Southern California Edison

[redacted]

WDAT

System Impact Study

Revision

November 25, 2015

SOUTHERN CALIFORNIA
EDISON
An EDISON INTERNATIONAL Company

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**SOUTHERN CALIFORNIA EDISON COMPANY**

# Executive Summary

Southern California Edison applied to Southern California Edison (SCE) for interconnection and wholesale distribution service for its proposed [redacted] pursuant to SCE's Wholesale Distribution Access Tariff (WDAT). SCE performed a System Impact Study as requested by Southern California Edison for a [redacted] The interconnection is an [redacted] which will be located inside of [redacted] The request is for a WDAT [redacted] with the ability to export and import a total capacity of [redacted] The initial request is for service to commence by May 1, 2017.[1]

The new energy storage facility, consisting of batteries, [redacted] will receive interconnection service from SCE's existing [redacted] via an underground line extension to the [redacted] where their protective device(s) will be installed. The generated power would be delivered to the California Independent System Operator (CAISO) grid at the [redacted]

The purpose of the System Impact Study is to determine the effect(s) of the proposed generating facility on the SCE distribution system and to identify the Interconnection Facilities, Distribution Upgrades, additions or modifications, and/or other facilities required to provide the requested service.

The study showed that the [redacted]

- Did not result in a violation of SCE's thermal loading criteria under both base case and N-1 conditions for the SCE distribution system for peak load and light load conditions.
- Did not result in a voltage rise exceeding Rule 2 requirements.
- Did not result in additional SCE protection requirements
- The addition of the [redacted] did result in the increase of three phase and/or single line to ground short circuit fault currents of [redacted] or more at one (1) distribution substation.

[1] Date as requested in the application. Actual operating date depends on design and construction requirements.

- The circuit breaker interrupting capabilities were reviewed at this substation and it was determined that zero (0) circuit breakers will be required to be upgraded as a result of the [redacted]

# Non-Binding Order of Magnitude Cost Estimate[2][3]

Non-binding order of magnitude cost estimates for the required interconnection facilities and system upgrades are as follows:

## Cost Estimate[4]

| | |
|---|---|
| **Distribution Upgrades** | $673 k |
| • [redacted] | |
| • Data Point additions | |
| • [redacted] | |
| • Ground Grid Study | |
| **Interconnection Facilities** | $795 k |
| • [redacted] | |
| • [redacted] | |
| • [redacted] | |
| **Telemetry** | $6.1 k |
| **ITCC (35%)** | $465 k |
| Total non-binding order of magnitude cost estimate | $1.94 M |

[2] The Cost Estimate does not include the cost required for civil work completed by the customer
[3] The Cost Estimates are in 2015 constant dollars
[4] This Cost Estimate does not include cost to provide Station Light and Power services that will be required.

# Contents

# Introduction to Part A

Southern California Edison applied to Southern California Edison (SCE) for interconnection and wholesale distribution service for its proposed [redacted] pursuant to SCE's Wholesale Distribution Access Tariff (WDAT). SCE performed a System Impact Study as requested by Southern California Edison for a [redacted] out of [redacted] The interconnection is an [redacted] which will be located inside of [redacted] The request is for a WDAT [redacted] with the ability to export and import a total capacity of [redacted] The initial request is for service to commence by May 1, 2017.[5]

The new energy storage facility, consisting of batteries, [redacted] will receive interconnection service from SCE's existing [redacted] via an underground line extension to the [redacted] where their protective device(s) will be installed. The generated power would be delivered to the California Independent System Operator (CAISO) grid at the [redacted]

The purpose of this study is to determine the impact of the proposed generating facility on the SCE distribution system and to identify the Interconnection Facilities, Distribution Upgrades, additions or modifications, or other facilities required to provide the requested service. This study was performed for the expected year 2015 through 2024 peak load conditions as well as low demand conditions.

The study was performed in two parts: Part A, performed by SCE's Distribution Engineering department, examines the impacts related to the SCE distribution system. Part B, performed by SCE's Transmission & Interconnection Planning department, examines the impacts and facilities related to the bulk power system. This is the Part A study report. More information related to Part B in included in Attachment B.

[5] Date as requested in the application. Actual operating date depends on design and construction requirements.

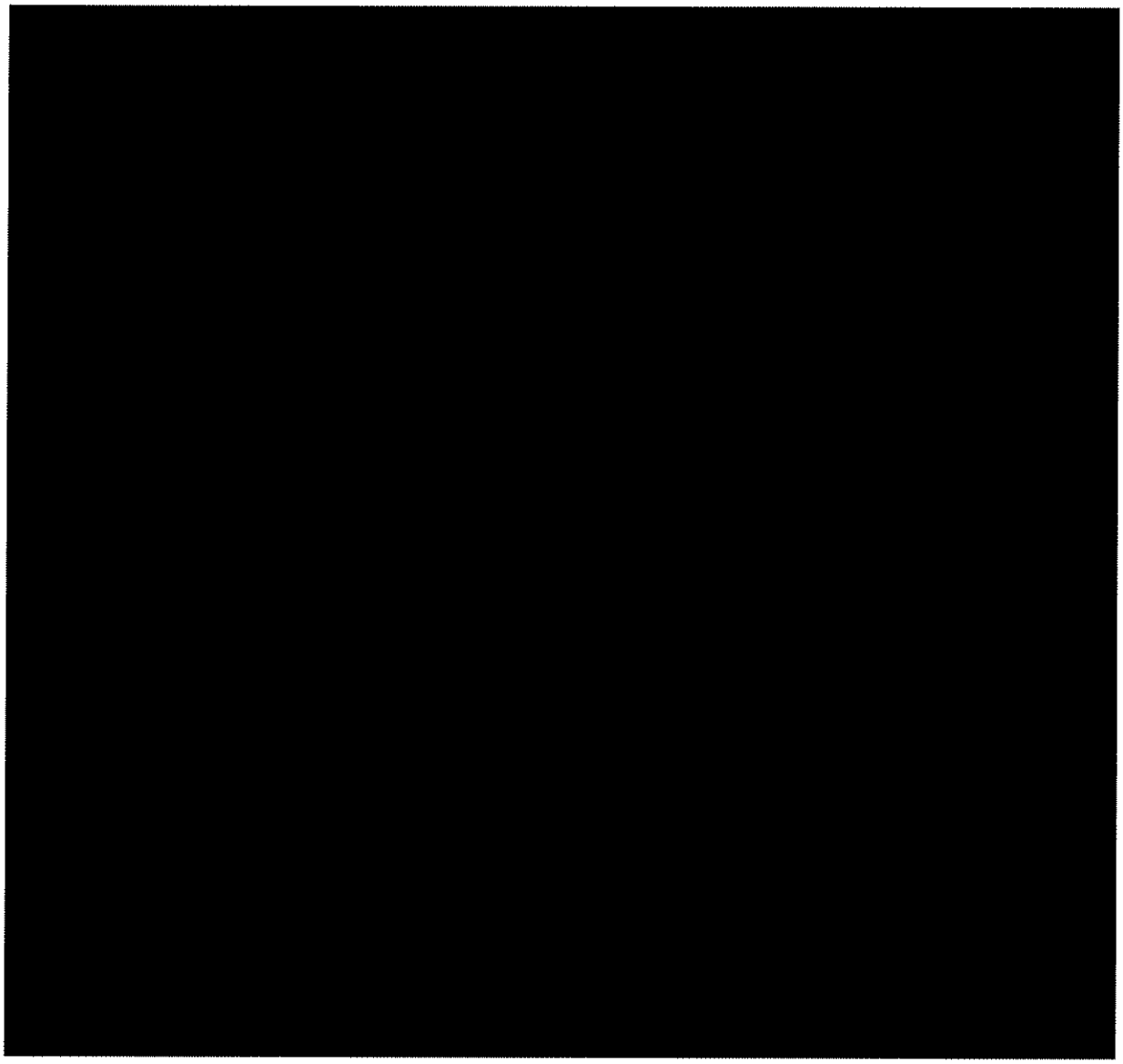


**Figure 1 – Proposed method of service**

***Note:** The [redacted] of the project will need to be metered separately from the retail load components. The IC should be prepared to install multiple sets of metering (i.e. separate sets of PT's & CT's and supporting metering equipment) for the project. Additional facilities will be required to accommodate the separate meter service for the retail load component of the project. The proposed method of service only identifies the method of service as to allow the [redacted] to interconnect to the Distribution System.

# Part A: System Impact Study Conditions & Methodology

**Planning Criteria**

The thermal rating of any conductor, connector, or apparatus shall not exceed 100% of its normal rated capacity with all facilities in service.

The thermal rating of any conductor, connector, or apparatus shall not exceed 100% of its emergency rating under N-1 conditions.

Operational flexibility and reliability of the distribution system shall be maintained at all times.

Circuit voltage profiles should be maintained to comply within CPUC's Rule 2 requirements.

**Energy Storage Facility Charging Considerations**

SCE's distribution standards and practices are in the process of being updated to address [redacted] The proposed method of service in this report may require changes to comply with the updated distribution design standards and practices.

This study assumes that the IC facility will include all equipment, software, appropriate controls, and other related equipment necessary to maintain the [redacted] demand profile per SCE requirements.

Upon execution of the Generator Interconnection Agreement, SCE will provide the IC with the required ramp rate[6] control parameters to operate the Generating Facility. The ramp rate controls will be a function of the demand on the distribution system, as well as SCE's Distribution System configuration (additional parameters maybe considered, as necessary).

Ongoing changes to the ramp rate control scheme may be required as determined by changes in the distribution system topology or other changes in the distribution system. However, typical ramp rates for facilities connected to SCE's Distribution System are 10% of nameplate rating, per minute.

A [redacted] which at this stage is a technical concept, is under development to incorporate the increased amount of [redacted] applications to SCE's Distribution System with minimal distribution upgrades. It is assumed that a [redacted] or similar system will be available prior to the In-Service Date of the [redacted] and further details will be available during the final engineering and design phase of the Project. The [redacted] will actively

[6] It is assumed that ramp rates for each [redacted] will be dependent upon their inherent technology types. While very quick response ramp rates (i.e. going from full charge to full discharge instantaneously, or vice-versa) may be beneficial for other grid services, the Distribution Provider, may, at its discretion, require establishing limits to maintain safety and reliability of its distribution system.

communicate allowable Project limits under charging mode to maintain safe and reliable operation of the distribution system.

The Project may need to participate in the [redacted] that will actively communicate to maintain safe and reliable operation of the distribution system.

In order to ensure limits are communicated in a timely and reliable manner, the IC is responsible for providing reliable communications between the Project and the [redacted] information system. Should the communication channel fail, the Project's operating limits will automatically revert to zero (no charging allowed).

The use of "charging" restrictions (or curtailment of energy storage facilities), in lieu of physical upgrades, are considered a viable alternative for this charging study [7] provided such restriction is implemented as part of the [redacted] Any restrictions identified here are purely projections. However, per the aforementioned section, the [redacted] will need to be further assessed and will only be allowed if it is ultimately determined that actual implementation is feasible for SCE's real-time system operations.

The [redacted] component of the Project will need to be metered separately from the retail load components. The IC should be prepared to install multiple sets of metering (i.e. separate sets of PTs & CTs and supporting metering equipment) for the Project. Additionally, the Project may also need to connect the [redacted] component to a dedicated transformer.

**System Conditions**

The new generating facility must be designed to operate within a power factor range from 0.95 leading to 0.95 lagging per WDAT tariff requirements.

Expected loading on the distribution system as projected by the SCE 2015-2024 plan was used.

The generation system must be designed to accommodate a VAR schedule provided by SCE. SCE will determine if the VAR schedule is necessary based on future re-arrangements of SCE's distribution system.

Distributed Generation Resources connected to the distribution system are analyzed offline and online during peak load and minimum load conditions during the day as to determine worst case scenario.

[7] The advent of distribution connected [redacted] brings with it challenges for utility planners, system operators, and regulatory/jurisdictional issues. More specifics of how the control systems of the future grid are to function will develop as progress is made in all of the aforementioned areas

The short circuit contribution from the inverter systems was determined using inverter manufacturer datasheets.

This study does not include analysis due related to the power output rate of change that may occur due to the following or other conditions;

1. System morning start up for solar systems. That is when each morning the generating facility commences to generate and export electrical energy to the distribution system.
2. Cloud Cover. Solar generating facilities have significant generation output variation (***Variability***) which can have an impact on distribution system voltage profiles.

The customer's generating facility will have equipment, software, and the appropriate controls as in place to be able to control the generation output rates of change, as specified by SCE, in order to maintain appropriate voltage levels under all conditions including, but not limited to, the conditions identified above. Upon execution of the appropriate Interconnection Agreement, SCE will provide the Interconnection Customer the required ramp rate control parameters. The ramp rate controls will be a function of the generation penetration on the distribution system as well as SCE's distribution system configuration but other parameters may be considered. Therefore, changes to the ramp rate control scheme may be required from time to time as required by increased in generation, changes in the distribution system topology, or other changes in the distribution system.

# Part A: System Impact Study Results (Generation)

**Short Circuit Analysis**

Using the short circuit models from the inverter systems being utilized for this [redacted] it was calculated that the addition of the [redacted] resulted in the increase of three phase and/or single line to ground short circuit duties of [redacted]

The circuit breaker interrupting capabilities were reviewed at this substation and it was determined that zero (0) circuit breakers will be required to be upgraded as a result of the [redacted]

**System Protection Considerations**

With this proposed method of service, changes to the protection system of the SCE electrical system are deemed not required.

**Thermal Loading**

Under light load and max generation conditions, the line section between the customer's facility and the [redacted] is expected to experience reverse power flow of approximately [redacted] Approximately [redacted] will flow back on the into the [redacted]

No thermal overloads were triggered by the [redacted]

Under emergency (N-1) conditions (loss of circuit), SCE may deem it necessary to isolate this project during emergency conditions until the distribution system returns to normal conditions.

Under emergency (N-1) conditions (loss of B-Bank), SCE may deem it necessary to isolate this project during emergency conditions until the distribution system returns to normal conditions.

**Distribution Voltage Control**

The [redacted] is not expected to experience a voltage rise exceeding allowable Rule 2 requirements under maximum generation and unity power factor during absolute minimum load conditions.

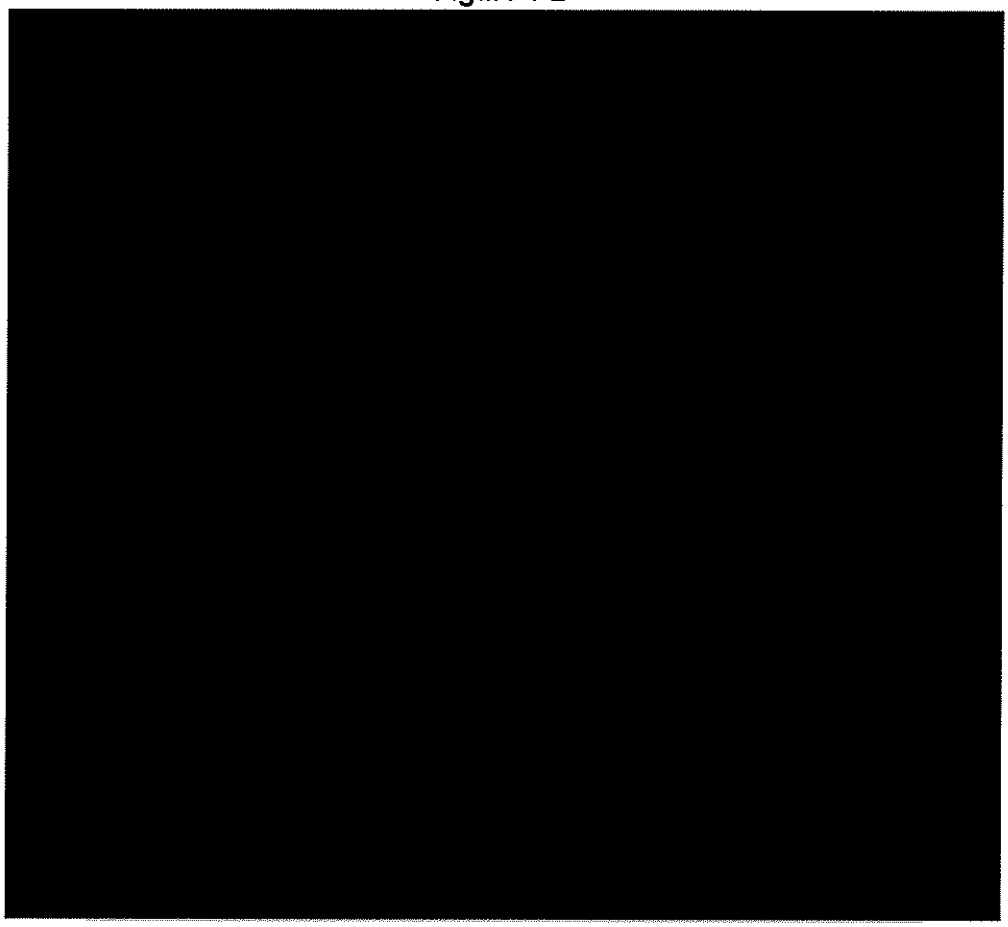
The [redacted] will be required to operate within a power factor of 0.95 leading and lagging at the point of interconnection as required by the WDAT tariff. Additionally, the generation system must be designed to accommodate a VAR schedule provided by SCE if necessary.

**Harmonic Impact**

The harmonic impact of the subject inverter based generation was not part of this System Impact Study. Despite the relatively low THD (<3%) of the equipment, impacts on voltage distortion levels may be significant due to the penetration level of the generation facility with respect to the local distribution grid strength. As with all equipment connected to the SCE distribution system, the generation project will be subject to the provisions of CPUC Rule 2.E, allowing SCE to require customer mitigation of interference with SCE service, including harmonic impacts, if harmonic interference is caused by the customer. Given the amount of generation and the strength of the distribution system, SCE will not require a harmonic study but encourages that the applicant completes a harmonic study during the Facility Study Phase to insure that the generation facility complies with the harmonic studies outlined in CPUC Rule 2.E. If the applicant chooses to complete a harmonic study, SCE will then provide the required SCE distribution system data that are to be used as part of the harmonic study.

# Part A: System Impact Study Results (Charging)

Figure 1-2 [8]



**Charging Analysis Load Assumptions**

The load assumptions used for SCE's Distribution System considers SCE's 2015 – 2024 Distribution Load Forecast and the previous year of historical data.

To model the hourly forecast demand performance of SCE's Distribution System, historical year 2014-2015 B-Bank and circuit data was obtained and adjusted to reflect the worst case year within SCE's Distribution Load forecast. The use of historical data established a baseline upon which to build a comparable hourly demand performance for the worst case year in SCE's Distribution Load Forecast

[8] For illustrative purposes only.

**Figure 1-3**

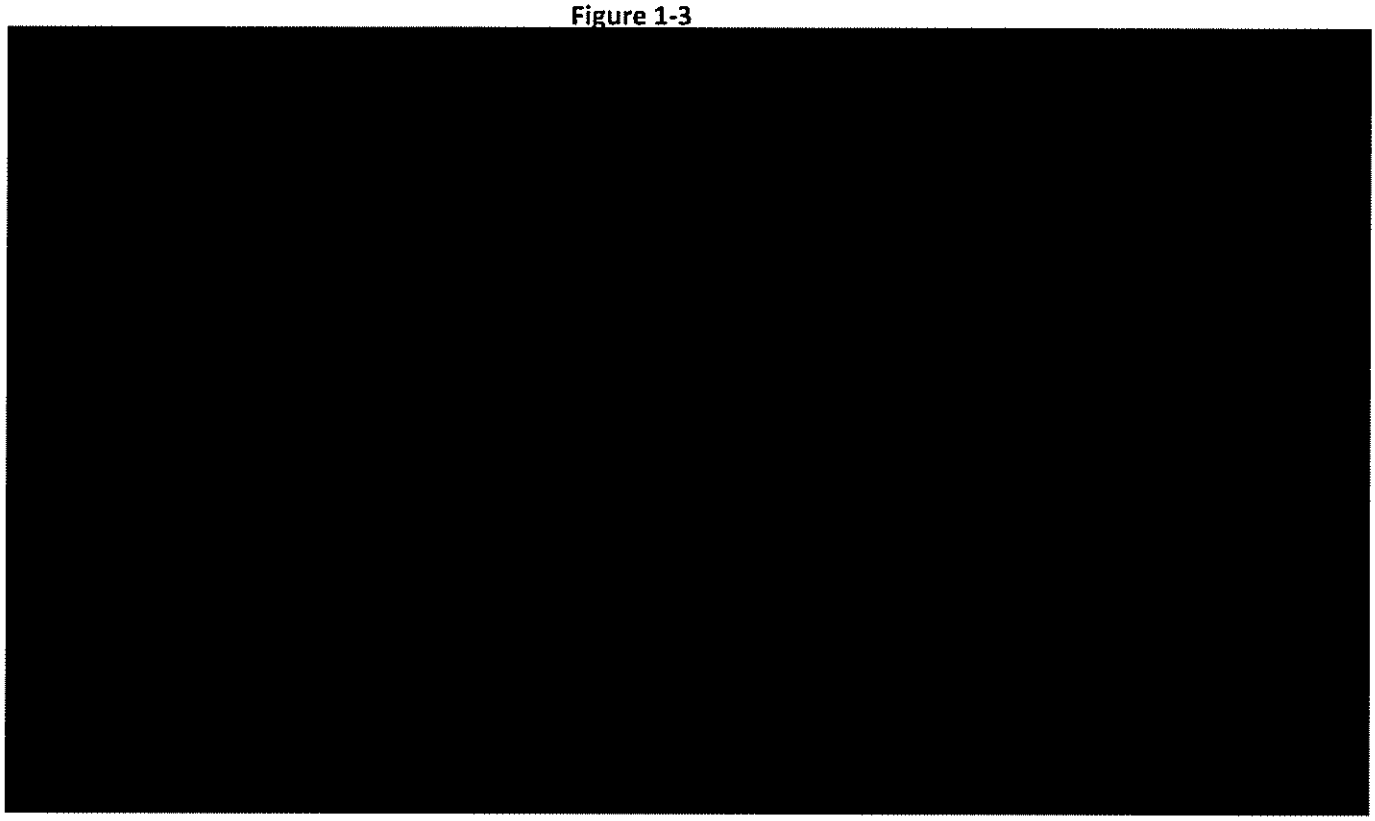


**Figure 1-4**

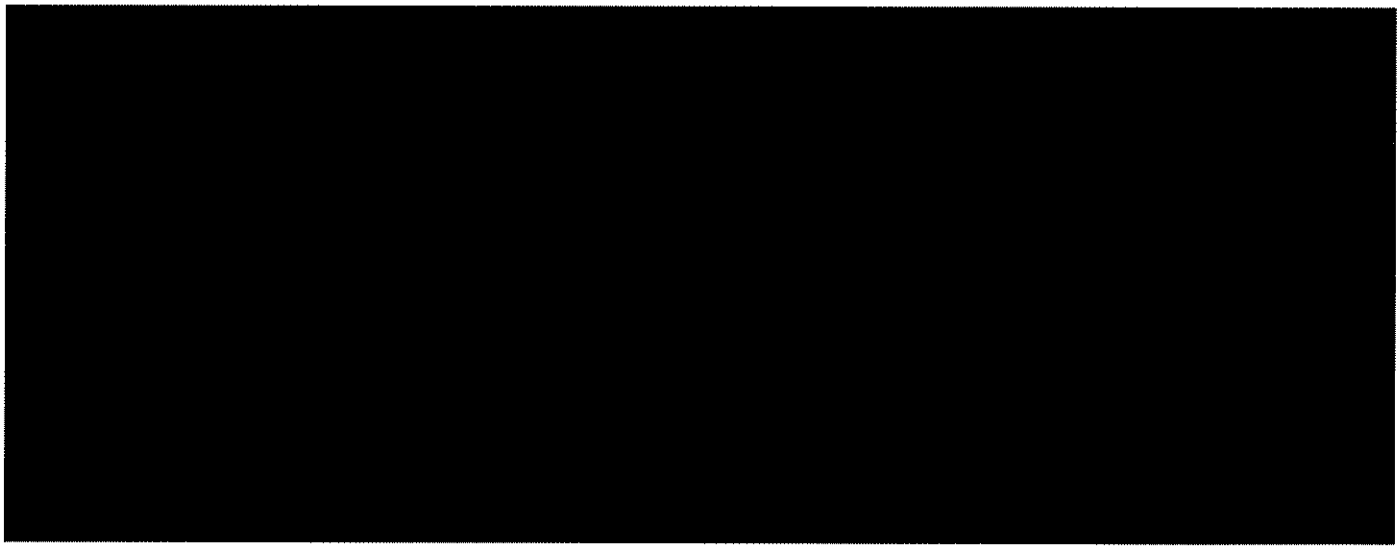
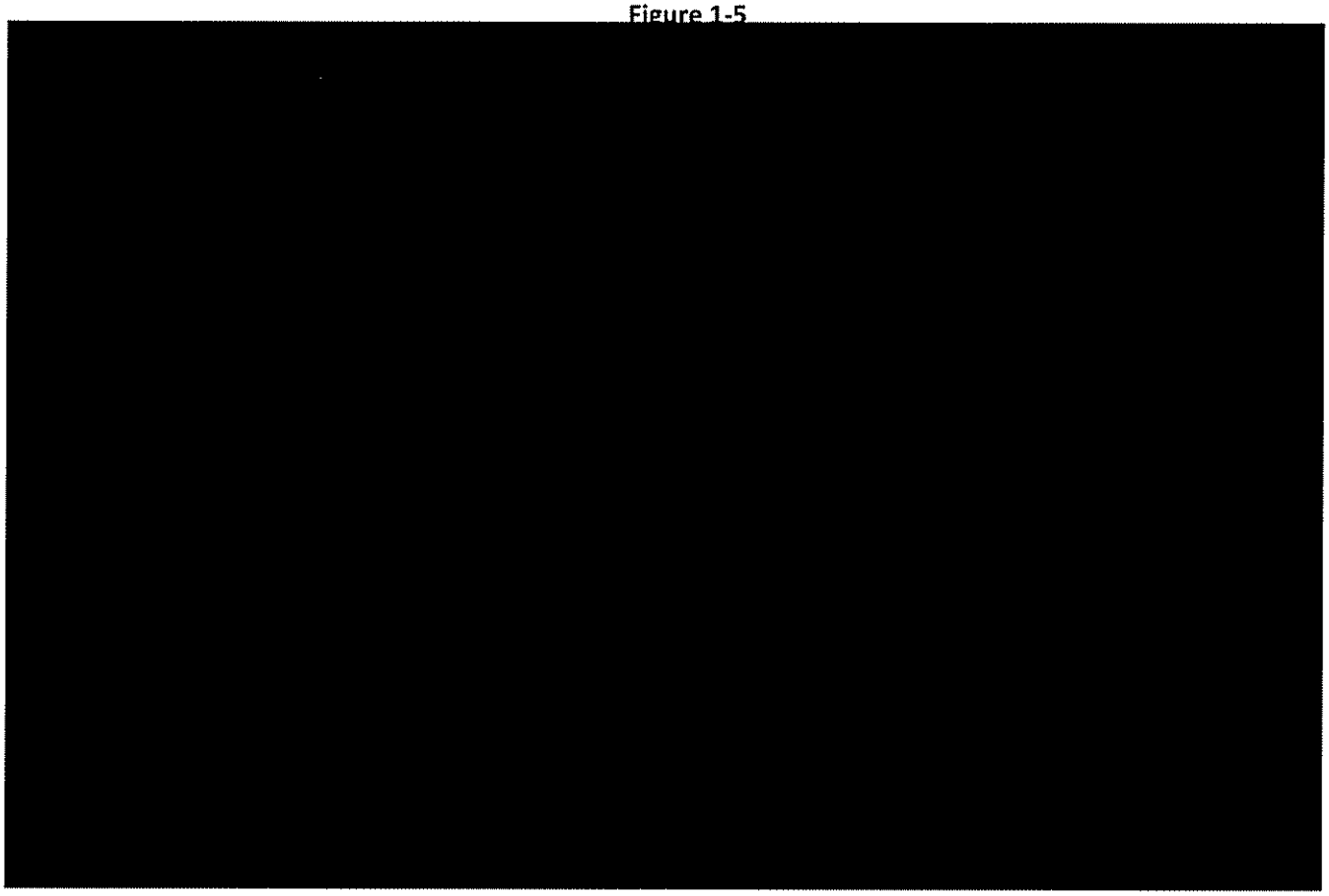


Figure 1-5



**Short Circuit Analysis**

Using the short circuit models from the inverter systems being utilized for this [redacted] it was calculated that the addition of the [redacted] resulted in the increase of three phase and/or single line to ground short circuit duties of [redacted]

The circuit breaker interrupting capabilities were reviewed at this substation and it was determined that zero (0) circuit breakers will be required to be upgraded as a result of the [redacted]

**System Protection Considerations**

With this proposed method of service, changes to the protection system of the SCE electrical system are deemed not required.

**Thermal Loading (Charging)**

Under peak load and max charging conditions, No thermal overloads were triggered by the [redacted]

Based on the assessment results, charging restrictions associated with the project may need to occur during different time periods. The need to restrict charging will increase over time as normal system demand continues to grow. The [redacted] will be used to actively communicate charging restrictions for the project.

Under emergency (N-1) conditions (loss of circuit), SCE may deem it necessary to isolate this project during emergency conditions until the distribution system returns to normal conditions.

Under emergency (N-1) conditions (loss of B-Bank), SCE may deem it necessary to isolate this project during emergency conditions until the distribution system returns to normal conditions.

**Distribution Voltage Control**

The [redacted] is not expected to experience a voltage problem below or above allowable Rule 2 requirements under maximum generation and unity power factor during daytime minimum load conditions and/or peak load conditions.

The [redacted] will be required to operate within a power factor of 0.95 leading and lagging at the point of interconnection as required by the WDAT 21 tariff. Additionally, the [redacted] must be designed to accommodate a VAR schedule provided by SCE if necessary.

**Harmonic Impact**

The harmonic impact of the subject inverter based generation was not part of this System Impact Study. Despite the relatively low THD (<3%) of the equipment, impacts on voltage distortion levels may be significant due to the penetration level of the generation facility with respect to the local distribution grid strength. As with all equipment connected to the SCE distribution system, the generation project will be subject to the provisions of CPUC Rule 2.E, allowing SCE to require customer mitigation of interference with SCE service, including harmonic impacts, if harmonic interference is caused by the customer. Given the amount of generation and the strength of the distribution system, SCE will not require a harmonic study but encourages that the applicant completes a harmonic study during the Facility Study Phase to insure that the generation facility complies with the harmonic studies outlined in CPUC Rule 2.E. If the applicant chooses to complete a harmonic study, SCE will then provide the required SCE distribution system data that are to be used as part of the harmonic study.

# Part A: General Description of Identified Upgrades

**Distribution Upgrades**

Distribution Upgrades will be required to interconnect the system. Distribution Upgrades include the installation of [redacted]

**Interconnection Facilities**

Interconnection facilities will be required to interconnect the system. Interconnection facilities include the installation of new [redacted] and associated substation equipment, new relays for line protection, and [redacted] and associated wiring.

Telemetry requirements

Real-time telemetry will be required. In order to meet the telemetry requirements SCE is planning to utilize a new method telemetry which utilizes a [redacted] concept. The cost estimate to comply with the telemetry requirements using the new method is $6.1 k[9]

Customer Equipment

The interface protection will be provided by the applicant and will include a [redacted] which is to be installed in an [redacted] The applicant's protection must be coordinated with SCE's Protective device(s) to provide adequate protection for the distribution system. The relay settings are subject to SCE approval prior to setting and certified timed trip testing report results using primary injection will need to be provided to SCE to verify relay and circuit breaker performance prior to energizing the service.

[redacted] must meet SCE's published Electrical Service Requirements ("ESR") to the extent applicable. Drawings required by the ESR shall be submitted, reviewed, and approved by SCE prior to release for fabrication/purchase of the equipment. Each medium voltage service is an individually engineered application at SCE.

Applicant generation interconnection equipment must comply with SCE's Interconnection Handbook in regards to generation protection and lockable, visible open disconnecting means at the point of interconnection. Additionally, the applicant will be responsible for the installation and costs of certain underground facilities (i.e. ducts, structures, etc.) to the extent required by the final design. The construction of the underground facilities will be as per SCE's project drawings.

[9] Cost estimate does not include 35% ITCC.

**System Study**

A Facilities Study may be performed to conclusively determine the detailed scope and cost of facilities required to interconnect the project.

# Part A: Non-Binding Order of Magnitude Cost Estimate

**Cost Estimate**[10,11,12]

| | |
|---|---|
| **Distribution Upgrades** | $673 k |
| • [redacted] | |
| • Data Point additions | |
| • [redacted] | |
| • Ground Grid Study | |
| **Interconnection Facilities** | $795 k |
| • [redacted] and associated substation equipment | |
| • New Relay's to provide line protection | |
| • [redacted] and associated wiring | |
| **Telemetry** | $6.1 k |
| **ITCC (35%)** | $465 k |
| Total non-binding order of magnitude cost estimate | $1.94 M |

[10] The Cost Estimate does not include the cost required for civil work completed by the customer.
[11] The Cost Estimates are in 2015 constant dollars.
[12] This Cost Estimate does not include cost to provide Station Light and Power services that will be required.

# Part A: Summary

The Part A System Impact Study showed:

1. Distribution Upgrades will be required to interconnect the system. Distribution Upgrades include the installation of a [redacted] and Data Point additions.

2. Interconnection facilities Interconnection facilities will be required to interconnect the system. Interconnection facilities include the installation of a new [redacted] and associated substation equipment, new relays to provide line protection, [redacted] and associated wiring.

3. Real time telemetry will be required for this project to provide Watts and VARs flow from the generating facility to the SCE distribution system.

4. Interconnection service pursuant to the WDAT would be expected to commence approximately 27 months from the execution of a Generator Interconnection Agreement (GIA). However, schedules and duration may change due to the number of projects approved and release dates. Stacked projects may impact resources, system outage availability, and environmental windows of construction.

5. Upgrades identified are general and preliminary descriptions only. The costs indicated are non-binding order of magnitude only. The schedule is projected and preliminary.

6. Applicant is responsible for the installation of Underground Structures and conduits needed for the interconnection in accordance with SCE design.

7. A Facilities Study detailing required scope and cost of the identified upgrades may be completed prior to proceeding with the project.

8. This System Impact is based on various technical data previously provided by the applicant. If any of that information changes significantly, as determined by SCE, the results of this study may no longer be appropriate and may necessitate a new study.

9. Current distribution standards are being updated to address generation interconnection systems. The proposed method of service on this report may change according on final design to comply with the updated distribution design standards.

10. This report does not include all Real Properties evaluations and cost estimates. Where formal rights of way, easements, land leases, or permits are required by SCE for installation of facilities, on or over Applicant's property, or the property of others, the Applicant shall grant SCE the rights of way and easements for the electrical facilities.

11. For SCE facilities and scope of work not subject to CPUC's GO 131-D, SCE will follow the requirements of all applicable environmental laws and regulations and issue an in-house Environmental Clearance before commencement of construction activities. The cost estimates provided assume that SCE will provide oversight on facilities and scope of work on the customer's property and/or SCE will perform all required environmental activities for SCE facilities and scope of work, located outside of the customer's property, from the siting through the post-construction phases. However, it is recommended for SCE facilities and scope of work to be included in the Generator's Environmental Licensing and Permitting documents to streamline the environmental process and avoid unnecessary delays in construction. The responsibilities for performing certain environmental activities may be negotiated during or after the Interconnection Agreement process.

12. This report does not consider potential milestone setbacks that could result from the local jurisdiction requiring underground construction of distribution facilities. SCE encourages the Interconnection Customer to consult with the local jurisdiction to identify existing underground ordinance to reduce the risk of complication associated with said ordinance.

13. This study does not include analysis related to the following system variability conditions:
    a. Generator ramp rate: Solar photovoltaic generator's increasing output profile during sunrise, i.e. system start-up
    b. Generator output variability: Solar photovoltaic generator's output variation correlated with weather conditions, i.e. cloud cover

    This study assumes that the Interconnection Customer's generating facility will include all equipment, software, and appropriate controls necessary to maintain the generator output profile per SCE requirements. The Interconnection Customer will be responsible for maintaining designated voltage levels under all conditions, including but not limited to the conditions identified above. Upon execution of the GIA, SCE will provide the Interconnection Customer with the required ramp rate control parameters. The ramp rate controls will be a function of the generation penetration on the distribution system, as well as SCE's distribution system configuration (additional parameters maybe considered, as need). Changes to the ramp rate control scheme may be required as determined by increased generation, changes in the distribution system topology, or other changes in the distribution system.

14. Applicable to projects requesting primary service: This study does not include analysis related to coordination of system protection equipment. A coordination study may be required during final engineering. The coordination study may identify additional interconnection requirements such as installing new protection equipment, reprogramming and/or relocating existing protection equipment. The additional scope of work may have an effect on the Interconnection Customer's requested in-service date.

15. In order to supply and maintain proper voltages for SCE's customers as required by the CPUC, SCE's primary distribution voltage may fluctuate by as much as ±5% from the nominal values. SCE uses various voltage regulation techniques to raise or lower primary distribution voltages in order to maintain the customer's service voltage at the desired level. Producers interconnected at primary distribution voltage levels must be able to withstand such voltage changes. The step-up transformer ratio must be chose such that the Producer can meet its voltage regulation obligations over the expected SCE system voltages. In the event, the customer is changing, replacing, or purchasing new equipment the customer shall acquire equipment to properly function with SCE's voltage regulation techniques.

# Attachment A: Part A - System Diagrams

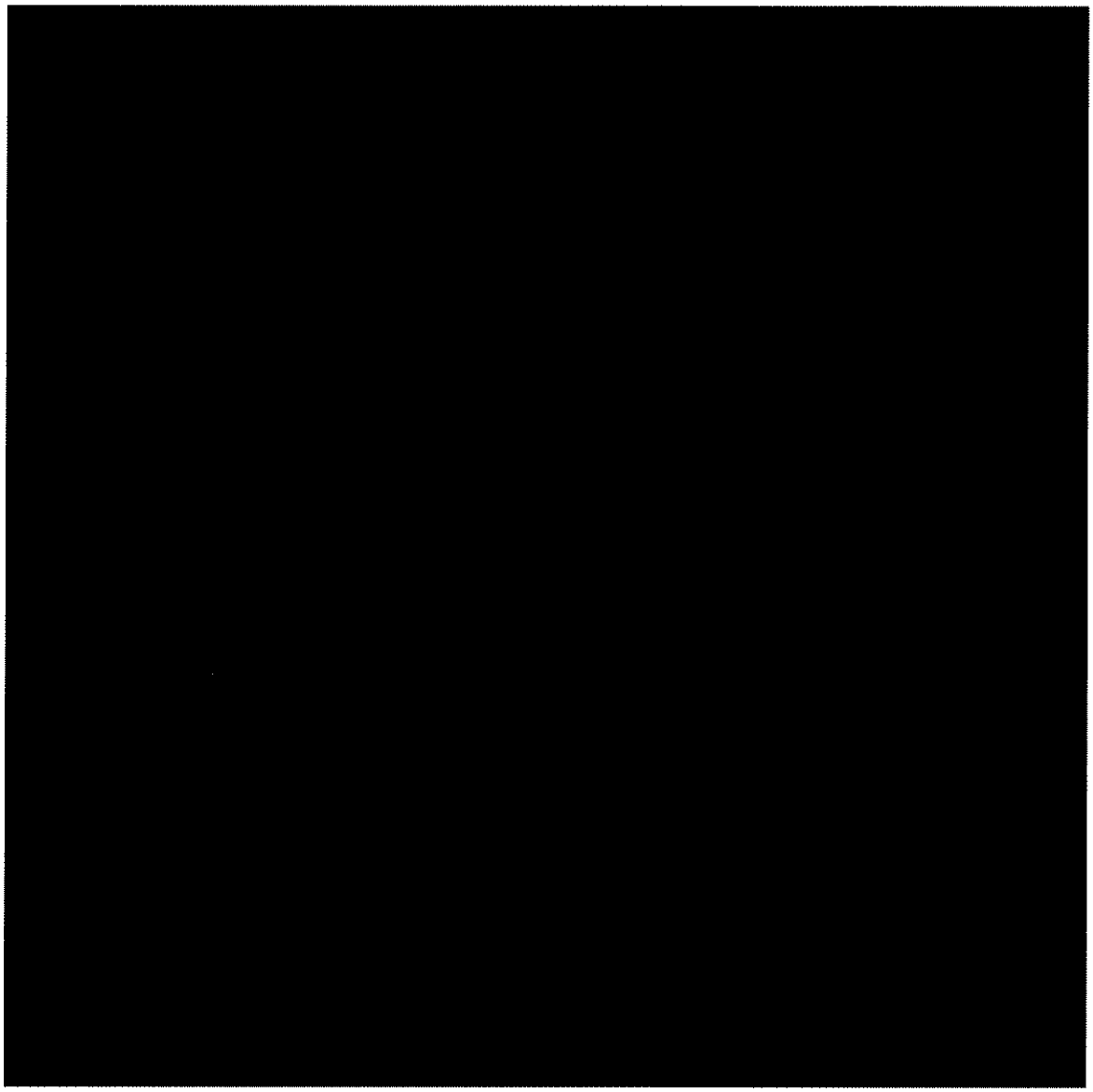


**Figure 1 – System without proposed project**

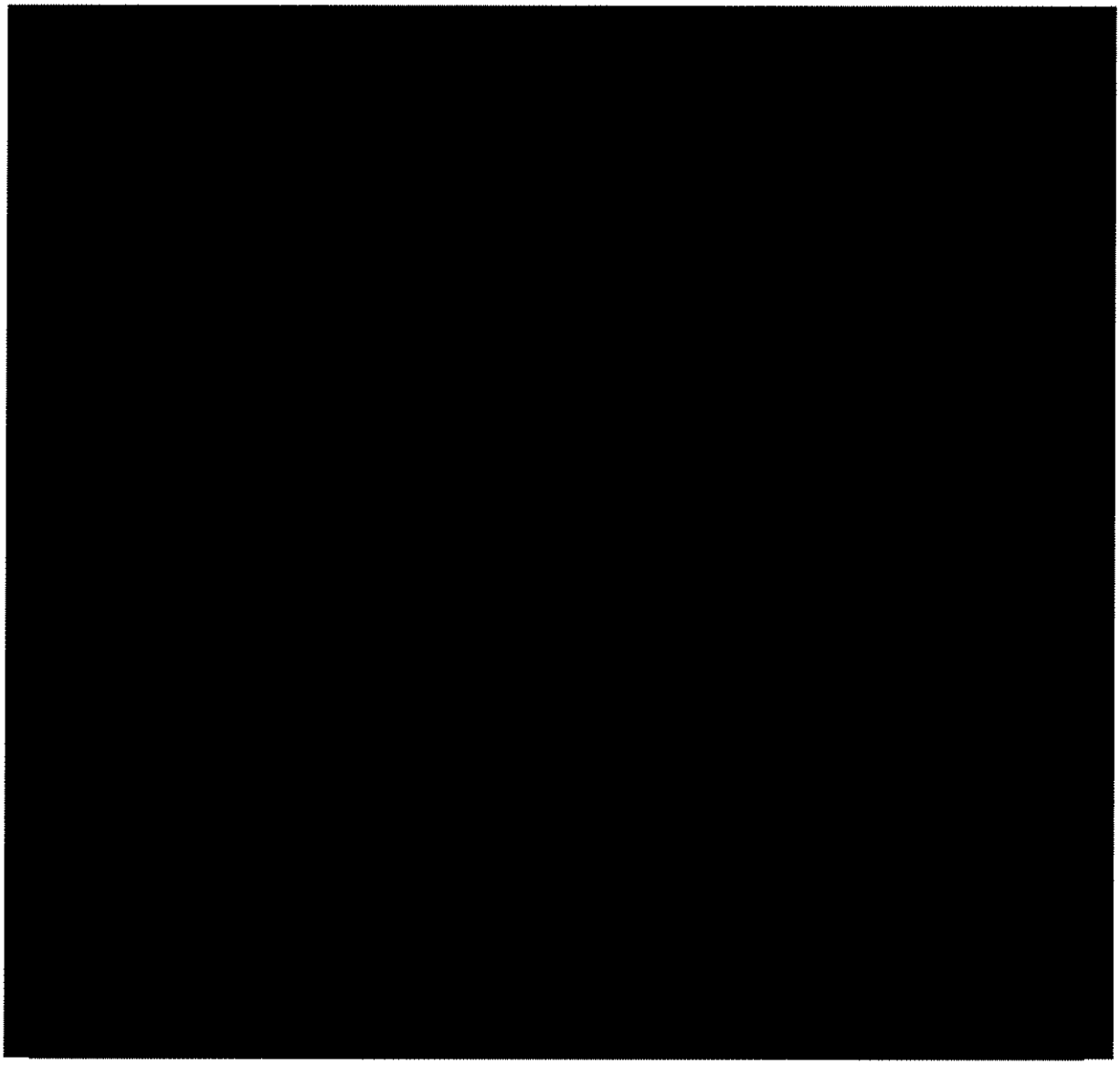


**Figure 2 – System with proposed method of service**

***Note:** The [redacted] of the project will need to be metered separately from the retail load components. The IC should be prepared to install multiple sets of metering (i.e. separate sets of PT's & CT's and supporting metering equipment) for the project. Additional facilities will be required to accommodate the separate meter service for the retail load component of the project. The proposed method of service only identifies the method of service as to allow the [redacted] to interconnect to the Distribution System.

# Attachment B: Transmission Assessment

This project does not adversely affect the 66 kV subtransmission system or bulk transmission system. This proposed project does not trigger short circuit duty related upgrades at [redacted]