[redacted]

WDAT 402

WDAT
SYSTEM IMPACT STUDY

May 13, 2011

SOUTHERN CALIFORNIA
EDISON
An *EDISON INTERNATIONAL*™ Company

Prepared by:

Matthew Rzyski
Roger Salas, P.E.
Distribution Field Engineering

Approved by:

Approved via Email
Alicia Lopez
Distribution Field Engineering Manager

SOUTHERN CALIFORNIA EDISON COMPANY

EXECUTIVE SUMMARY

[redacted] 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") Small Generator Interconnection Procedures. SCE performed a System Impact Study as requested by [redacted] for a 12 kV interconnection and distribution service from an existing 12 kV distribution line ("Discovery 12 kV"). The interconnection is an applicant-owned 12 kV switchgear, which will be located approximately 3.0 miles south of [redacted] on the Discovery 12 kV circuit out of SCE's Goldtown 66/12 kV Substation. The request is for a WDAT photovoltaic ("PV") generation facility with a total capacity of 10 MW. The initial request is for service to commence by [redacted]

The new proposed generation project consists of photovoltaic cell panels, [redacted] inverters, and [redacted] kVA 270 V/12 kV transformers. The proposed project would receive interconnection service from SCE's existing 12 kV circuitry on the Discovery 12 kV line out of [redacted] via an overhead and underground line extension to the applicant-owned 12 kV switchgear. The generated power would be delivered to the California Independent System Operator ("CAISO") grid at the 66 kV bus of SCE's [redacted]

The purpose of this System Impact Study is to determine the effect of the proposed generation addition on the SCE distribution system and the portion of SCE's electrical system that is part of the CAISO controlled grid, and to identify in general additional Interconnection Facilities, Distribution Upgrades, additions or modifications, or other facilities required to provide the requested service. The study was performed in two parts: Part A (performed by SCE's Distribution Field Engineering department) examines impacts related to that part of the SCE distribution system energized at less than 66 kV and also briefly summarizes the results of Part B, while Part B [redacted] examines impacts and facilities related to the portion of the SCE electrical system energized at 66 kV and above (the bulk power system), and impacts and facilities associated with the CAISO controlled portion of the SCE grid. This is the Part A study report; a detailed report of the Part B study results is included as Attachment B.

The Part A study was performed for expected year 2010 through 2019 projected peak load conditions as well as 2010 through 2019 minimum load conditions.

The Part A System Impact Study consisted of a power flow analysis, three-phase short circuit duty analysis and circuit voltage profile analysis. The analyses were performed to determine whether the energy associated with the [redacted] can be transmitted through SCE's distribution system to the ISO grid at the 66 kV bus of Goldtown Substation without creating the need for modifications to SCE's distribution system and/or to the ISO grid. The study showed that, with the [redacted] on-line:

- The addition of the [redacted] resulted in SCE's protective relays on the Discovery 12 kV line and the 12 kV bus tie at [redacted] to be increased due to the added load flow on the circuit.

- For both peak load and light load conditions, the addition of the [redacted] Project resulted in no violations of SCE's thermal loading criteria under base case. However, the addition of the [redacted] resulted in a violation of the SCE's thermal loading criteria under N-1 conditions for the SCE distribution system.

- The addition of the [redacted] resulted in voltage rise exceeding allowable Rule 2 limits under base case and N-1 conditions operating at unity power factor.

- The addition of the [redacted] resulted in increases of three-phase short-circuit duties by 0.1 kA or more at [redacted] distribution substations. The circuit breaker interrupting capabilities were reviewed at these substations and it was determined that [redacted] circuit breakers will be required to be upgraded under this project.

- With all queued ahead generation projects and all corresponding facility upgrades modeled, and with the system reconfigurations proposed as part of EKWRA, the power flow study identified base case and contingency overloads on the [redacted] 220/66 kV transformer banks with the addition of the [redacted] For the Windhub 220/66 kV overloads the study found that the addition of a new 220/66 kV transformer will be required.

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

Interconnection Facilities

Electrical Distribution Facilities	$0.707 M[1]

- Approximately 5,000 feet of 336 ACSR conductor
- Pad-mounted Enclosure
- Underground Remote Controlled Switch (RCS)
- Ground Detector
- Approximately 150 feet of 1000 JCN conductor
- Metering CTs
- Metering VTs
- Meters
- Associated Wiring

Telemetry	$0.212 M[1]

- Power System Controls (PSC)
- Telecom Facilities

Distribution Upgrades

12 kV Distribution Upgrades	$0.000 M[1]
Total non-binding order of magnitude cost estimate	$0.919 M[1]

[1] Cost estimates include 35% ITCC. Cost estimates are in nominal/2011 dollars.

PAGES OMITTED FOR CEII REGULATIONS

CONTENTS

	PAGE
I. INTRODUCTION TO PART A	6
II. PART A: SYSTEM IMPACT STUDY CONDITIONS & METHODOLOGY	7
III. PART A: SYSTEM IMPACT STUDY RESULTS	7
IV. PART A: GENERAL DESCRIPTION OF IDENTIFIED UPGRADES	9
V. PART A: NON-BINDING ORDER OF MAGNITUDE COST ESTIMATE	10
VI. PART A: SUMMARY	11

Attachment A: Part A: SYSTEM DIAGRAMS

- **A1 – System without proposed project**
- **A2 – System with proposed project**
- **A3 – System with proposed method of service**

Attachment B: PART B: System Impact Study

I. INTRODUCTION TO PART A

[redacted] 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") Small Generator Interconnection Procedures. SCE performed a System Impact Study as requested b[redacted] for a 12 kV interconnection and distribution service from an existing 12 kV distribution line ("Discovery 12 kV"). The interconnection is an applicant-owned 12 kV switchgear, which will be located approximately 3.0 miles south of Goldtown Substation on the Discovery 12 kV circuit out of SCE's [redacted] 66/12 kV Substation. The request is for a WDAT photovoltaic ("PV") generation facility with a total capacity of 10 MW. The initial request is for service to commence by December 1, 2012, and is subject to change after additional study results and other factors, including by not limited to the following: permitting requirements, design, engineering, procurement of material lead times, and land issues.

[redacted]

[redacted]

The new proposed generation project consists of photovoltaic cell panels [redacted] inverters, an [redacted] 270 V/12 kV transformers. The proposed project would receive interconnection service from SCE's existing 12 kV circuitry on the Discovery 12 kV line out of [redacted] via an overhead and underground line extension to the applicant-owned 12 kV switchgear. The generated power would be delivered to the California Independent System Operator ("CAISO") grid at the 66 kV bus of SCE's Goldtown Substation.

The purpose of this System Impact Study is to determine the impact of the proposed generation addition on the SCE distribution system and to identify in general additional Interconnection Facilities, Distribution Upgrades, additions or modifications, or other facilities required to provide the requested service. This study was performed for expected year 2010 through 2019 peak load conditions as well as low demand conditions.

II. PART A: SYSTEM IMPACT STUDY CONDITIONS & METHODOLOGY

Planning Criteria

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

The thermal rating of any conductor, connector, or apparatus should 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.

System Conditions

The power factor for the new generation facility was assumed to be within WDAT requirements of 0.95 lagging or leading.

Expected loading on the distribution system as projected by the SCE 2010 - 2019 plan was used.

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

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

III. PART A: SYSTEM IMPACT STUDY RESULTS

Short Circuit Analysis

Using the short circuit models from the inverter systems being utilized in this solar generation system it was calculated that the short circuit contribution at [redacted] substation buses were more than 0.1 kA thus a breaker analysis was required due to this generation. The circuit breaker analysis concluded that [redacted] reakers replacements are required as part of this project.

System Protection Considerations

[redacted] which is the proposed inverter for the [redacted] SCE requires UL 1741/IEEE 1547 certification in order to interconnect to the distribution system without additional protection systems at the point of interconnection. [redacted] SCE will be requiring additional protection to be installed at the point of interconnection in order to comply with the anti-islanding requirements. The [redacted] shall have adequate protective devices to perform the following:

a) Detect faulted conditions on SCE distribution system for 3-phase and phase-ground and clear the generator system from SCE system once a fault condition occurs.

b) Detect the voltage and frequency excursions from guidelines.

For additional details regarding the protection devices required to satisfy the above requirements please refer to the *SCE's Interconnection Handbook.*

The addition of the [redacted] also resulted in SCE's protective relays on the Discovery 12 kV line and the 12 kV bus tie at [redacted] to be increased due to the added power flow on the circuit. In order to accommodate the increased current flowing in this radial branch between [redacted] and the generation facility, protection relay settings must be raised.

Thermal Loading

With the [redacted] on the Discovery 12 kV line, the line section of the Discovery 12 kV between the applicant's 12 kV point of interconnection and the 12 kV bus at [redacted] 66/12 kV Substation is expected to experience an aggregate total reverse power flow of approximately 9.7 MW. Of that 9.7 MW, approximately 8.6 MW is expected to flow back into the bus at [redacted]. No thermal overload is calculated due to this reversal of power flow under base case conditions. However, a thermal overload is calculated under N-1 conditions. In the event of an N-1 condition, the [redacted] will be switched off if SCE deems it necessary until the distribution system in returned to normal.

Distribution Voltage Control

The section of 12 kV distribution line near the project area is expected to experience voltage rise of 3.6%, which would exceed the allowable CPUC Rule 2 requirements by 3.1% as a result to the addition of the [redacted] under the generating facilities conditions of maximum generation and unity power factor. This voltage rise could be mitigated by operating the generating facility to consume reactive power (VARs). Therefore, when the project commences operation, it must be operated at power factor range of 96% leading and lagging or absorb 3.123 MVARs at the point of interconnection, which is within the tariff requirements. Future distribution system configurations may require to operate at a +/- 0.95 PF as required by the tariff. To accomplish the VAR requirements, the generation project must be able to draw the reactive power on a schedule which SCE will provide when project is ready to go into service. Additionally, an overvoltage is also calculated under N-1 conditions. In the event of an N-1 condition, the [redacted] will be switched off if SCE deems it necessary until the distribution system in returned to normal.

Harmonic impact

The harmonic impact of the subject inverter based generation was not studied, however, despite the relatively low THD (<3%) of the equipment, impacts on voltage distortion levels are believed to be possibly significant due to the high 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 installation will be subject to the provisions of Rule 2.E, allowing SCE to require customer mitigation of interference with SCE service, including harmonic impacts, should interference occur. The provided THD values are for individual inverters and not for the total generation requested. In order to better establish whether mitigation will be required in this case, a harmonic impact study is required to be provided to SCE by the Interconnection Customer. Interconnection Customer shall commission such a study, discuss study structure with SCE prior to commencing study, and provide results to SCE with adequate lead time for SCE to direct any needed mitigation prior to detailed project design and construction.

SCE notes that the allowed harmonic voltage distortion limits on the distribution system are the product of the impacts of all customers' equipment, not the limit to be applied to each individual installation.

IV. PART A: GENERAL DESCRIPTION OF IDENTIFIED UPGRADES

Distribution Upgrades

The addition of this project requires no Distribution Upgrades at the distribution 12 kV circuit.

Interconnection Facilities

Interconnection facilities include the installation of an overhead line extension of approximately 5,000 feet of 336 ACSR to interconnect the generation facility to the distribution 12 kV circuit, new Underground RCS, a 12 kV underground line extension of approximately 150 feet of 1000 JCN between the Discovery 12 kV line extension and applicant's 12 kV switchgear, ground detector, metering CTs, VTs, meters, and associated wiring. The cost estimate for the required interconnection facilities is $0.707 M[1].

Telemetry requirements

Real-time telemetry will be required. In order to provide the adequate telemetry requirements, a new RTU and Telecom must be installed. The telecom cost estimate assumes the ability of a local phone company to provide a T1 line to the project area. If the local phone company cannot provide a T1 line, then the cost estimate for telemetry may increase significantly. Applicant should be aware of the monthly fee for the leasing of a T1 line from the local phone company. The cost estimate for the required telemetry at the generating facility without additional monthly fees to lease a T1 line is $0.212 M[1].

Customer Equipment
The interface protection will be provided by the applicant and will include a 12 kV circuit breaker which is to be installed on an applicant-owned 12 kV switchgear. The applicant's protection must be coordinated with SCE's Goldtown Substation circuit breaker controls 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 th[redacted]

The switchgear must meet SCE's published Electrical Service Requirements ("ESR") to the extent applicable. Drawings required by the ESR shall be submitted, reviewed, modified, 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 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.

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

V. NON-BINDING ORDER OF MAGNITUDE COST ESTIMATE

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

Interconnection Facilities

Electrical Distribution Facilities	$0.707 M[1]

- Approximately 5,000 feet of 336 ACSR conductor
- Undeground Remote Controlled Switch (RCS)
- Ground Detector
- Approximately 150 feet of 1000 JCN conductor
- Metering CTs
- Metering VTs
- Meters

- Associated Wiring

Telemetry	$0.212 M[1]

- Power System Controls (PSC)
- Telecom Facilities

Distribution Upgrades

12 kV Distribution Upgrades	$0.000 M[1]
Total non-binding order of magnitude cost estimate	$0.919 M[1]

VI. PART A: SUMMARY

The Part A System Impact Study showed: The addition of this project requires no Distribution Upgrades at the distribution 12 kV circuit.

1. The addition of this project requires no distribution upgrades a t the distribution 12 kV circuit.

2. Interconnection facilities include the installation of an overhead line extension of approximately 5,000 feet of 336 ACSR to interconnect the generation facility to the distribution 12 kV circuit, new Underground RCS switch, a 12 kV underground line extension of approximately 150 feet of 1000 JCN between the Discovery 12 kV line extension and applicant's 12 kV switchgear, ground detector, metering CTs, VTs, meters, and associated wiring.

3. Real time telemetry will be required. It will be required to install a RTU and telecommunication system as required to provide Watts and VAR flow from the generation facility to the SCE distribution system as well as other required information.

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

   Facilities and System Upgrades are as follows:

Interconnection Facilities	$0.707 M[1]
Telemetry	$0.212 M[1]
Distribution Upgrades	$0.000 M[1]

[1] Cost estimates include 35% ITCC. Cost estimates are in nominal/2011 dollars.

Total non-binding order of magnitude cost estimate $0.919 M[1]

5. Interconnection service and distribution service pursuant to the WDAT would be expected to commence within 6-9 months of executing a Small Generator Interconnection Agreement ("SGIA") and associated Distribution Service Agreement.

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

7. A Facilities Study detailing required scope and cost of the identified upgrades is required to proceed with the project.

8. This System Impact Study 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. The System Impact Study is based on applicant's queue position. Additional studies may be needed if any changes occur in the projects ahead in the queue.

10. Additional information is required from Interconnection Customer regarding the [redacted] VAR control capabilities as indicated in the Distribution Voltage Control of section III on page 8.

11. SCE is still developing Standards on interconnection equipment, which may change the interconnection equipment during the final design phase.

PAGES OMITTED FOR CEII REGULATIONS