projects up to and including the 2022-2023 TPP were modeled in the study. Due to the timing of the commencement of the 2024 TPD Allocation study, projects approved in the 2023-2024 TPP were not modeled in the initial cases. In some cases, these projects were considered as mitigations as appropriate. Transmission constraints which can be mitigated by approved transmission planning projects and are no longer binding in 2024 TPD study are eliminated from the current estimate.

The transmission capability estimates are developed using the current deliverability methodology. FCDS capability estimates are based on on-peak deliverability assessment methodology[3]. Off-peak deliverability assessment was not performed in 2024 TPD Allocation study. The EODS capability is generally estimated using FCDS estimate and adding existing energy storage and thermal generation

[2] The boundary diagrams for PG&E area constraints may also include buses without generation, which are generally not included in the substation list included

[3] https://www.caiso.com/documents/on-peak-deliverability-assessment-methodology.pdf

capacity on top of it. This is to take into account that thermal generation units can be turned off and battery storage units can be dispatched in charging mode to address off-peak deliverability constraints.

Since the deliverability network upgrades were not evaluated in the 2024 TPD Allocation study, the incremental FCDS and EODS and cost estimates for any potential network upgrade were based on the best available information or were carried over from previous version.

As in the previous version, both the FCDS and EODS estimates are expressed based on the resource-specific output assumptions used in deliverability studies, which makes the resulting capability values resource neutral.

In the previous transmission capability estimates the deliverability currently utilized by OTC generation was added to the incremental transmission capability estimates. However, since the OTC generation owners can choose to transfer that deliverability to replacement generation that they develop, and because these transmission capability numbers will also be utililized for a generation interconnection screening process, we did not add the OTC generation deliverability to the latest transmission capability estimates in this report.

After an ISO stakeholder initiative during 2023 and early 2024, the ISO modified the On-Peak Generation Deliverability Methodology.[4] The revisions were applied in the 2024 TPD Allocation study and those results are incorporated in these transmission capability estimates. The changes include the elimination of the SSN study and the use of a 10% DFAX cutoff for 500 kV line constraints. This resulted in changes to the constraint boundaries associated with 500 kV line constraints.

In addition, the ISO has updated the On-Peak solar and wind study factors as shown in Table 3.1-1 below.[5]

3 Updated transmission capability estimates

The updated transmission capability estimate information is provided in Attachment A. At a high level, the transmission capability estimate information provided includes to the extent possible:

- Estimates of the capability of the existing and approved transmission to accommodate resources with full capacity deliverability status (FCDS) and energy only deliverability status (EODS) that covers all areas where there is commercial interest even if deliverability constraints are not identified[6],

[4] https://stakeholdercenter.caiso.com/InitiativeDocuments/Final-Proposal-Generation-Deliverability-Methodology-Review-Jan-04-2024.pdf

[5] https://www.caiso.com/documents/deliverability-assessment-dispatch-methodology-jun-26-2024.pdf

[6] In those cases where buses with commercial interest are not included in any constraint, CPUC may use queue information upto QC 14 to derive default transmission capability limits

- Approved transmission projects that the transmission capability estimates rely on
- Previously identified conceptual transmission upgrades that increase transmission capability along with cost estimates,
- The incremental FCDS and EODS capability provided by the conceptual transmission upgrades,
- Constraint boundary diagrams and/or substation bus lists showing BES substation buses inside each constraint zone (provided as Attachment B), and
- Other information that may be helpful to the CPUC in implementing the estimates

3.1 Sources of transmission capability information

As noted earlier the ISO relies primarily on generation interconnection process (GIP) studies for developing transmission capability estimates. In some cases, the information is supplemented by information obtained from Transmission Planning Process (TPP) studies.

1. <u>Generation interconnection process (GIP) studies</u>

   As part of the generation interconnection process, the ISO conducts deliverability assessments of active generation in its interconnection queue. These assessments lead to the identification of deliverability constraints and network upgrades that are needed to mitigate the constraints identified.

   Previous GIP studies lend themselves particularly well to development of transmission capability estimates because the amount of active generation in ISO's generation interconnection queue far exceeds the total generation resources that are typically selected as part of the resource portfolios transmitted by the CPUC. Thus, those GIP studies reveal transmission constraints that would otherwise not be identified in TPP assessments of the CPUC's resource portfolios. For this reason, the ISO has relied on GIP studies as the primary source of information for developing transmission capability estimates.

   The ISO has heavily leveraged deliverability assessments performed as part of the 2024 TPD Allocation studies in producing the current transmission capability estimate. The information obtained from that study and previous studies includes the transmission constraints that limit resource development, the locational boundary of resources that contribute to each constraint, the maximum amount of new FCDS resources that can be added behind each constraint without and with transmission upgrades along with the scope, cost, and lead time to construct the transmission upgrades. As stated in Section 2, off-peak deliverability was not performed in 2024 TPD Allocaiton studies, so the EODS capability was calculated using the method described earlier.

2. <u>Transmission Planning Process (TPP) studies</u>

   In each TPP study cycle, the ISO conducts studies that assess whether transmission upgrades or other measures are needed to meet reliability, policy and economic criteria. As part of the policy-driven assessment in the TPP, the ISO assesses the transmission impacts of the base and sensitivity portfolios transmitted by the CPUC. These assessments provide insights into the reliability impact of the portfolios on the transmission system, constraints that would limit portfolio resource deliverability and renewable curtailment observed in production cost simulations. These insights are used as a supplementary source of information in the development of transmission capability estimates.

3.2 Elements of transmission capability estimate information

The information contained in the transmission capability estimates is described in more detail below.

1. Transmission constraints

   The transmission capability estimates are primarily based on the on-peak and off-peak area deliverability constraints that are found in GIP studies to limit the deliverability of resources. The constraints are identified in accordance with the deliverability methodology. The transmission capability estimates associated with identified transmission constraints are referred in this paper as "actual" transmission capability estimates. Some Transmission Constraints include multiple facility overloads.

   There are also parts of the system where the amount of resources in the generation interconnection queue was not found to be sufficient to cause on-peak, off-peak or either of the deliverability constraints. In the absence of actual transmission constraints, the amount of resources studied in the corresponding case are provided as "default" transmission capability estimates.

2. Affected zones

   The affected zone information is intended to provide a general idea as to the location of resources that contribute to and will be limited by the transmission constraint. In order to provide more detailed information regarding the parts of the system affected by each constraint, the points of interconnection (POI) substations and transmission lines that are located inside the boundary of each constraint (5% DFAX boundary or 10% DFAX for 500 kV line constraint) are identified using substation bus-line diagrams and/or substation lists. The diagrams and lists are provided as Attachment B. As can be seen from the diagrams, the resource zones affected by the transmission constraints can be isolated, nested or overlapping.

3. Condition under which constraint is binding

   This information indicates whether the constraint was identified in the on-peak scenario, off-peak scenario, both scenarios or neither scenario. The information determines whether the associated FCDS and EODS transmission capability estimates are actual or default values as explained above.

4. Estimated transmission plan FCDS capability

   The transmission plan FCDS capability estimates associated with actual on-peak deliverability constraints represent the transmission plan deliverability (TPD) calculated for the constraint in accordance with the on-peak deliverability methodology. ISO-approved transmission upgrades are modeled in the assessment. Retirement of Diablo Canyon is accounted for in the estimates assuming the replacement resources are at the same or similar locations.

Estimated existing system FCDS capability is expressed based on the resource-specific output assumptions used in on-peak deliverability assessment rather than based on installed capacity or Net MW to Grid also known as Interconnection Service Capacity (ISC). As a result, the FCDS capability estimates are resource-type neutral and can be translated into any combination of resource types by applying the applicable resource output factors. The resource output assumptions used in the on-peak deliverability methodology reflect the transmission capacity various resource types are assumed to take up during the on-peak deliverability assessment hours.

The resource output factors applied for intermittent resources like solar and wind in the deliverability study are a fraction of their installed capacity. For new non-intermittent resources, the resource output applied is 100% of the resource's ISC. For energy storage resources, the 4-hour discharging capacity is modeled as the resource's output. The resource output factors currently applied in on-peak deliverability assessments are shown in Table 3.1-1.

Table 3.1-1: Resource output factors used in on-peak deliverability assessment

Resource type	PG&E	SCE	SDGE	VEA
Solar	15%	13%	6%	8%
Wind	50%	48%	35%	48%
Non-Intermittent resources	NQC or 100%			
Energy storage	100% if duration is ≥ 4-hour or 4-hour equivalent if duration is < 4-hour			
Hybrid	[The lesser of Net MW to Grid (ISC) or the sum of the study amounts of the individual paired resources]/ISC			
New Mexico Wind	67%			
Wyoming/Idaho Wind	67%			
Off Shore Wind	85%			

5. Estimated incremental FCDS capability due to ADNU

GIP reports are the primary source of the information for the estimated incremental FCDS capability. The reports include conceptual Area Delivery Network Upgrades (ADNUs) that are needed to mitigate area deliverability constraints identified in the study along with an estimate of the incremental deliverable capacity provided by each ADNU. The incremental FCDS estimate reflects the incremental amount of additional queued generation behind the constraint that could be made deliverable by the identified ADNU. Incremental FCDS capability is not provided for areas with default existing system FCDS limits where on-peak deliverability constraints are not identified.

Like transmission plan FCDS capability, incremental FCDS capability is expressed based on the resource output assumptions used in on-peak deliverability assessment shown in Table 3.1-1 above.

6. Description of ADNU

A description of the ADNU, which is the basis for the incremental FCDS capability, is included as part of the transmission capability estimate information to enable the CPUC to identify ADNUs that are also identified to increase EODS capability and thereby avoid the possibility of double counting transmission upgrade cost. The information also includes time to construct for each ADNU that can be used to determine when the associated incremental capacity can become available.

In cases where the FCDS estimate of a constraint is dependent upon a CAISO approved transmission upgrade, the transmission upgrade and the estimated in-service date is provided.

7. ADNU cost estimate

The ADNU cost information along with the incremental FCDS capability will allow the CPUC to co-optimize resource and transmission by enabling it to evaluate the trade-off between limiting the amount of FCDS resources to within the transmission plan capability versus selecting resources beyond the transmission plan capability and triggering the additional transmission cost. Costs estimates for network upgrades are provided in 2022 dollar[7].

8. Estimated transmission plan EODS capability

In the past, the EODS constraints and the associated transmission plan EODS capability estimates were determined based on the off-peak deliverability methodology. The off-peak deliverability methodology was developed to ensure some minimal level of protection for renewable generation from otherwise potentially unlimited curtailment. By definition, off-peak deliverability constraints and the associated transmission capability limits derived using the off-peak deliverability methodology represent the limits on the amount of renewable resources beyond which curtailment would become excessive and potentially trigger transmission upgrades. As such, off-peak deliverability limits were used as the basis for EODS capability estimates.

However, the current transmission capability estimates are mainly based on the 2024 TPD Allocation study results where the off-peak deliverability study was not performed. As such the EODS capability estimates are calculated using FCDS capability estimates and adding existing energy storage and thermal generation capacity behind the constraint on top of it. This is to take into account that energy storage is in discharging mode in on-peak deliverability study while it can be dispatched in charging mode to address off-peak deliverability constraints. To avoid overestimating EODS capability, only existing energy storage resources capacity is used. Same for the thermal units as they can be turned off in off-peak deliverability study.

The existing system EODS capability estimates are expressed based on the resource output assumptions used in off-peak deliverability assessments rather than based on installed capacity or ISC. Table 3.1-2 provides resource output factors currently applied in off-peak deliverability assessments. The solar and wind resource output factors vary depending on whether the resources in the study area are predominantly wind or solar resources.

[7] There has been no updated ADNU analysis since the last transmission capability estimate paper, so the cost estimate was carried over from the last version.

Table 3.1-2: Resource output factors used in off-peak deliverability assessment

Resource type	Wind Area			Solar Area		
	SDG&E	SCE	PG&E	SDG&E	SCE	PG&E
Solar	68%			79%	77%	79%
Wind	69%	64%	63%	44%		
Hydro	30%					
Off-shore Wind	100%					
New Mexico Wind	67%					
Wyoming/Idaho Wind	67%					
Thermal	0%[8]					
Energy storage	100% in charging mode if duration is ≥ 4-hour or 4-hour equivalent if duration is less than 4-hour[9]					

9. Estimated incremental EODS capability due to AOPNU

GIP reports and study data are the primary source of the information for the estimated incremental EODS capability. The reports include conceptual Area Off-Peak Network Upgrades (AOPNUs) that are needed to mitigate area off-peak deliverability constraints identified in the study, which can be the same as the ADNUs that are identified to mitigate on-peak constraints. The incremental EODS capability estimate reflects the incremental amount of queued generation behind the constraint that can be accommodated by the identified AOPNU. The actual incremental EODS capability may be higher. Incremental EODS capability is not provided for areas with default transmission plan EODS limits where off-peak deliverability constraints are not identified.

Like transmission plan EODS capability, incremental EODS capability is expressed based on the resource output assumptions used in off-peak deliverability assessment as shown in Table 3.1-2.

10. Description of AOPNU

A description of the AOPNU, which is the basis for the incremental EODS capability provided, is included as part of the transmission capability estimate information to enable the CPUC to identify AOPNUs that also increase FCDS capability and thereby avoid the possibility of double counting transmission upgrade cost. The information also includes the estimated time to construct for each AOPNU that can be used to determine when the associated incremental capacity can become available.

11. AOPNU cost estimate

The estimated AOPNU cost provided along with the incremental EODS capability will allow the CPUC to co-optimize resource and transmission by enabling it to evaluate the trade-off between limiting

[8] Thermal resources are initially dispatched at 15% in off-peak deliverability assessments but can be reduced to 0% to mitigate constraints

[9] Energy storage is initially switched off in off-peak deliverability assessments but can be dispatched in charging mode at 100% of its capacity if duration is ≥ 4-hour or 4-hour equivalent capacity if duration is less than 4-hour to mitigate constraints.

the amount of EODS resources to within the transmission plan capability versus selecting resources beyond the transmission plan capability and triggering the additional transmission cost. Costs estimates are provided in 2022 dollar.

12. Designation as Wind Area or Solar Area

    The transmission capability estimate includes the designation of constrained areas as Wind Area or Solar Area in accordance with the off-peak deliverability methodology. The information indicates which wind and solar resource output factors from Table 3.1-2 are applied in the transmission plan and incremental EODS capability estimates. The same factors should be applied to implement the EODS capability estimates in RESOLVE and in the bus bar mapping process.

4 Implementation of transmission capability estimates in IRP

This section provides guidance as to how the transmission capability limits provided in this paper may be implemented in RESOLVE, the bus bar mapping process and when making any desired manual adjustments to the resulting resource portfolios.

The CPUC may adjust the implementation approach proposed in this white paper due to practical limitations or other reasons in consultation with the ISO.

4.1 Representation of constraints as linear expressions

As explained in the previous sections, all of the transmission capability estimates provided in this white paper are expressed based on the applicable resource-type specific output assumptions used in deliverability assessments as described in Table 3.1-1 and Table 3.1-2 rather than on the basis of installed capacity or ISC. As a result, the transmission capability estimates are resource-type neutral and can be translated into any combination of resource types by applying the respective deliverability study resource output factors. On the other hand, implementing the transmission capability estimates based on installed capacity allows different resource types with the same installed capacity to take up the same transmission headroom during resource optimization, despite resource-type specific deliverability capacity factors being applied in deliverability studies that are used to develop the transmission capability estimates.

In order to align the implementation of transmission capability estimates with the deliverability assessment methodology, the FCDS and EODS transmission capability estimates provided can be implemented using three linear expressions for each constraint. In the linear expressions, the capacities of the various resource types selected by RESOLVE or are mapped behind a constraint are the variables and the applicable resource output factors are the coefficients as described further below.

1. Implementation of FCDS capability estimates

In order to ensure FCDS resources selected in IRP portfolios do not exceed on-peak deliverability constraints in the HSN scenario, each FCDS capability estimate can be implemented using the linear expression shown below.

<u>HSN Scenario</u>

*FCDS capability estimate ≥ Sum of the capacity of each resource type selected * respective resource output factor for the HSN scenario*

Where FCDS capability estimate is the transmission plan FCDS capability estimate or the transmission plan FCDS capability plus the incremental FCDS capability due to ADNU.

2. <u>Implementation of EODS capability estimates</u>

Each EODS capability estimate can be implemented using the linear expression below.

*EODS capability estimate ≥ Sum of the capacity of each non-storage resource type selected * respective resource output factor for the off-peak scenario – Storage capacity selected (or 4-hour equivalent if duration is less than 4-hours)*

Where EODS capability estimate is the transmission plan EODS capability estimate or the transmission plan EODS capability plus the incremental EODS capability due to AOPNU and the resource output factors for wind or solar area consistent with the designation of the constrained area.

Energy storage selected is subtracted from the right hand side of the expression because it increases EODS capability since it is dispatched in charging mode to address off-peak deliverability constraints.

4.2 Baseline reconciliation

As noted earlier, the transmission capability estimates are over and above the baseline resources that were operational on January 1, 2024. The CPUC will need to adjust the estimates to account for additional resources that have been added to the baseline since then. The respective resource output factors should be applied when adjusting the FCDS and EODS capability estimates. The on-peak transmission plan capability estimates assume Diablo Canyon is retired.

Attachment A: Transmission Capability Estimates

Attachment B: Constraint Boundary Definitions