Subtransmission Assessment Report

WDT1382

[redacted]

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1. Purpose

One (1) project is seeking to interconnect to 12 kV distribution facilities served out of the Santiago 66 kV Subtransmission System, which is not under CAISO control, via the Independent Study Process (ISP). Impacts of the Project on the 12 kV distribution facilities are addressed in the SCE Field Engineering (FE) Report. Identification of impacts to the Santiago 66 kV Subtransmission System involved additional analysis which considered various levels of load demand with maximum generation dispatch. In addition, maximum charging of energy storage facilities was evaluated under a minimal generation within the local subtransmission system coupled with maximum levels of load demand.

The purpose of this study is to determine the adequacy of SCE's Santiago 66 kV Subtransmission System (non-CAISO controlled) to accommodate the Project and to identify system limitations that would require Distribution Upgrades on the subtransmission system to mitigate any identified impacts. The study included all existing and queued ahead generation projects in the Santiago 66 kV Subtransmission System, regardless of the in-service dates of such prior queued generation projects. Results of the study will be used as the basis to determine the cost allocation for the identified Distribution Upgrades. An operational study if required is performed to determine the timing need of any identified upgrade. Such timing need is directly related to actual projects moving forward as not all queued ahead generation projects have progressed towards project execution. It is important to note that withdrawals of any queued ahead projects could result in reallocating cost of any previously identified Distribution Upgrades.

The accuracy of the subtransmission assessment results are contingent on the accuracy of the technical data provided as part of the IR. Any changes from the data provided could void the study results and would need to be evaluated as part of a Material Modification Assessment (MMA) to determine if such change results in a material impact to queued-behind generation requests. The modifications would only be allowed if the MMA determines no material impacts to queued-behind generation requests. The study report provides detailed study assumptions and conditions of the Santiago 66 kV Subtransmission System in which the study was performed.

This Subtransmission Assessment Report provides the following:

- Subtransmission system impacts caused by the addition of the Project requesting interconnection within the Santiago 66 kV Subtransmission System.
- Subtransmission system impacts associated with energy storage projects seeking interconnection modeled as operating in charge mode.

To determine the system impacts caused by the Project seeking interconnection in the Santiago 66 kV Subtransmission System, the following studies were performed:

- Steady State Power Flow Analyses
- Post Transient Voltage Stability Analysis
- Subtransmission and Distribution voltage level Short-Circuit Duty Analyses

2. Project Interconnection Information

The WDT1382 IR is seeking interconnection to the Santiago 66 kV Subtransmission System. The IR consist of 3 MWs of energy storage projects. Please refer to the FE Report for specific Project details.

3. System Assumptions

3.1 Planning Criteria

The generator interconnection studies were conducted utilizing SCE's Reliability Planning Criteria. More specifically, the main criteria applicable to this study are as follows:

Power Flow Analysis

The following contingencies are considered for subtransmission lines and 220/66 kV transformer banks ("A-Banks"):

- Single Contingencies (N-1) – Loss of one line or one A-Bank
- Double Contingencies (N-2) – Common-mode loss of two lines

The following reliability criteria are used:

Subtransmission Lines	Base-Case	Limiting Component Normal Rating
	N-1 and N-2	Limiting Component Emergency Rating
220/66 kV Transformer banks (A-Banks)*	Base Case	Normal Loading Rating
	Long Term Emergency Loading Limit (LTELL) & Short Term Emergency Loading Limit (STELL)	As defined by SCE Operating Bulletin

* Please note that Normal and Emergency Ratings are reduced to reflect 95% of rating for charging cases.

3.1.1. Normal Overloads

Normal overloads are those that exceed 100 percent of normal facility rating with all facilities in-service (base case), except where otherwise indicated, such as A-Bank loading for charging cases. Mitigation will be required to address any identified normal overload triggered by the inclusion of these projects.

3.1.2. Contingency Overloads

Contingency overloads are those that exceed 100 percent of emergency ratings under outage conditions. Mitigation will be required to address any identified contingency overload triggered by the inclusion of these projects.

3.1.3. Voltage Criteria

Voltage performance under single and double outage conditions will be limited to 5 percent and 10 percent deviation, respectively.

3.1.4. Power Factor Criteria

All projects will need to comply with SCE's Interconnection Handbook requirements.

3.2 Load Assumptions

The load assumptions used for local subtransmission system initially considered a 2014 – 2023 load forecast. The load forecast was derived using SCE's Distribution Engineering A-Bank Planning load forecast as well as the individual load serving substation (B-bank) load forecast for 2014-2023. Figure 3.1 below provides the local subtransmission load forecast values at the A-Bank level under Normal (1-in-2 year) and Criteria (1-in-5 year) Planning assumptions.

Figure 3.1
Santiago A-Bank Load Forecast

[redacted]

The A-Bank Normal and Criteria load forecast was distributed to each individual B-Bank substation (lower voltage substations served from the 220/66 kV substation) on a pro-rata basis. The resulting individual B-Bank substation values are shown below in Table 3.1 and were used as the basis for evaluating the subtransmission system performance.

Table 3.1
Subtransmission System Load Assumptions

Santiago System Load Serving Substations	2020	
	Normal	Criteria
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

To model year hourly forecast load performance, historical A-Bank data were obtained and normalized (maximum historical load = 1.0). This was done in order to provide a means for scaling to reflect comparable hourly performance with each load forecast. Shown below, Figure 3.2., is the normalized local subtransmission system A-Bank hourly load performance.

Figure 3.2
Normalized Local Subtransmission System
A-bank Hourly Load Performance

[redacted]

The assessment evaluating maximum generation output considered various load demand for this study. Utilizing the normalized hourly load performance shown above in Figure 3.2, the lowest per-unit load was applied to define two maximum generation output scenarios. The first scenario would use the minimum per-unit load during the daytime (shown as L1) while the second scenario would use the minimum value identified at any time of the day (shown as L2). In addition, the study considered a scenario representing maximum load demand (L5) with maximum generation.

For energy storage, the assessment evaluating maximum charging considered four scenarios with the maximum load. The first charging scenario would use the maximum per-unit load during the 2:00 AM – 6:00 AM time period (shown as L3). The second charging scenario would use the maximum per-unit load during the 8:00 AM – 12:00 PM time period (shown as L4). The third charging scenario would use the maximum per-unit load during the 2:00 PM – 6:00 PM time period (shown as L5). Lastly, the fourth charging scenario would use the maximum per-unit load during the 8:00 PM – 12:00 AM time period (shown as L6).

These per-unit values were used to define the specific load distribution assumptions at each load serving substation for each year evaluated. These values were used in the base cases developed for each load scenario. The base cases multiplied the per-unit value identified for the respective load scenario, L1 through L6, with the "Normal" load distribution except for L5, which used the "Criteria" load distribution. The resulting information for year 2014 and 2020 are provided below in Table 3.2 and Table 3.3 respectively.

Table 3.2
Year 2014 B-Bank Load Distribution

Santiago System Load Serving Substations	Minimum Load		Maximum Load			
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table 3.3
Year 2020 B-Bank Load Distribution

Santiago System Load Serving Substations	Minimum Load		Maximum Load			
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

3.3 Generation Assumptions

Generation dispatch of local subtransmission system generation (existing and queued) was done in a manner that would provide for a stressed export of generation in the system. In order to assess the subtransmission system and stress it to its maximum capacity, all local generation resources were dispatched. The existing and queued ahead local generation that was turned on for the Santiago 66 kV Subtransmission System assessment is listed in the table below.

Table 3.3
Existing and Queued Ahead Local Generation

Generation	Status	Resource	Size (MW)
Coygen	Existing Generation	Gas	20.0
WDT292	In service 1/2016	Synchronous	19.6
WDT1294	Study Phase	BESS	10
WDT1372	Study Phase	BESS	2
		TOTAL MW	51.6

3.4 Subtransmission System Assumptions

As part of the operational studies performed for WDT1382, the study modeled the existing Santiago 66 kV Subtransmission System without any additional upgrades to determine if interconnection of the Project is dependent on the completion of planned subtransmission upgrades. The study also considered existing system operating bulletins/procedures, if applicable.

In addition, the Study included an evaluation with the inclusion of all planned subtransmission upgrades including those identified to be needed to support queued ahead generation projects. Below is a summary of these subtransmission upgrades:

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

3.5 Study Methodology

3.5.1. Power Flow Study

While it is impractical to study all combinations of system load and generation levels during all seasons and at all times of the day, the base cases were developed to represent stressed scenarios of loading and generation conditions for the study group area. This assessment is comprised of power flow study scenarios that represent load conditions reflected in Table 3.2. A pre-case without the inclusion of WDT1382 and a post-case with the inclusion of WDT1382 were modeled for the applicable load conditions reflected in Table 3.2. Mitigation measures will be recommended for any power flow criteria violation identified to be triggered with the inclusion of WDT1382. The critical outage conditions evaluated are provided below in Table 3.5.1.

Table 3.5.1
List of Contingencies Evaluated

No.	Description
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted] Macarthur 66 kV Subtransmission Lines (Common Tower and Common Vault)

Notes:

a) Though other relevant contingencies were also evaluated, only those listed above were the most critical and seen to create overloads that could be attributed to the addition of the Project.

b) There is an operational risk associated with non-common corridor N-2 outages. Loss of such two lines is considered an N-1-1 contingency event which allows for manual system adjustments between contingencies if an overload is anticipated for the next contingency that follows the first contingency (N-1). Consequently, it is important to note that under such potential conditions, curtailment of generation output will be implemented, if required, in advance of the second outage to ensure potential overload is properly mitigated.

c) Due to short-circuit duty operational limitation, the loss of an A-bank on Santiago A 220/66 kV assumption is that the bus-tie breaker will remain open (normal split bus configuration) to prevent operating three A-banks in parallel. The figures below in Section 4.2 represent loading under this assumption.

3.5.2. Post Transient Voltage Study

The power flow study voltage results were used as a screen to identify those contingencies that may require additional post-transient voltage studies. Contingencies identified in the power flow to have a voltage drop in excess of 5% were selected for post-transient voltage analysis. The post-transient voltage studies compare voltage deviations to the reliability requirements for contingency outages on the subtransmission system. Mitigation measures will be recommended for any criteria violation identified to be triggered with the inclusion of the Project.

3.5.3. Short-Circuit Duty Study

To determine the impact on short-circuit duty within the subtransmission system after inclusion of the Projects, the study calculated the maximum symmetrical three-phase-to-ground (3PH) and single-line-to-ground (SLG) short-circuit duties. Generation and transformer data represented in the generator and transformer data sheets provided by the customers were utilized. Bus locations where short-circuit duty is increased with the inclusion of the Projects by at least 0.1 kA and the duty is in excess of 60% of the minimum breaker nameplate rating are flagged for further review.

Upon completion of the detailed circuit breaker review, mitigation will be identified for circuit breakers exposed to fault currents in excess of 100 percent of their interrupting capacities. Mitigation measures can involve circuit breaker upgrade, circuit breaker replacement, system reconfiguration to lower short-circuit duty, or the use of operating procedures. Cost for short-circuit duty mitigation will be allocated to the appropriate Projects if the study identifies that the upgrades are triggered by the inclusion of the Projects for which this study is performed. It is important to note that costs for mitigation measures triggered by queued ahead projects may ultimately be reallocated if the triggering entities ultimately withdraw and the need for the upgrades is still required and triggered by the inclusion of later queued projects following any such withdrawals.

3.5.4. Ground Grid Analysis

The short-circuit studies are used to determine substations within the subtransmission where the Project can potentially cause the need for upgrade to the existing station ground grid. The assessment will flag substations where single-phase-to-ground short-circuit duty is increased by 0.25 kA or more and seek further engineering review.

4. Power Flow Results

Given that the Project is seeking interconnection under ISP, no power flow impacts are identified on the CAISO controlled system since all ISP requests are treated as Energy Only Interconnection. Any overloads identified are subject to mitigation via the use of congestion management protocols and no network upgrades are required to address power flow impacts corresponding to Energy Only Interconnections.

4.1 Maximum Generation Coupled with Maximum Load Conditions

Under maximum generation coupled with maximum load conditions, the inclusion of the Project did not result in any identified power flow system impacts under base case or outage conditions.

4.2 Maximum Generation Coupled with Minimum Daytime Load Conditions

Under maximum generation coupled with minimum daytime load conditions, the inclusion of Project did not result in any identified power flow system impacts under base case or outage conditions.

4.3 Maximum Generation Coupled with Minimum Anytime Load Conditions

Under maximum generation coupled with minimum anytime load conditions, the inclusion of the Project did not result in any identified power flow system impacts under base case or outage conditions.

4.4 Maximum Energy Storage Coupled with Minimum Generation Dispatch

The storage facility charging study was performed using the load assumptions discussed above in Table 3.3. Study results for each applicable time-block are provided below.

4.4.1 Contingency: Time Block L3 (2 AM – 6 AM)

The study did not identify any issues under this time block period.

4.4.2 Contingency: Time Block L4 (8 AM – 12 PM)

With the inclusion of the Project, the study identified overloads on the Santiago A-Banks, a portion of the Santiago-Estrella-Las Lomas 66 kV line, and Santiago-Irvine No. 2 66 kV line during this time block as summarized in Table 4.4.2 below.

Table 4.4.2
Overloads for L4

[redacted]

Note 1: Please note that an SCE mitigation project has been identified to replace CBs at Irvine 66 kV and Santiago 66 kV to increase emergency rating to 1,470 A. Planned for an in-service date of 2021, which will eliminate this N-1 overload.

Note 2: An SCE mitigation project has been identified to replace CBs at Irvine 66 kV, Las Lomas 66 kV and Santiago 66 kV to increase the emergency rating to 1,470 A. Planned for an in-service date of 2017 for Las Lomas 66 kV, and Irvine 66 kV and Santiago 66 kV for 2021, which will lessen the severity of the N-2 overloads.

4.4.3 Contingency: Time Block L5 (2 PM – 6 PM)

With the inclusion of the Project, the study identify overloads on the Santiago A A-Banks, a portion of the Santiago-Estrella-Las Lomas 66 kV line, and Santiago-Irvine No. 2 66 kV line during this time block as summarized in Table 4.4.3 below.

Table 4.4.3
Overloads for L5

[redacted]

Note 1: Please note that an SCE mitigation project has been identified to replace CBs at Irvine 66 kV and Santiago 66 kV to increase emergency rating to 1,470 A. Planned for an in-service date of 2021, which will eliminate this N-1 overload.

Note 2: An SCE mitigation project has been identified to replace CBs at Irvine 66 kV, Las Lomas 66 kV and Santiago 66 kV to increase the emergency rating to 1,470 A. Planned for an in-service date of 2017 for Las Lomas 66 kV, and Irvine 66 kV and Santiago 66 kV for 2021, which will lessen the severity of the N-2 overloads.

4.4.4 Contingency: Time Block L6 (8 PM – 12 AM)

With the inclusion of the Project, the study identify overloads on the Santiago A A-Banks, a portion of the Santiago-Estrella-Las Lomas 66 kV line, and Santiago-Irvine No. 2 66 kV line during this time block as summarized in Table 4.4.4 below.

Table 4.4.4
Overloads for L6

[redacted]

Note 1: [redacted]

4.5 Subtransmission Assessment Power Flow Mitigations

4.5.1. Maximum Generation

Based on the study results obtained under maximum generation dispatch conditions, no mitigation is required to accommodate the Project under discharge operation.

4.5.2. Maximum Energy Storage Coupled with Minimum Generation Dispatch

Based on the study results obtained under maximum energy storage "charging" coupled with minimum generation dispatch internal to the subtransmission system, the Santiago 66 kV Subtransmission System is inadequate to accommodate the Project without mitigation. The recommended mitigation involves the use of a storage management system which would limit or restrict charging based on loadings on the Santiago 220/66 kV transformer banks as well as loading on the Santiago-Estrella-Las Lomas 66 kV and Santiago-Irvine No. 2 66 kV lines. The details pertaining to cost allocation is provided in the Distribution Assessment.

4.6 Subtransmission System Energy Storage Restrictions

Based on the load forecast used in this study, current system configuration, and the amount of Energy Storage (MW) seeking interconnection as part of the ISP, the estimated restrictions and arming of the storage management system is illustrated below in Figure 4.6.1

Figure 4.6.1
Charging Restrictions and Arming of Storage Control System
Limitation: Santiago A-Banks

[redacted]

A summary of the hourly performance for each month assuming future load performance mimics historical load performance (same load shape pattern) is shown below in Figure 4.6.2. The performance takes into account the use of the storage management system and therefore summarizes the time periods where charging is expected to be restricted (cells highlighted in red with the number of hours where restriction is expected shown in the cell).

Figure 4.6.2
Monthly Time of Day Performance Expectations
Charging Restrictions and Arming of Storage Control System

[redacted]

These values are specific to restrictions associated with loadings on the Santiago A-Banks. Additional restrictions not identified in this study may exist for projects which are seeking interconnection to low-voltage distribution (12 kV) served out of the Santiago 66 kV Subtransmission System. Capacity issues on the 12 kV distribution feeders and/or the 66/12 kV transformer bank (B-Bank) may further restrict these projects. Results of the low-voltage distribution performance for projects seeking interconnection to low-voltage distribution are provided in the FE Report.

It is important to note that incremental or new charging restrictions beyond those identified in the study may occur in the future under the following conditions, but not limited to:

- Incremental load growth beyond forecasts
- Decrease in amount of internal generation in the area assumed to be available
- Additional energy storage interconnection requests beyond this ISP
- Limitations on CAISO network corresponding to operating conditions that involve loss of multiple elements
- Maintenance and/or unplanned outage conditions

Should incremental or new charging restrictions arise in the future, a storage management system will be implemented at such time that the need arises to ensure system reliability is maintained. Consequently, the Project may be required to participate in future restrictions.

5. Post Transient Voltage Stability Assessment Results

Review of the power flow study results identified that no voltage deviation exceeded the criteria discussed above. As a result, no further post-transient voltage stability analysis was performed.

6. Short-Circuit Duty Assessment Results

Meaningful contributions to short-circuit duty were identified to be limited to the Subtransmission System. Consequently, the Projects did not impact the Bulk Electric System.

6.1 Application Queue

6.1.1. Subtransmission Level (66 kV)

Short Circuit Duty assessment have been performed as part of End of Queue Generation study. No impacts were identified to the Santiago 66 kV Subtransmission system that would necessitate mitigation.

6.1.2. Distribution Level (less than 66 kV)

Short-circuit duty results for distribution level less than 66 kV are provided in the FE Report.

6.2 Ground Grid Evaluation

The study did not identify any substation in the Santiago 66 kV Subtransmission System where the single line to ground short-circuit duty contribution from the Project increased duty in excess of 0.25 kA. Therefore, no further ground grid evaluation for substations served out of the Santiago 66 kV Subtransmission System is required.

7. Conclusion

Based on the study results, the inclusion of the Project did not trigger new impacts requiring mitigation beyond those that are already existing as mentioned in Section 4.5.2. Consequently, the Project can proceed to interconnection without any new subtransmission level upgrades.