The Interconnection Handbook

Southern California Edison Company

Rev. 12

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Original Signed by

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INTRODUCTION AND SUMMARY OF TECHNICAL REQUIREMENTS

Southern California Edison Company's (SCE) Interconnection Handbook (Handbook) is broken up into three distinct parts based on the customer project type that are being connected, planned to be connected, or facility additions and modifications to existing customer facilities interconnected to the SCE's electric system.

The three parts of the handbook address:

- Generator Interconnections;
- End-User Facility Interconnections; and
- Transmission Interconnections

Collectively these types of interconnections are referred to in the Handbook as "Interconnected Facility (INTFAC)."

There is a fourth section in the Interconnection Handbook that addresses how SCE will work towards a solution to mitigate any adverse impact on affected systems using the California Independent System Operator (CAISO) tariff.

The Handbook specifies what is necessary for facilities to interconnect to SCE's electric system (Requirements), or locations where SCE is the operating agent, which shall be referred to as "SCE's electric system". These Requirements provide for safe and reliable operation of SCE's electric system.

As a Transmission Owner (TO), SCE is required to provide and maintain a Handbook to guide entities that need to interconnect to SCE's electric system. Please note that generators directly connecting to SCE's transmission facilities must also adhere to the CAISO generation interconnection procedures. This is because these facilities are under CASIO operational control and they perform the Transmission Operator (TOP) function for them.

Link to CAISO Fifth Replacement Federal Energy Regulatory Commission (FERC) Electric Tariff: http://www.caiso.com/rules/Pages/Regulatory/Default.aspx

1.1 Introduction

1.1.1 Purpose of Interconnection Handbook

The Handbook was written to provide SCE's customers an overview of the Requirements to address interconnection requests, and to support compliance with North American Electric Reliability Corporation (NERC) Reliability Standard, FAC-001-3, and Facility Connection Requirements. It also provides a means to facilitate communication of technical information to SCE regarding the INTFAC, and are **<u>not meant to be used as a design specification</u>** for the INTFAC.

SCE's Requirements do not cover all aspects of the necessary technical criteria applicable to an INTFAC project, and the final design of facility connections to SCE's electric system will be subject to SCE review and approval on a case-by-case basis.

The Handbook considers the following general items that need to be addressed by customers in their interconnection request to SCE:

- Procedures for requesting a new Facility interconnection or material modification to an existing interconnection
- Data required to properly study the interconnection
- Voltage level and MW and MVAR capacity or demand at the point of interconnection
- Breaker duty and surge protection
- System protection and coordination
- Metering and telecommunications
- Grounding and safety issues
- Insulation and insulation coordination
- Voltage, Reactive Power (including specifications for minimum static and dynamic reactive power requirements), and power factor control
- Power quality impacts
- Equipment ratings
- Synchronizing of Facilities
- Maintenance coordination
- Operational issues (abnormal frequency and voltages)
- Inspection requirements for new or materially modified existing interconnections
- Communications and procedures during normal and emergency operating conditions

Please note some of the items in the list above do not apply to all applicable entities – and some applicable entities may have requirements that are not included in the list. SCE has compiled a list of additional technical standards and criteria that the INTFAC must adhere to, as referenced in the Requirements, and is provided in Appendix A.

Once the initial facility information has been provided SCE will determine and communicate any additional project-specific technical requirements necessary from the INTFAC. It is in the customer's best interest to discuss their project plans with SCE prior to making any major financial commitment such as the purchasing or installation of equipment.

SCE will follow notification procedures for new or modified facilities in the Transmission Control Agreement (TCA) per Section 4.2.3, with respect to the CAISO Register.

In addition, customers may also inquire about SCE's interconnection procedures and for notification of new or modified generation, transmission, and end-user facilities from the following contact:

Contact	Mailing Address
Manager, Grid Interconnection & Contract Development	P.O. Box 800 2244 Walnut Grove Avenue Rosemead, California 91770

1.1.2 Conformity

The INTFAC shall comply with all applicable NERC Reliability Standards, Western Electricity Coordinating Council (WECC) Reliability Criteria and Guidelines, along with any WECC, SCE and CAISO system planning and performance guidelines for its facilities. SCE will not assume any responsibility for complying with mandatory reliability standards for such facilities and offers no opinion whether the Interconnection Customer must register with NERC pursuant to Section 215 of the Federal Power Act. If required to register with NERC, the INTFAC shall be responsible for complying with all Applicable Reliability Standards for its facilities.

The INTFAC is responsible for conforming to applicable:

- FERC Rules, Regulations, and Orders
- NERC Standards
- WECC Regional Criteria, Policies, and Guidelines
- CAISO Planning Standards
- SCE Reliability Criteria, as well as good engineering and utility practice.

1.1.3 Requirements are Subject to Change

These Requirements are subject to change. INTFACs have the responsibility to ensure that they comply with the most recent version of the Interconnection Requirements. The current version may be accessed at SCE's internet site, https://www.sce.com/. Each page of the Handbook displays its effective date in the upper right hand corner.

1.1.4 Applicability

Upon execution of an Interconnection Agreement per the appropriate tariff, the INTFAC should make reference to this document in its entirety during the construction process.

PART 1

Generator Interconnection Requirements

CONTENTS

TABLES

FIGURES

SECTION 1 GENERATOR INTERCONNECTION OVERVIEW

The Generator Interconnection Section specifies what is necessary for generation facilities to interconnect to SCE's electric system and gives customers an overview of the requirements to address interconnection requests. It also provides a means to facilitate the communication of technical information to SCE regarding the generation facilities interconnecting to SCE's electric system.

Throughout this section the term "Producer" shall refer to the owner, its agents, or the operator of facilities being interconnected to SCE's electric system that includes performing the functions of supplying energy and a service (exclusive of basic energy and transmission services) to support the reliable operation of the transmission system.

All Producers with generation connected to SCE's electrical system, regardless of voltage or classification, are required to adhere to SCE's Generation Modeling Data Requirements.

SCE's Generation Modeling Requirements can be found at "Link"

SECTION 2 PARALLEL SYSTEMS

These requirements apply to interconnecting generating facilities that intend to operate in parallel with SCE's electric system, and, in some instances, ultimately deliver power to the CAISO grid (directly to the transmission system, or via SCE's Distribution system).

Subject to FERC, California Public Utilities Commission (CPUC) regulations, and SCE approval, a Producer may elect to operate a generator facility in parallel with SCE or as a separate system with the capability of non-parallel load transfer between the two independent electrical systems. Induction generators, and some systems using inverter devices, must be operated in parallel to produce energy. Synchronous generators may be operated either in parallel or as a separate system. However, please note that the requirements provided in this document are applicable to interconnecting generators intending to operate in parallel.

2.1 Parallel Operation

A parallel operation is one in which the Producer's generating facilities operated connected to SCE's electric system. A consequence of such parallel operation is that the parallel generator becomes a part of SCE's electric system, and must, therefore, be considered in planning the protection of SCE's electric system. To be allowed to operate in parallel with the electric grid, the generating facility must meet Southern California Edison Transmission Planning Criteria and the technical specification as outlined in the relevant section of this document.

2.2 Need for Protective Devices

Prudent electrical practices require that certain protective devices (relays, circuit breakers, etc.) must be installed at any location where a Producer desires to operate its generating facilities in parallel with the SCE system. The purpose of these devices is to isolate faults from the Electrical Grid and promptly disconnect the Producer's generating equipment from the SCE system when faults or abnormal operation jeopardize the reliable operation of equipment or the safety of personnel. Other modifications to electrical system configuration or protective relays may also be required to accommodate parallel generation. SCE assumes no responsibility for determining protective equipment needed to protect Producer's facilities.

2.3 Hazards

SCE's transmission and distribution lines are subject to a variety of natural and man-made hazards. Among these are lightning, earthquakes, wind, animals, automobiles, mischief, fire, and human error. Producer's electric systems are subject to these same hazards but not nearly to the same degree because SCE's electric system has greater exposure to these hazards.

The electric problems that can result from these hazards are principally short circuits, grounded conductors, and broken conductors. These fault conditions require that damaged equipment be de-energized as soon as possible to ensure public safety and continued operation of the remainder of SCE's electric system.

Where SCE controls the only source of supply to a given transmission or distribution line, it has the sole responsibility to install protective equipment to detect faulted equipment or other operating abnormalities and to isolate the problem from the remainder of SCE's electric system. A non-SCE generating facility connected to and operated in parallel with an SCE line represents another source of power to energize the line. Accordingly, SCE requires that such facilities also have adequate protective devices installed to react to abnormal electric system conditions and isolate from SCE's electric system.

2.4 Islanding

Generating facilities operating in parallel with SCE's electric system must also be equipped to detect another condition referred to as "unintentional islanding." Islanding is the abnormal operating condition where a portion of SCE's electric system and loads become isolated from the remainder of SCE's electric system while still connected to and receiving energy from generating facilities within an electrical island. When unintentional islanding occurs, all generating facilities within the electrical island must be disconnected to prevent continued operation.

The protective devices and other requirements identified in Section 3 are intended to provide protection against hazards, such as those noted above, by ensuring that parallel generating facilities are disconnected when abnormal operating conditions occur. The following sections reflect the fact that these requirements are typically minimal for small installations but increase in scope and/or complexity as the size of the generation installation increases. SCE may require voltage and frequency protective functions or relays to detect islanding and shut down generation during periods of islanding.

2.5 UPS

Uninterruptible Power Supply (UPS) systems will be classified as either a separate or a parallel system depending on the following criteria. If such UPS systems are not capable of transfer of electric power from the emergency source to SCE's electric system, they will be classified as a separate system generating facility. If such UPS systems are capable of transfer of power, they must meet the requirements for parallel generation.

SECTION 3 PROTECTION REQUIREMENTS

Protective devices (relays, circuit breakers, synchronizing equipment, etc.) must be installed for the protection of SCE's electric system as required by SCE. Generally, the protective devices may differ with the relative electrical capacity of the installation. The larger the installation, the greater the effect it may have on SCE's electric system. For instance, a manual disconnecting device must be provided by the Producer, but the form of this device will vary with the service voltage and generating facility capacity.

While some protection requirements can be standardized, the detailed protection design highly depends on the Producer's generator size, type and characteristics, number of generators, interconnection line characteristics (i.e., voltage, impedance, and ampacity), as well as the existing protection equipment and configuration of SCE's surrounding electric system. Fault duty, existing relay schemes, stability requirements, and other considerations may impact the selection of protection systems. Consequently, identical generation facilities connected at different locations in SCE's electric system can have widely varying protection requirements and costs. The varying protection requirements will be used to define the corresponding Telecommunications requirements (See Section 8.)

For voltage classes 200 kV and above, primary relay protection for network transmission circuits will be designed to clear transmission line faults within a maximum of 6 cycles. Project stability studies may indicate that faster clearing times are necessary. To ensure the reliability of the electric system, protective relays, and associated equipment require periodic maintenance/replacement. Typically the frequency of transmission line relay replacement does not exceed once every fifteen (15) years, but equipment failure, availability of replacement parts, system changes, or other factors may alter the relay system replacement schedule. If equipment does fail, that may impact the reliability of the electric system and it shall be replaced according to the Interconnection Agreement.

For Generation interconnections utilizing a sub-transmission line interconnection at voltage 66 and 115 kV or transmission line at 161 kV, 220 kV and 500 kV, Producers shall utilize Protection Requirements as defined in this Interconnection Handbook Part 3 Transmission Interconnection Requirements Section 2.

Categories: SCE's requirements identify three different categories for Producer generating facilities connecting to the SCE electric system each with distinctive protection requirements. These categories are:

1. Interconnection voltage above 34.5 kV
2. 200 kVA and above capacity, interconnection voltage 34.5 kV or below
3. Less than 200 kVA capacity, interconnection voltage 34.5 kV or below

Aggregation: Where multiple generating facilities (with a single owner) are allowed to connect to SCE's electric system through a single point of interconnection, the interconnection is said to have aggregated generating facilities. The appropriate category of aggregated generating facilities is calculated by summing the KVA ratings of the multiple generators.

Disclaimer: The categories above have been established for convenience and are based on urban/suburban circuits with normal load density. The final decision as to the specific requirements for each installation will be made by SCE depending on several factors that could include Producer load magnitude, the magnitude of other load connected to that circuit/system, available short circuit duty contribution, and other conditions SCE deems prudent.

The Protection Requirements of the above three categories are described in Sections 3.1 to 3.3. These sections include Figures 3a through 3i which illustrate typical installations for protection equipment. The following is a legend of device numbers referred to in these figures:

Legend

Protective Device Numbers and Description

4	Master Contactor
25	Synchronizing or Synchronism Check
27	Under-voltage
32	Power Direction
40	Loss of Field Detection
46	Current Balance
47	Voltage Phase Sequence
50	Breaker Failure
51	Time Over-current
51G	Ground Time Over-current
51N	Neutral Time Over-current
51V	Voltage Restrained/Controlled Time Over-current
59	Over-voltage
59G	Over-voltage Type Ground Detector
67V	Voltage Restrained/Controlled Directional Time Over-current
78	Loss of Synchronism (Out-of-Step)
79	Reclosing Relay
81O	Over-frequency
81U	Under-frequency
87	Current Differential
87L	Transmission Line Differential
NOTE:	For additional information on device numbers, refer to ANSI C37.2.

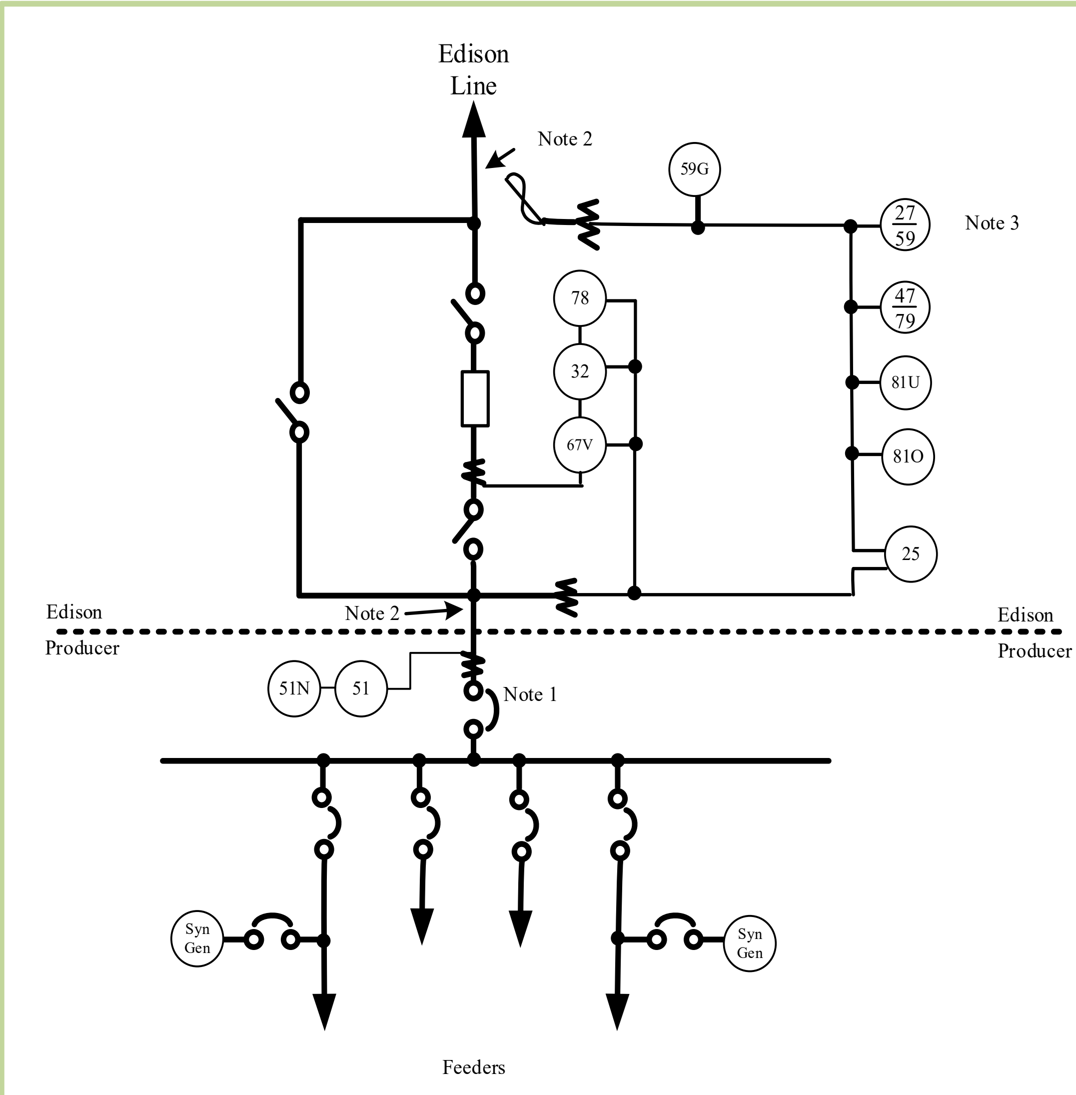
3.1 Category 1: Voltage Over 34.5 kV

This Category is limited to generating facilities interconnecting at a single point with interconnection voltage above 34.5 kV. This requirement applies to all interconnections to the CAISO Controlled Grid, and to interconnections to SCE owned and operated facilities above 34.5 kV.

Typical Installations

Figures 3a, 3b, and 3c show typical installations with the SCE interface.

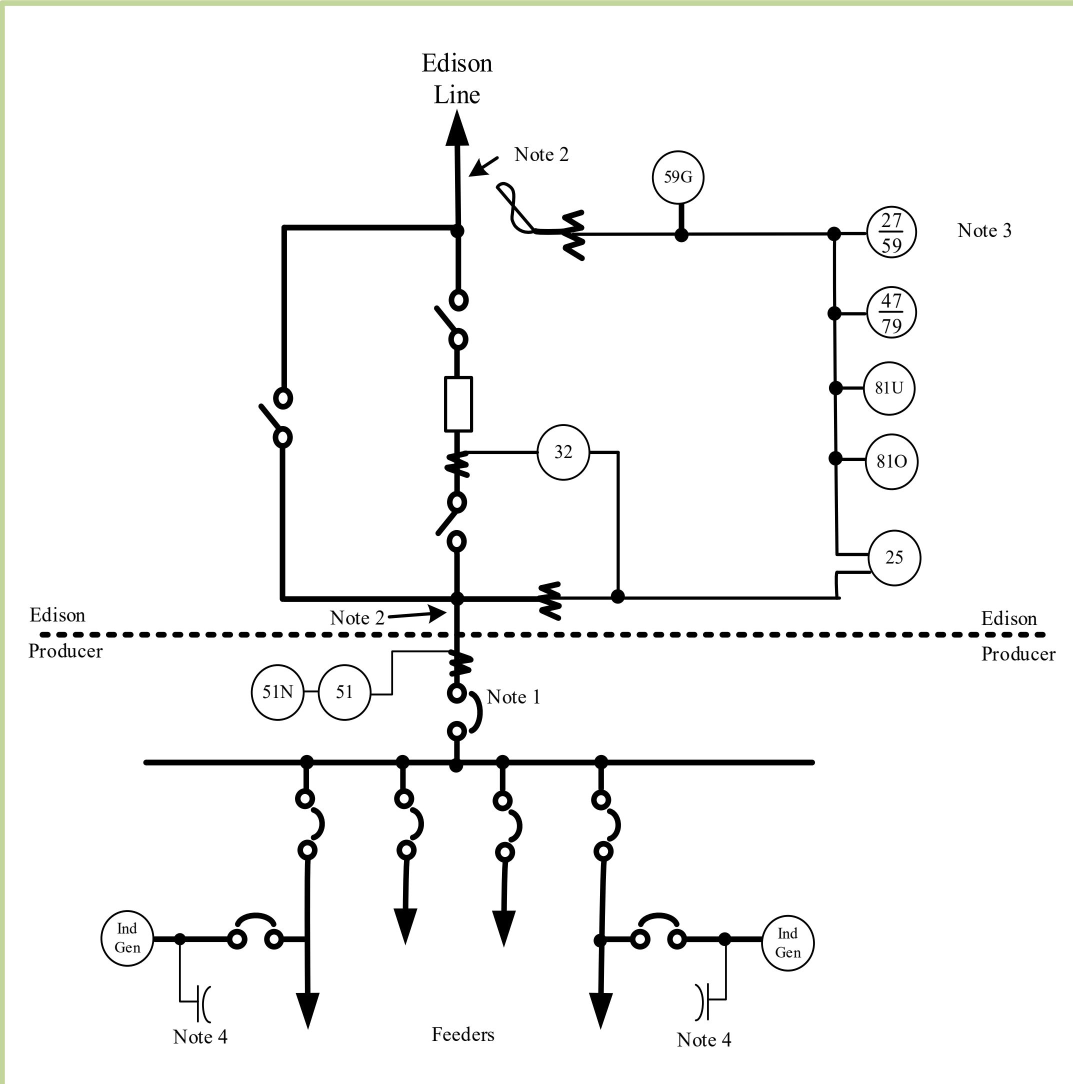
Figure 3a: Typical Synchronous Parallel Generation with Assumed SCE Owned Protection (> 34.5 kV)



Notes: 1 Producer's main breaker or switch.
2. Transformation, if required, may be by SCE or the Producer.
3. Relay operates on two different phase-to-phase voltages.

Not all Producer-side protective relaying is shown.

Figure 3b: Typical Induction Parallel Generation with Assumed SCE Owned Protection (>34.5 kV)

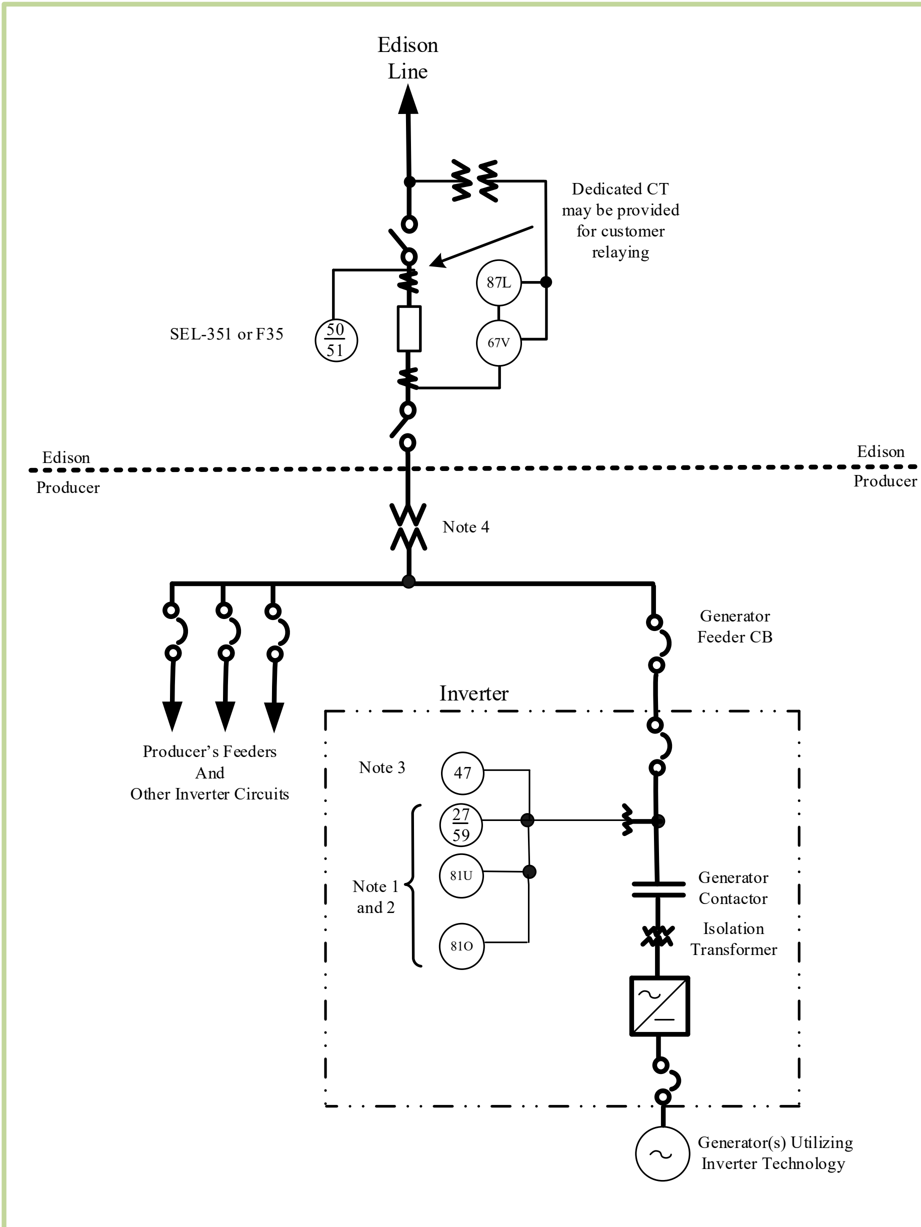


Notes:
1. Producer's main breaker or switch.
2. Transformation, if required, may be by SCE or the Producer.
3. Relay operates on two different phase-to-phase voltages.
4. See Section 5.8.

Not all Producer-side protective relaying is shown.

For induction generation interconnection facilities, the Producer is responsible for installing the appropriate VAR supporting equipment at its facility to maintain unity power factor at the point of interconnection.

Figure 3c: Typical Parallel Generation Utilizing Inverter Technology Assumed SCE Owned Protection (>34.5 kV)



Notes:

1. Producer's main breaker or switch.
2. Transformation, if required, may be by SCE or the Producer.
3. Relay operates on two different phase-to-phase voltages.
   Not all Producer-side protective relaying is shown.
4. Grounding transformer or ground detector (by Edison or the Producer.) Required unless main transformer is wye-grounded-delta
5. Protective and synchronizing relays required if the Producer desires to serve isolated load during Edison outage. If not provided at main circuit breaker, these functions should be provided at generator breaker.

3.1.1 Specific Requirements for Category 1

a) Typically, an SCE-owned and controlled circuit breaker is relied upon -to isolate generation facilities during SCE's electric system disturbances.

b) Producer-owned and controlled circuit breaker(s) or disconnect switch(es)- (as required – refer to Section 5.14 Isolating Equipment Requirements and Switching and Tagging Rules) are required at the main to disconnect for Producer system trouble. If desired, SCE may permit the Producer to trip and/or close the SCE breaker by remote control. If synchronizing is to be done with SCE, SCE will install synchronizing supervision relays and telecommunications as required.

c) Producer to provide synchronizing relays or equipment at the main, generator, and other breakers as appropriate. Either induction starting, automatic synchronizing, or manual synchronizing supervised by a synchronizing relay must be provided by the Producer.

d) Induction starting will be permitted only where the inrush will not exceed SCE prescribed limits. Producer shall never attempt to parallel its system with SCE's electric system when the Producer's synchronizing facilities are malfunctioning or inoperative. Manual synchronizing without a supervising relay is not permitted. Automatic synchronizing may be required for synchronous generators which contribute short circuit current exceeding 5 (%) percent of the pre-existing short circuit current at the point of interconnection with SCE's distribution system.

e) Protection related telecommunications may be required as determined by SCE Protection Engineering.

3.1.2 Protective relays which perform the following functions

a) Short Circuit Protection (Devices 51V or 67V, 51N or 59G)

The designated relays will detect faults on the SCE electric system to which the Producer's generating facility is connected. Generally, the phase relays are voltage restrained overcurrent type or impedance torque controlled overcurrent type. Occasionally, pilot relays or transferred tripping relays may be required. In ground fault protection, a directional overcurrent relay or ground fault voltage detector may be used. A grounding transformer may be required to avoid dangerous overvoltages which could occur during accidental isolation of the line from the main system while the generator is in operation. Adequate grounding can be provided either by the use of a wye-grounded-delta main power transformer or by installing an appropriate grounding transformer. To limit the effects of such grounding on SCE's ground relay sensitivity, SCE may require that the grounding impedance be limited to the highest value suitable for neutral stabilization. Devices 51V or 67V are normally omitted for induction or inverter-based generator installations because of the absence of sustained fault currents from these generators.

b) Islanding Protection (Devices 27/59, 81-O, 81-U)

During the course of fault clearing or due to accident, equipment malfunction, or malicious mischief, it is possible for a SCE circuit/system to become separated from the main system, leaving customers on the circuit supplied from the Producer's generator. To protect customers from abnormal voltage or frequency excursions under these conditions, and to facilitate rapid restoration of normal service, relays for islanding protection are required. Generally, these relays will provide over and under frequency functions and three phase over- and under-voltage functions with instantaneous overvoltage tripping. For generating facilities aggregating 10 MW and greater, SCE may elect to use a voltage phase comparison system (Telesync) for islanding protection while retaining the voltage and frequency relays for backup.

c) Breaker Closing/Reclosing Control (Devices 25, 47/79)
It is important that the closing of the SCE circuit breaker be controlled so that it can only be closed when it is safe to do so. Inadvertent closing of the circuit breaker could result in paralleling out of synchronism or energizing of de-energized facilities, and hazardous conditions could result. The required logic for manual closing of the SCE breaker is:

- The line side of the breaker is energized with proper voltage and phase sequence, the load side of the breaker is de-energized and the Producer's main breaker (or generator breaker) is open, or
- Synchronism check across the breaker is satisfactory which, in most cases, indicates that either the breaker bypass switch is closed or interconnection with the Producer already exists elsewhere.

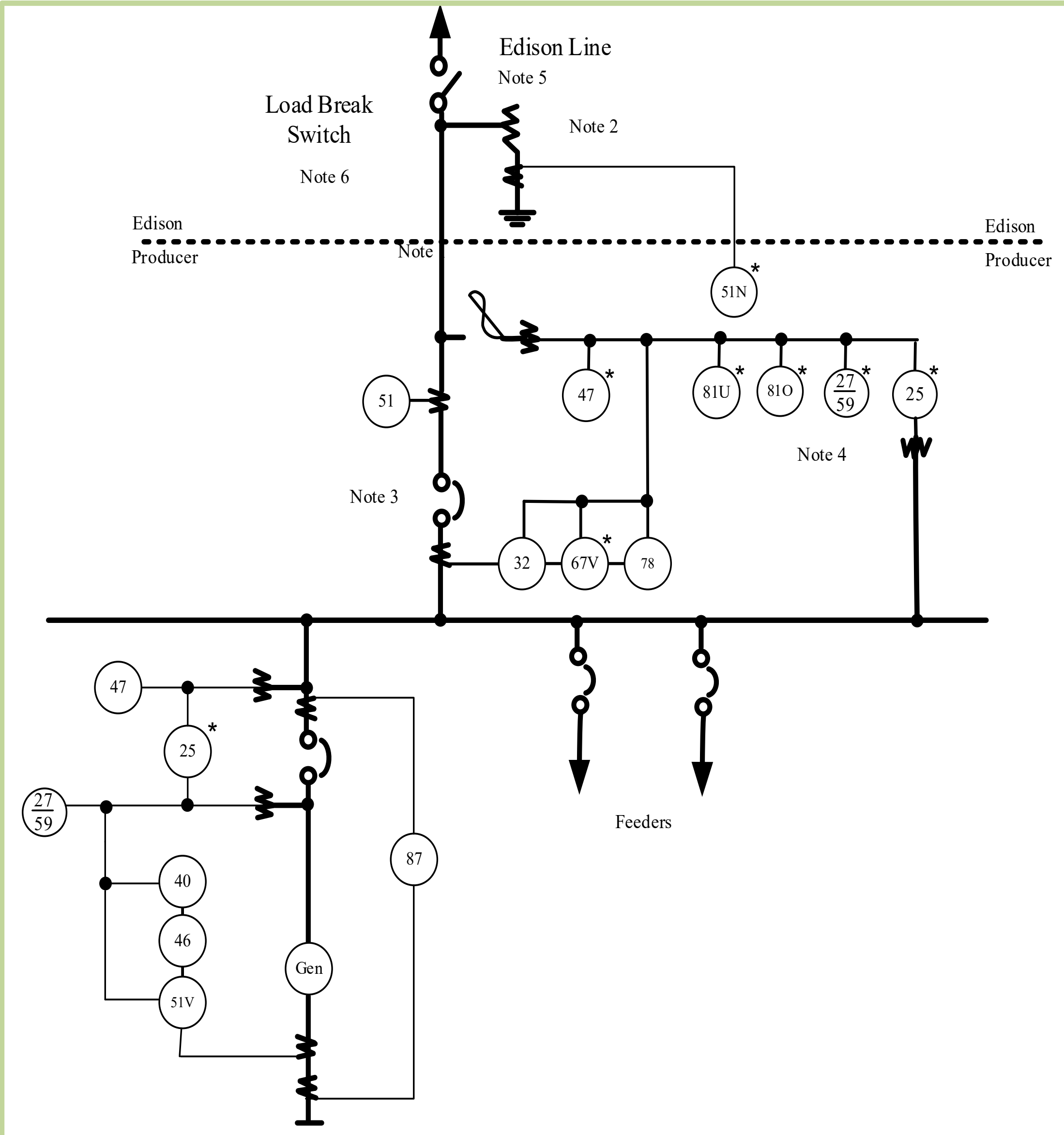
To provide the best continuity of service to the Producer, automatic reclosing of the SCE breaker subsequent to fault clearing is engineered into the control circuitry. If the trouble is permanent, the breaker will trip again and lockout. No further reclosing will take place until the breaker has been reclosed manually. The required conditions for automatic reclosing are the same as for manual closing. Where provision is made for closing of the SCE circuit breaker by the Producer, the required conditions for closing will be the same as for manual closing by SCE. The Producer's closing control will enable SCE's synchronizing relay to close the breaker.

d) Loss of Synchronism (Device 78)
Operation of the Producer's synchronous generator out of synchronism with SCE may cause large voltage fluctuations to SCE's customers and may cause severe damage to the generator. If SCE determines that the relative capacities of its system and of the Producer's generating facility are such that this situation is likely to occur or for those installations which have experienced such voltage fluctuations, specific relays for detection of loss-of-synchronism (out-of-step) will be required.

3.2 Category 2: Total Generation 200 kVA and Above, Voltage at 34.5 kV or Below

All installations in this Category require SCE review of the protective functions to be provided by the Producer. Refer to Figures 3d, 3e, and 3f for typical installations. Producers must ensure their compliance to SCE's Telemetering Requirements as stated in Section 7 of these Requirements.

Figure 3d: Typical Synchronous Parallel Generation with Assumed Producer Owned Protection (> 200 kVA, ≤ 34.5 kV)

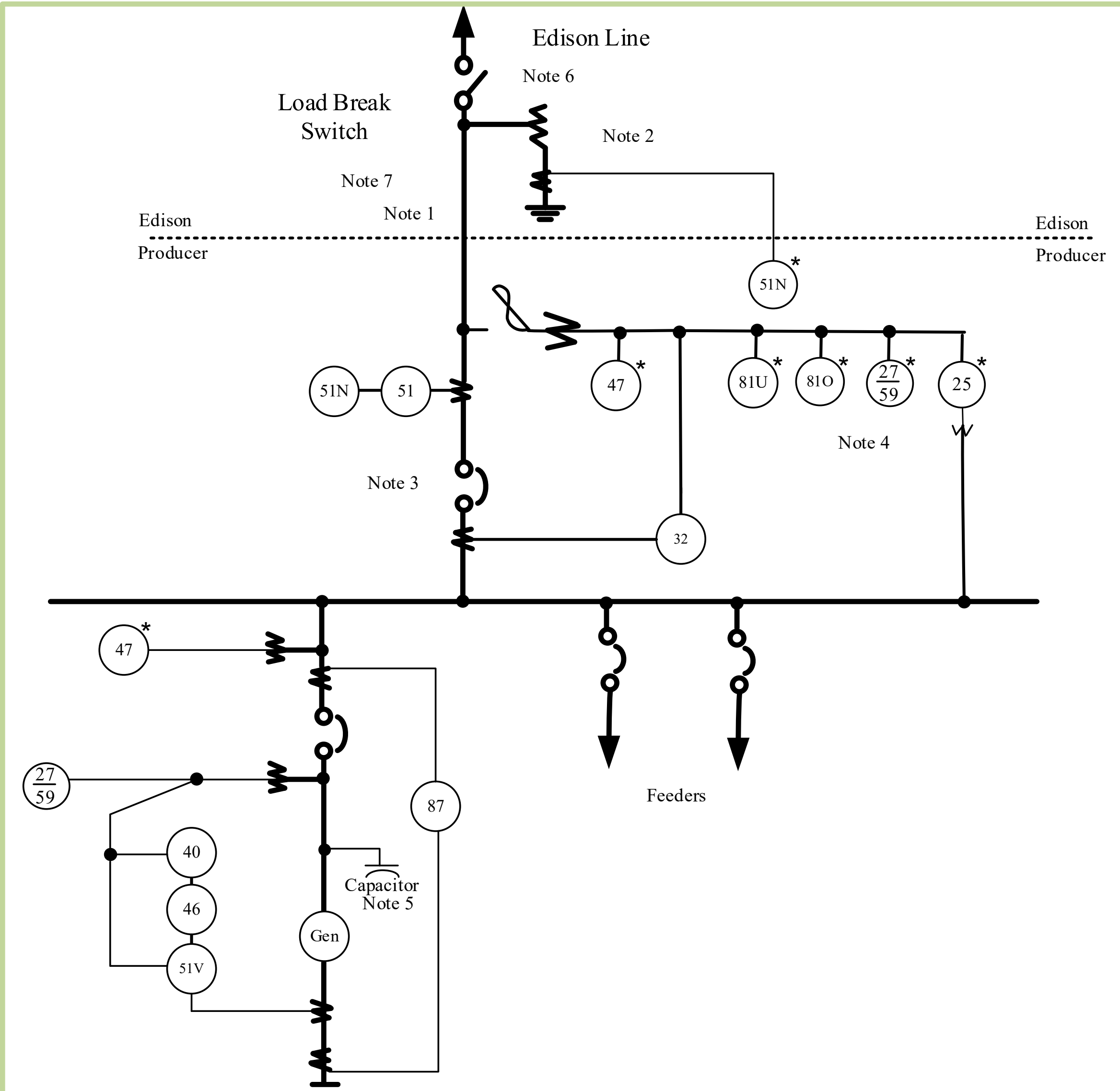


Notes:

1. Transformation (as required) by SCE or the Producer.
2. Grounding transformer or ground detector is required to be supplied by SCE unless the main transformer is wye-grounded-delta. (See 3.2.3.d for requirements)
3. Protective and synchronizing relays required if the Producer desires to serve isolated load during SCE outage. If not provided at main circuit breaker, these functions should be provided at generator breaker.
4. Two phase-to-phase connected or three phase-to-neutral connected relays required.
5. Load break switch to be installed when required by SCE's Distribution Design Standards.
6. Projects exporting 1MW and larger will require an automated device (e.g. Remote Control Switch for Generation – RCS-G) as required by SCE's Distribution Design Standards.

"*" Indicates devices required by SCE. Others are shown as conventional practice.

Figure 3e: Typical Induction Parallel Generation with Assumed Producer Owned Protection (> 200 kVA, ≤ 34.5 kV)



Notes: 1. Transformation (as required) by SCE or the Producer.

2. Grounding transformer or ground detector is required to be supplied by SCE unless the main transformer is wye-grounded-delta. (See 3.2.3.d for requirements)

3. Protective and synchronizing relays required if the Producer desires to serve isolated load during SCE outage. If not provided at main circuit breaker, these functions should be provided at generator breaker.

4. Two phase-to-phase connected or three phase-to-neutral connected relays required.

5. Refer to Section 5.8.

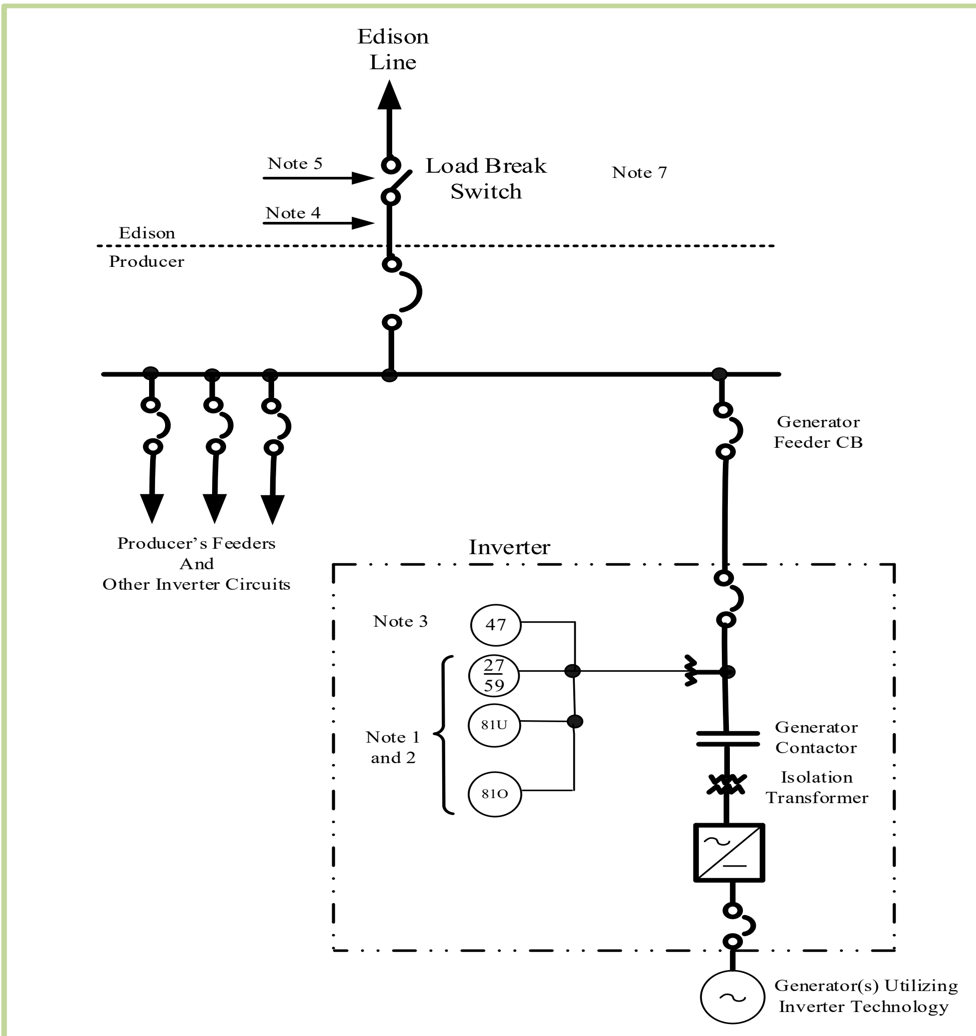
6. Load break switch to be installed when required by SCE's Distribution Design Standards.

7. Projects exporting 1MW and larger will require an automated device (e.g. Remote Control Switch for Generation – RCS-G) as required by SCE's Distribution Design Standards.

"*" Indicates devices required by SCE. Others are shown as conventional practice.

For induction generation interconnection facilities, the Producer is responsible for installing the appropriate VAR supporting equipment at its facility to maintain unity power factor at the point of interconnection.

Figure 3f: Typical Parallel Generation Utilizing Inverter Technology With Assumed Producer Owned Protection (≥ 200 KVA, ≤ 34.5 kV)



Notes:

1. **Protective devices required by SCE for all installations**. $\frac{27}{59}$ shall be a 3Ø unit or two 1Ø units.
2. UL1741 certified inverters meet noted protection requirements without additional relays provided all inverters are UL1741 compliant.
3. Recommended for three phase generators.
4. Transformation as required by SCE or the Producer.
5. Load break switch to be installed when required by SCE's Distribution Design Standards.
6. Drawing does not show metering requirements.
7. Projects exporting 1MW and larger will require an automated device (e.g. Remote Control Switch for Generation – RCS-G) as required by SCE's Distribution Design Standards.
8. Producer is responsible for other protective devices not shown on the diagram because of large variations with type of inverter.

3.2.1 The Producer shall provide adequate protective devices

a) Detect and clear the generator(s) from short circuits or grounds on SCE's electric system serving the Producer.

b) Detect the voltage and frequency changes that can occur if the SCE electric system serving the Producer is disconnected from the main system, and clear the Producer's generating facilities from the islanded system.

c) Prevent reparalleling the Producer's generation, after an incident of trouble, unless the SCE service voltage has been of normal magnitude and frequency continuously for a pre-determined period of time (typically five minutes).

3.2.2 Protection devices which may be required to satisfy the above Requirements

a) Phase over-current trip devices (Device 51, 51V, or 67V)

In most cases these will have to be voltage-restrained or voltage-controlled over-current relays to provide coordination with SCE relays. Devices 51V or 67V are normally omitted for induction or inverter-based generator installations because of the absence of sustained fault currents from these generators.

b) Residual over-current or over-voltage relays to trip for ground faults on the SCE electric system (Devices 51N or 59G)

In ground fault protection, a directional overcurrent relay or ground fault voltage detector may be used. A grounding transformer may be required to avoid dangerous overvoltages which could occur during accidental isolation of the line from the main system while the generator is in operation. Adequate grounding can be provided either by using a wye-grounded-delta main power transformer or installing an appropriate grounding transformer. To limit the effects of such grounding on SCE's ground relay sensitivity, SCE may require that the grounding impedance be limited to the highest value suitable for neutral stabilization. The required type of device (51N or 59G) depends on the characteristic of SCE's interconnecting system. Contact SCE for information for a specific location.

c) Over/under voltage relays (Device 59/27)

Two over/under voltage relays measuring different phase-to-phase voltages or three over/under voltage relays each measuring a phase-to-neutral voltage is required. A single multiphase over/under voltage relay is acceptable if it has separate voltage measurement elements for each phase or phase pair. Under voltage relays should be adjustable from 75-90% of nominal voltage and have time delay to prevent unnecessary tripping on external faults. Over voltage relays should be adjustable from 110-120% of nominal voltage and be instantaneous or a combination of instantaneous and time delayed. Setting changes with temperature variation should not exceed +2 volts over the expected temperature range.

d) Over/under frequency relays (Device 81-O or 81-U)
The over/under-frequency relay should be adjustable per the applicable standards (e.g. CAISO, NERC, and IEEE) requirements and regional requirements (WECC). Setting change with temperature variation over the expected range, or voltage variation over +10%, should not exceed +0.05 Hz.

e) Phase sequence under-voltage relay (Device 47/27)
To permit paralleling only when SCE voltage and phase sequence are normal.

f) Automatic Separation: In some cases, protective devices supplied with the generating equipment will meet some or all of these requirements, provided that it is acceptable to trip the generator whenever the SCE source is lost. If the Producer desires to automatically separate from SCE and commence isolated operation upon loss of the SCE source, additional devices will be necessary to effect the separation.

g) Loss of Synchronism (Device 78)
In specific installations, particularly with large generators (over 10,000 kVA), SCE may require specific additional protection functions such as loss of excitation, loss of synchronism and over-excitation protection, if these conditions would have an impact on SCE's electric system.

h) Potential for exports greater than contractual allowances: Generating Facility whose net MW output is less than the gross nameplate MW value of the generation units(s) may require additional protection facilities for the unlikely event that the facility generates more than the allowable contractual amount.

3.2.3 Other protection devices for Category 2 Generation

a) **Utility Quality Relays:** Depending on the size of the generating facility and the size of the distribution or subtransmission system to which it is connected, SCE may require the Producer to utilize "utility quality" protective relays. Such relays have more stringent tolerances and more widely published characteristics than "industrial quality" relays and have the ability to coordinate protective settings with utility settings. This Requirement will be invoked only if the generating facility is large enough to require close coordination with SCE relays. In general, installations aggregating less than 1,000 kVA will not be subject to this Requirement.

b) **Relay Operation Recorders:** All protective devices supplied to satisfy the requirements in Category 2 generating facilities shall be equipped with operation indicators (targets) or shall be connected to an annunciator or event recorder so that it will be possible to determine, after the fact, which devices caused a particular trip.

c) **Relay Testing:** All protective devices supplied to satisfy the requirements in this Category shall be tested by qualified personnel prior to SCE approving parallel operation, and at intervals at least as frequent as those used by SCE for the relays protecting the line(s) serving the Producer. Special tests may also be requested by SCE to investigate apparent missed operations. Each routine or special test shall include both a calibration check and an actual trip of the circuit breaker from the device being tested. For each test, a report shall be prepared and sent to SCE listing the tests made and the "as found" and "as left" settings/calibration values.

d) **Four-wire Multi-grounded Neutral versus three-wire Distribution Circuits:** In projects where the Producer is served from an SCE four-wire multi-grounded neutral distribution circuit, adequate grounding must be provided to ensure neutral stability during accidental isolation of the line from the main system. This is necessary to avoid dangerous over-voltages on other customers served from phase-to-neutral connected distribution transformers. Adequate grounding can be provided either by the use of a wye-delta main power transformer or by installing an appropriate grounding transformer. To limit the effects of such grounding on SCE's ground relay sensitivity, SCE may require that the grounding impedance be limited to the highest value suitable for neutral stabilization. For three-wire distribution circuits, installation of a ground detector will be required, to provide detection of ground faults in SCE's three-wire distribution circuit. This requirement does not apply to Category 2 inverter-based generation.

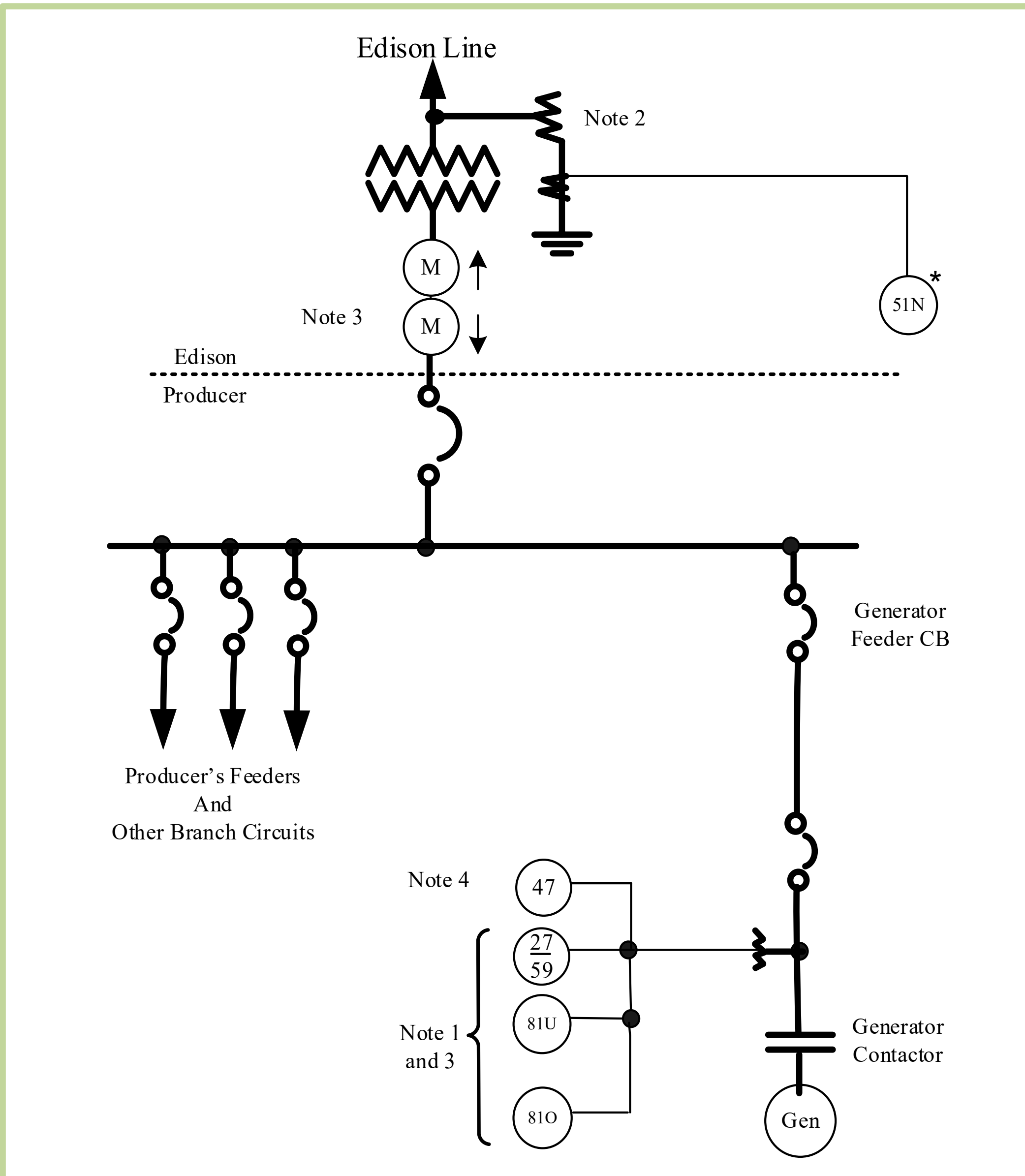
3.2.4 Exemption for Installing Phase Over-Current Protective Devices

Where induction or inverter-based generators are employed rather than synchronous machines, the phase over-current protective devices required by SCE generally will be waived since these generation sources will not deliver sustained over-currents. All other specified protective devices are required.

3.3 Category 3: Total Generation Less Than 200 kVA, in Voltage at 34.5kV & Below

The following requirements for small generating facilities are based on an assumed low density of parallel generation on the serving circuit. Other requirements may be imposed should the density exceed a tolerable limit. Refer to Figure 3g and Figure 3h.

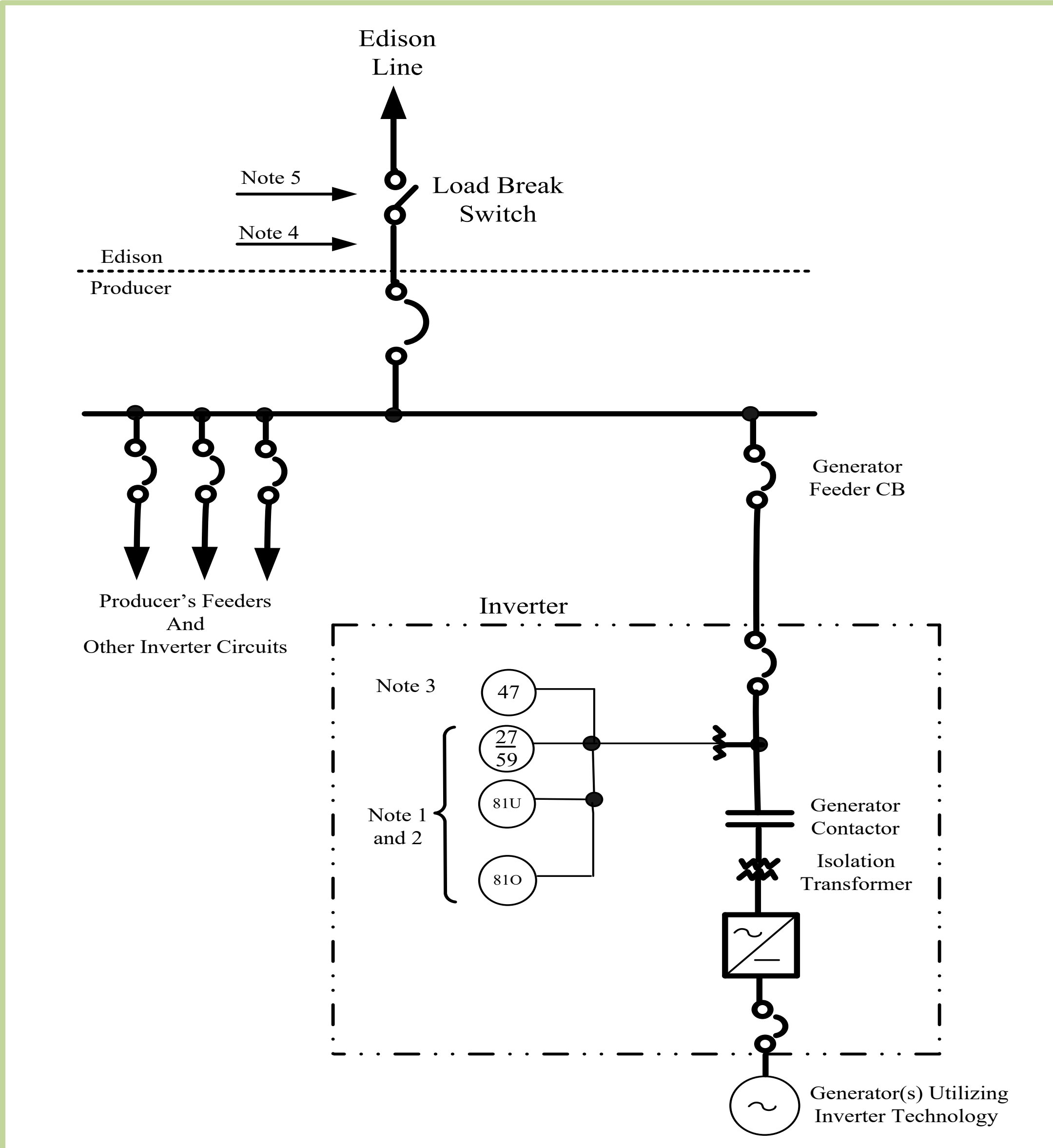
Figure 3g: Typical Parallel Generation Under 200 kVA



Notes:

1. Protective devices required by SCE for all installations. Other protective devices for generator not shown because of large variations with type of generator.
2. Grounding transformer or ground detector is required to be supplied by SCE unless the main transformer is wye-grounded-delta. (See 3.2.3.d for requirements)
3. Self-contained metering is typical.
4. Required for three phase generators.

Figure 3h: Typical Parallel Generation Utilizing Inverter Technology With Assumed Producer Owned Protection (< 200 KVA, ≤ 34.5 kV)



Notes:

1. Protective devices required by SCE for all installations. $\frac{27}{59}$ shall be a 3Ø unit or two 1Ø units.
2. UL1741 certified inverters meet noted protection requirements without additional relays provided all inverters are UL1741 compliant.
3. Recommended for three phase generators.
4. Transformation as required by SCE or the Producer.
5. Load break switch to be installed when required by SCE's Distribution Design Standards.
6. Drawing does not show metering requirements.
7. Producer is responsible for other protective devices not shown on the diagram because of large variations with type of inverter.

a) **Line Voltage Relay or Contactor:** Producer generator controls are to be equipped with a line voltage relay or contactor which will prevent the generator from being connected to a de-energized or single-phased (if normally three-phase) source. This relay is to disconnect the generator from a de-energized utility line and prevent its reconnection until the line has been re-energized by SCE and has maintained nominal voltage and frequency continuously for a pre-determined period of time (typically five minutes).

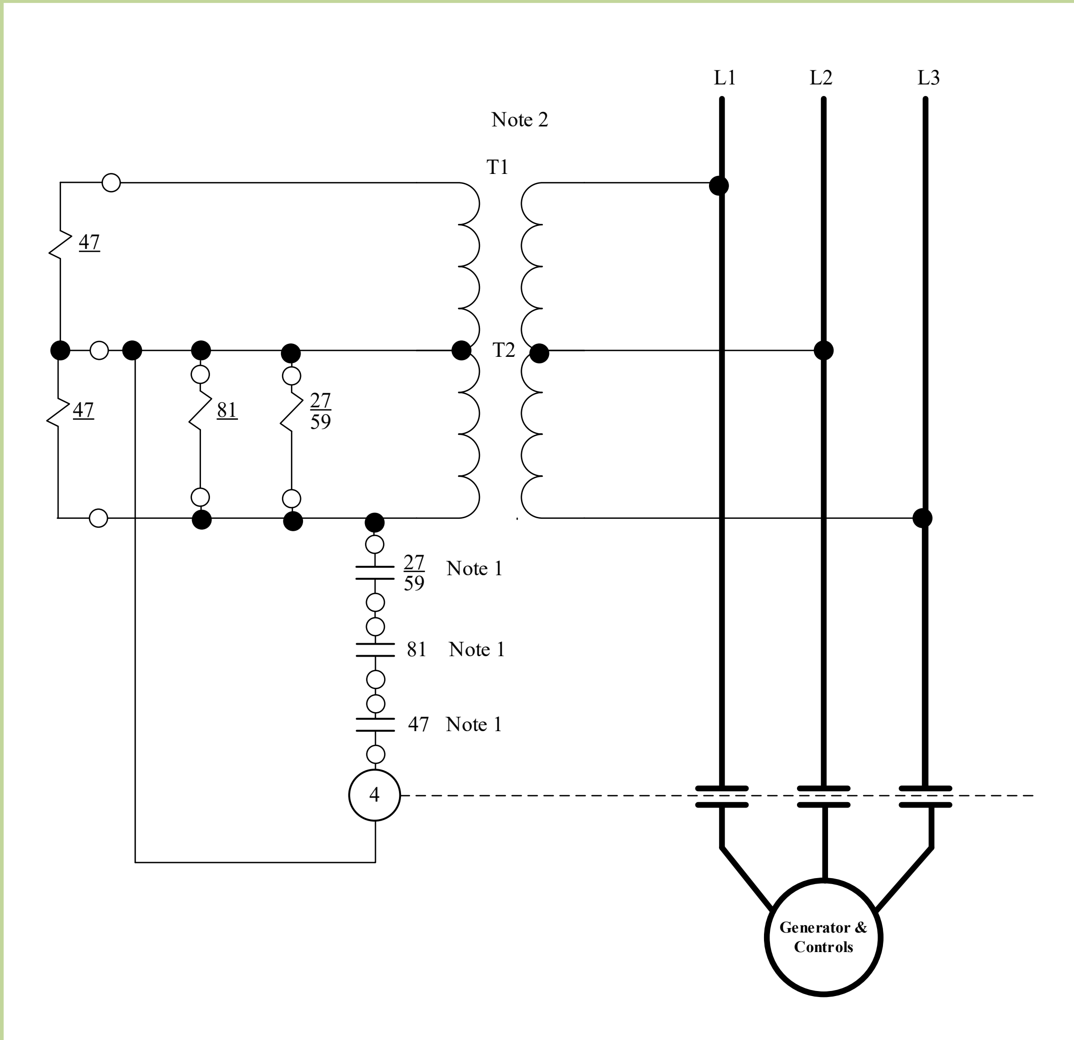
b) **Relays to Detect Islanding:** Producer generators are to be equipped with over/under frequency and over/under voltage relays for islanding detection. These relays must meet the specifications listed in Section 3.2.2, paragraphs (c) and (d). The relays may be arranged to de-energize the contactor as shown in Figure 3f. The Producer generator islanding protection must be able to detect an islanded condition and cease to energize SCE's distribution system within two seconds. Other requirements may be imposed on those installations unable to meet this requirement.

c) **Fault Detection:** The Producer shall provide adequate protective relays to detect and clear the generator(s) from short circuits or grounds on SCE's electric system serving the Producer.

d) **Four-wire Multi-grounded Neutral versus three-wire Distribution Circuits:** In projects where the Producer is served from an SCE four wire multi grounded neutral distribution circuit, adequate grounding must be provided to ensure neutral stability during accidental isolation of the line from the main system. This is necessary to avoid dangerous over-voltages on other customers served from phase to neutral connected distribution transformers. Adequate grounding can be provided either by the use of a wye delta main power transformer or by installing an appropriate grounding transformer. To limit the effects of such grounding on SCE's ground relay sensitivity, SCE may require that the grounding impedance be limited to the highest value suitable for neutral stabilization. For three-wire distribution circuits, installation of a ground detector will be required, to provide detection of ground faults in SCE's three-wire distribution circuit. This requirement does not apply to Category 3 inverter-based generation.

Figure 3i: Typical Relay/Contactor Arrangement Under 200 kVA

This drawing is intended to show the relay/contactor arrangement only. Other over-current or switching devices may be required by local authorities.



Notes: 1. Contacts closed with normal voltage, frequency and phase sequence.

2. Control transformers as required to match relay/contactor voltage to supply voltage. Arrangement shown is for three phase system. For single phase omit L3, T1, Dev. 47.

e) **Dedicated Distribution Transformer:** SCE may require the Producer to be served through a dedicated distribution transformer which serves no other customers. The purpose of the dedicated transformer is to confine any voltage fluctuations or harmonics produced by the generators to the Producer's own system.

f) **Harmonic Requirements for Inverters:** See "Voltage Imbalance and Abnormal Voltage or Current Waveforms" Section 5.10.

g) **SCE Telecommunications:** Typically not required for protective purposes in Category 3 generating facilities except as required to coordinate with SCE's protective relays.

h) **Exception to Protection Devices:** Producers generating facilities may, as an alternative to the requirements specified in this Category 3 generating facility section above, utilize an approved inverter/interface device meeting applicable safety and performance standards established by the National Electrical Code, the Institute of Electrical and Electronics Engineers ("IEEE"), and accredited testing laboratories such as Underwriters Laboratories ("UL"). These requirements include, but are not limited to, the provisions of IEEE Standard 929, IEEE Standard 1547, and UL Standard 1741.

3.4 Breaker Duty and Surge Protection

3.4.1 SCE Duty Analysis

The recognized standard for circuit breakers rated on a symmetrical current basis is IEEE Standard C37.010-1999(R2005), "IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis," and ANSI/IEEE Standard C37.5 for circuit breakers rated on a total current basis. SCE will review breaker duty and surge protection to identify any additions required to maintain an acceptable level of SCE system availability, reliability, equipment insulation margins, and safety. Also, the management of increasing short-circuit duty of the transmission system involves selecting the alternative that provides the best balance between cost and capability. System arrangements must be designed so that the interrupting capability of available equipment is not exceeded.

When studies of planned future system arrangements indicate that the short-circuit duty will reach the capability of existing breakers, consideration should be given to the following factors:

a) Methods of limiting duty to the circuit breaker capability, or less:
   1. De-looping or rearranging transmission lines at substations;
   2. Split bus arrangements.

b) Magnitude of short circuit duty.

c) The effect of future projects on the duty.

d) Increasing the interrupting capability of equipment.

e) The ability of a particular breaker to interrupt short circuits considering applicable operating experience and prior test data.

Please note that SCE performs an annual short circuit duty analysis, which may include reevaluation of the facility breakers.

3.4.2 Customer Owned Duty/Surge Protection Equipment

In compliance with Good Utility Practice and, if applicable, the requirements of SCE's Interconnection Handbook, the Producer shall provide, install, own, and maintain relays, circuit breakers and all other devices necessary to remove any fault contribution of the generation facility to any short circuit occurring on SCE's electric system not otherwise isolated by SCE's equipment, such that the removal of the fault contribution shall be coordinated with the protective requirements of SCE's electric system. Such protective equipment shall include, but not limited to, a disconnecting device and a fault current-interrupting device located between the generation facility and the SCE electric system at a site selected upon mutual agreement (not to be unreasonably withheld, conditioned or delayed) of the Parties. The Producer shall be responsible for protection of the generation facility and other equipment from such conditions as negative sequence currents, over- or under-frequency, sudden load rejection, over- or under-voltage, and generator loss-of-field. The Producer shall be solely responsible to disconnect their facility if conditions on SCE's electric system are impacted by the generation facility.

3.5 Underfrequency Relays

For voltage classes 161 kV and above, it is essential that the underfrequency protection of generating units and any other manual or automatic actions are coordinated with underfrequency load shedding relay settings. For further information, please refer to Section 3.2.2.d.

Since the facilities of SCE's electric system may be vital to the secure operation of the Interconnection, CAISO/SCE shall make every effort to remain connected to the Interconnection. However, if the system or control area determines that it is endangered by remaining interconnected, it may take such action as it deems necessary to protect the system.

Intentional tripping of tie lines due to underfrequency is permitted at the discretion of SCE's electric system, providing that the separation frequency is no higher than 57.9 Hz with a one second time delay. While acknowledging the right to trip tie lines at 57.9 Hz, the preference is that intentional tripping not be implemented.

SECTION 4 MISCELLANEOUS REQUIREMENTS:

4.1 Power System Stabilizers (PSS)

All new Producers' synchronous generators, larger than 30 MVA and interconnecting at a voltage 60 kV or higher are required to install PSS with a suitable excitation system, unless an exemption has been obtained from WECC. Suitable excitation systems are defined in the WECC report; "Criteria to Determine Excitation System Suitability for PSS," dated December 1992.

Unless an exemption has been received from the WECC, all new generators are assumed suitable for PSS, and must abide by the following requirements:

a) The generator excitation system must be equipped with a PSS. The PSS improves stability in the electrical system when system power disturbances occur.
b) The PSS equipment must be approved by SCE prior to installation and operation.
c) The PSS must be calibrated and operated in accordance with WECC standard procedures for calibration, testing, and operation of PSS equipment.
d) Calibration and test reports must be submitted to SCE for review and approval. The generating facility shall not be considered operational until calibration of the PSS has been performed to SCE's satisfaction.
e) The PSS shall be properly maintained and in service when the generator is online for power production.

In addition to the foregoing requirements, Producers must conform to all applicable current or future WECC Criteria. Specific to PSS, these Criteria currently include “WECC Power System Stabilizer Design and Performance Criteria,” approved by the Technical Operations Subcommittee, September 15, 2003.

4.2 Governor “Droop” Shall Be Set At 5%

All new Producers’ generators having suitable systems must comply with the WECC minimum operating reliability criteria for governor droop.

These requirements are necessary to provide an equitable and coordinated system response to load/generation imbalances. Governor droop shall be set at 5%. Governors shall not be operated with excessive dead-bands, and governors shall not be blocked unless required by regulatory mandates.

4.3 Wind Turbine Generating Facilities

4.3.1 Wind Turbine Set-Back Criteria

a) The Producer shall locate its wind-driven generating unit such that it does not encroach onto SCE transmission right of way or edge of any electric operating property.
b) The Producer shall be responsible for performing its appropriate grounding requirements for its wind-driven generating units.

4.3.2 Generator Electric Grid Fault Ride-Through Capability and Power Factor Criteria

SCE currently supports a Low Voltage Ride-Through[1] Criterion that the WECC has adopted to ensure continued reliable service. The Criteria are summarized as follows:

a) Generator is to remain in-service during system faults (three phase faults with normal clearing and single-line-to-ground with delayed clearing) unless clearing the fault effectively disconnects the generator from the system.

b) During the transient period, the generator is required to remain in-service for the low voltage and frequency excursions specified in WECC Disturbance-Performance Table of "Allowable Effects on Other Systems" as applied to load bus constraint. These performance criteria are applied to the generator interconnection point, not the generator terminals.

c) Generators may be tripped after the fault period if this action is intended as part of a Remedial Action Scheme.

d) This Standard will not apply to individual units or to a site where the sum of the installed capabilities of all machines is less than 10MVA, unless it can be proven that reliability concerns exist.

e) The performance criterion of this Standard may be satisfied with performance of the generators or by installing equipment to satisfy the performance criteria.

f) The performance criterion of this Standard applies to any generation independent of the interconnected voltage level.

No exemption from this Standard will be given because of minor impact to the interconnected system. This criterion also applies to existing generators that go through any refurbishments or any replacements.

4.4 Reclosing Circuit Breakers and Hot Line Reclose Blocking

Because most short circuits on overhead lines are of a temporary nature, it is SCE's practice to reclose the circuit breakers on such lines within a few seconds after they have automatically tripped. This practice improves continuity of service to all SCE's customers. The protective relays specified by SCE for parallel generation interfaces are intended to disconnect the generating facilities from faulty or isolated lines before reclosing occurs. Should the Producer desire additional protection against the possibility that reclosing might occur with his generator still connected to the line (a potentially damaging occurrence for synchronous generators), SCE can provide, at the Producer's expense, "Hot Line Reclose Blocking" at the necessary points on its system. Transfer trip protection may be required to facilitate restoration of service to SCE's customers. SCE's preference is to avoid such equipment because of the possible adverse effects on service continuity and the problems of moving or rearranging the equipment to accommodate system changes. Costs for installing, maintaining, and/or rearranging such equipment will be borne by the Producer(s) requesting the equipment.

[1] Ride-through - A generating plant remaining connected and continuing to generate current after a voltage or frequency disturbance.

4.5 Unbalanced Currents

Producers with three-phase generators should be aware that certain conditions in the utility system may cause negative sequence currents to flow in the generator. It is the sole responsibility of the Producer to protect its equipment from excessive negative sequence currents.

4.6 Sub-Synchronous Interaction Evaluations

Generators interconnected within electrical proximity of series capacitor banks on the transmission system or Flexible Current Transmission Systems (FACTS) are susceptible to Subsynchronous Interaction (SSI) conditions which must be evaluated. Sub-Synchronous Interaction evaluations include Subsynchronous Resonance (SSR) and Subsynchronous Torsional Interactions (SSTI) for conventional generation units, and Subsynchronous Control Instability (SSCI) for inverter-based generators using power electronic devices (e.g. Solar PV and Wind Turbines).

A study must be performed to evaluate the SSI between generating facilities and the transmission system for projects interconnecting in close electrical proximity of series capacitor banks on the transmission system or FACTS devices to ensure that the Generator Project does not damage SCE's control systems. The SSI study may require that the INTFAC provide a detailed PSCAD model of its Generating Facility and associated control systems, along with the manufacturer representative's contact information. The study will identify any mitigation(s) that will be required prior to initial synchronization of the Generating Facility. The study and the proposed mitigation(s) shall be at the expense of the INTFAC.

The Interconnection Customer is 100% responsible for the cost associated with SSI studies and mitigations. It is the INTFAC's responsibility to select, purchase, and install turbine/inverter-based generators that are compatible with the series compensation in the area and the FACTS devices.

4.6.1 Sub-Synchronous Resonance Studies

SSR occurs when the network natural frequencies (below fundamental frequencies) coincide with the turbine-generator torsional-mode frequencies causing the turbine-generator to stress that may result in shaft failure. The turbine-generator and the system may interact with SSR into two main ways: Torsional Interaction (TI) and Torque Amplification (TA). To evaluate a potential SSR condition on a new generator installation near series compensated lines or FACTS devices a screening study needs to be conducted to identify any TA or TI impact on the series compensation level or FACTS devices controls. If a case is identified by the initial screening process (Frequency Scanning Study) a more detailed time domain study is required to quantify the potential damage and provide with mitigation measures.

4.6.2 Sub-Synchronous Control Interaction Studies

SSCI risk occurs on zero-crossing reactance when going from negative (capacitive) to positive (inductive) reactance. To evaluate a potential SSCI condition on a new generator installation near series compensated lines or FACTS devices a screening is performed through impedance scans looking out into the system from the inverter-based plant, with the plant disconnected. If a case is identified by the initial screening process, a more detailed study is required to quantify the potential damage and provide with mitigation measures.

4.7 Voltage Control

Generating units 10 MVA and larger shall be equipped with automatic voltage control equipment. All generating units with automatic voltage control equipment shall normally be operated in voltage control mode. These generating units shall not be operated in other control modes (e.g., constant power factor control) unless authorized to do so by the balancing authority. The control mode of generating units shall be accurately represented in operating studies.

All new Producers' synchronous generators, regardless of size and interconnecting at a voltage 55kV or higher, must abide by the following requirements:

a) The synchronous generator shall have an excitation system with a continuously acting Voltage Control equipment.
b) The Voltage Control equipment must be approved by SCE prior to installation and operation.
c) The Voltage Control equipment must be calibrated and operated in accordance with WECC standard procedures for calibration, testing, and operation of Voltage Control equipment.
d) Calibration and test reports must be submitted to SCE for review and approval. The generating facility shall not be considered operational until calibration of the Voltage Control has been performed to SCE's satisfaction.
e) The Voltage Control equipment shall be properly maintained and in service when the generator is online for power production.

Automatic voltage control equipment on generating units, synchronous condensers, and Flexible Alternating Current Transmission System (FACTS) shall be kept in service to the maximum extent possible with outages coordinated to minimize the number out of service at any one time. Such voltage control equipment shall operate at voltages specified by either the

- CAISO for generators directly connected to SCE owned portions of the Bulk Electric System; or
- SCE for generators connected to SCE's Local Distribution System, which are facilities not under CASIO operational control.

4.8 Insulation Coordination

Insulation coordination is the selection of insulation strength and practice of correlating insulation levels of equipment and circuits with the characteristics of surge-protective devices such that the insulation is protected from excessive overvoltages. Insulation coordination must be done properly to ensure electrical system reliability and personnel safety.

The Producer shall be responsible for an insulation coordination study to determine appropriate surge arrester class and rating on the generating facility's equipment. In addition, the Producer is responsible for the proper selection of substation equipment and their arrangements from an insulation coordination standpoint.

Basic Surge Level (BSLs), surge arrester, conductor spacing and gap application, substation and transmission line insulation strength, protection, and shielding shall be documented and submitted for evaluation as part of the interconnection plan.

4.9 Ratings

4.9.1 Facility Ratings

The ratings of facilities are the responsibility of the owner of those facilities. Ratings of facilities must conform to current NERC Reliability Standard governing Facility Ratings.

4.9.2 Ratings Provided by Equipment Manufacturers

Equipment installed on SCE's electric system is rated according to the manufacturer's nameplate or certifications, and ANSI/IEEE standards. The manufacturer's nameplate rating is the normal rating of the equipment. ANSI/IEEE standards may allow for emergency overloads above the normal rating under specified conditions and often according to an engineering calculation. Emergency loading may impact the service life of the equipment. In some cases, the manufacturer has certified equipment for operation at different normal or emergency loads based on site-specific operation conditions. Older technology equipment is rated according to the standards under which it was built unless the manufacturer, ANSI/IEEE standards, or SCE's determination indicates that a reduced rating is prudent or an increase rating is justified.

4.9.3 Rating Practice

The normal and emergency ratings of transmission lines or the transformation facilities shall equal the least rated component in the path of power flow.

4.9.4 Ambient Conditions

Since SCE's territory is in a year-round moderate climate, SCE does not establish equipment ratings based on seasonal temperatures. That is, SCE standard ratings for normal and emergency ratings are the same throughout the year and reflect summer ambient temperatures coincident with ANSI/IEEE standards, i.e., 40°C (104°F). However, in some cases SCE may calculate site-specific ratings that consider the local ambient conditions based on ANSI/IEEE rating methods.

4.9.5 Transmission Lines

The transmission circuit rating is determined according to the least rated component in the path of power flow. This comprises of the transmission line conductor/cable, the series devices in the line, the allowable current that will not cause the conductors to sag below allowable clearance limits, the allowable current that will not cause the cables to operate above the designed temperature limit, and the termination equipment.

4.9.6 Overhead Conductors

The transmission line conductor ratings are calculated in accordance with the latest applicable version of the ANSI/IEEE 738 For Aluminum Conductor Steel Reinforced (ACSR) conductor the normal conductor rating allows a total temperature of 90°C, and the emergency rating allows 135°C. Similarly, for aluminum and copper conductors, SCE permits 85°C and 130°C. For Aluminum Conductor Steel Supported (ACSS), SCE base the normal rating at 120°C, and 200°C for the emergency rating. Higher or lower temperature limits may be permitted as appropriate depending on engineering justification.

4.9.7 Underground Cable

The transmission line cable ratings are calculated in accordance with IEC 60287. For cross-linked polyethylene (XLPE) insulated cable, the normal cable rating allows a total temperature of 90°C and the emergency rating allows 105°C for 4 hours. Higher or lower temperature limits may be permitted as appropriate depending on engineering justification and/or component tested data.

4.9.8 Series and Shunt Compensation Devices

Series capacitor and reactors are only permitted to be loaded to ANSI/IEEE limits or as specified by the manufacturer. VAR compensators shall be rated according to the ANSI/IEEE standards where applicable and according to the manufacturer's limitations. These ratings are reported to CAISO Transmission Register. Shunt capacitors and reactors are not in the path of power flow so they are not directly a "limiting component." However, their reactive power capacity is reported to CAISO Transmission Register.

4.9.9 Terminal Equipment

Terminal equipment comprises: circuit breakers, disconnect switches, jumpers, drops, conductors, buses, and wave-traps, i.e., all equipment in the path of power flow that might limit the capacity of the transmission line or transformer bank to which it is connected. The normal and emergency ampere rating for each termination device is reported to CAISO in its Transmission Register.

4.9.10 Transformer Bays

The rating of a transformer bay is determined by the least rated device in the path of power flow. This comprises ratings of the transformer, the transformer leads, the termination equipment, and reduced parallel capacity where applicable. The transformer rating is compared to the termination equipment ratings and lead conductors to establish the final transformation rating based on the least rated component.

4.9.11 Transformer Normal Ratings

The "normal" rating is the transformer's highest continuous nameplate rating with all of its cooling equipment operating. The only exception is when a special "load capability study" has been performed showing that a specific transformer is capable of higher than nameplate loading and for which the test data or calculations are available.

4.9.12 Transformer Emergency Ratings

A transformer's emergency rating is arrived at by one of two methods. First, if no overload tests are available then a 10% overload is allowed. Second, if a factory heat-run or a load capability study has been performed, the emergency rating may be as high as 20% above normal as revealed by the test. For transformers on the transmission system, (i.e., primary voltage of 500 kV), the short term load limit (STELL) is 1-hour and the allowed duration of the long term emergency load limit (LTELL) is 24-hours. For transformers with a primary voltage of 161 kV to 220 kV, the STELL is 1-hour and the allowed duration of the LTELL is thirty days.

4.9.13 Parallel Operation of Transformers

When two or more transformers are operated in parallel, consideration is given to load split due to their relative impedances such that full parallel capacity is not usually realized. The permissible parallel loading is calculated according to ANSI/IEEE standards.

4.9.14 Relays Protective Devices

In cases where protection systems constitute a loading limit on a facility, this limit is the rating for that facility. These limiting factors are reported to the CAISO Transmission Register and are so noted as to the specific reason, e.g., "limited to 725 A by relay setting."

4.9.15 Path Ratings

As stated in Section 2 of the WECC Procedures for Project Rating Review, new facilities and facility modifications should not adversely impact accepted or existing ratings regardless of whether the facility is being rated. New or modified facilities can include transmission lines, generating plants, substations, series capacitor stations, remedial action schemes or any other facilities affecting the capacity or use of the interconnected electric system.

4.10 Synchronizing of Facilities

Testing and synchronizing of a generation facility may be required depending on SCE's electric system conditions, ownership, or policy, and will be determined based on facility operating parameters. Such procedures should provide for alternative action to be taken if lack of information or loss of communication channels would affect synchronization.

Appropriate operating procedures and equipment designs are needed to guard against out-of-sync closure or uncontrolled energization. (Note: SCE's transmission lines utilize ACB phase rotation, which is different than the national standard phase rotation). The Producer is responsible to know and follow all applicable regulations, industry guidelines, safety requirements, and accepted practice for the design, operation and maintenance of the facility.

Synchronizing locations shall be determined ahead of time; required procedures shall be in place and be coordinated with SCE. SCE and the Producer shall mutually agree and select the initial synchronization date. The initial synchronization date shall mean the date upon which a facility is initially synchronized to the SCE's electric system and upon which trial operation begins.

For additional technical information regarding the synchronizing of generators refer to Section 3 Protection Requirements.

4.11 Maintenance Coordination and Inspection

The security and reliability of the interconnected power system depends upon periodic inspection and adequate maintenance of the generation facility and associated equipment, including but not limited to control equipment, communication equipment, relaying equipment, and other system facilities. Entities and coordinated groups of entities shall follow CAISO procedures and are responsible for disseminating information on scheduled outages and for coordinating scheduled outages of major facilities which affect the security and reliability of the interconnected power system.

4.12 Abnormal Frequency and Voltages

4.12.1 Joint Reliability Procedures

Where specific transmission issues have been identified, those entities affected by and those entities contributing to the problem shall develop joint procedures for maintaining reliability.

4.12.2 Voltage and Reactive Flows

CAISO shall coordinate the control of voltage levels and reactive flows during normal and Emergency Conditions. All operating entities shall assist with the CAISO's coordination efforts.

4.12.3 Transfer Limits Under Outage and Abnormal System Conditions

In addition to establishing total transfer capability limits under normal system conditions, transmission providers and balancing authority shall establish total transfer capability limits for facility outages and any other conditions such as unusual loads and resource patterns or power flows that affect the transfer capability limits.

4.13 Communications and Procedures

4.13.1 Use of Communication System

It is essential to establish and maintain communications with the SCE GCC, the Alternate Grid Control Center (AGCC) or a jurisdictional Switching Center should a temporarily attended station or area of jurisdiction become involved in a case of system trouble. It is equally important that communication services be kept clear of nonessential use during times of system trouble to facilitate system restoration or other emergency operations.

4.13.2 Remedial Action Schemes Communication Equipment Requirements

Generation facilities will require the necessary communication equipment for the implementation of Remedial Action Schemes (RAS). This equipment provides line monitoring and high-speed communications between the Generation Facility breaker and the central control facility, utilizing applicable protocols. RASs may also be applied to generators that may be required to trip to relieve congestion on SCE's electric system. Thus, allowing a RAS to incorporate disconnection into automatic control algorithms under contingency conditions, as needed.

RASs are fully redundant systems. The following paragraph is an excerpt from the WECC Remedial Action Scheme Design Guide that specifies the Philosophy and General Design Criteria for RAS redundancy. *"Redundancy is intended to allow removing one scheme following a failure or for maintenance while keeping full scheme capability in service with a separate scheme. Redundancy requirements cover all aspects of the scheme design including detection, arming, power, supplies, telecommunications facilities and equipment, logic controllers (when applicable), and RAS trip/close circuits."* Excerpt from: WECC Remedial Action Scheme Design Guide (11/28/2006)

4.13.3 Critical System Voltage Operation

Voltage control during abnormal system configurations requires close attention with consideration given to what operations will be necessary following loss of the next component. Voltages approaching 10% above or below the normal value are considered critical with rate of change being of principal importance.

SECTION 5 GENERAL OPERATING REQUIREMENTS:

a) System Operating Bulletins: Generator facilities connecting into SCE's electric system may be subject to operating requirements established by SCE, the CAISO or both. SCE's general operating requirements are discussed in the sections below. SCE may also require additional operating requirements specific to a generator facility. If so, these requirements will be documented in SCE's System Operating Bulletins (SOB), Substation Standard Instructions (SSI), and/or interconnection and power purchase agreements. SCE's SOBs and/or SSIs specific to a generator facility, and any subsequent revisions, will be provided by SCE to the Producer as they are made available.

b) Producer's Responsibility: It is the Producer's responsibility to comply with applicable operating requirements. Operating procedures are subject to change as system conditions and system needs change. Therefore, it is advisable for the Producer to regularly monitor operating procedures that apply to its generating facilities. The CAISO publishes its operating procedures on its internet site, but it is prudent for the Producer to contact the CAISO for specific requirements.

c) Quality of Service: The interconnection of the generator facility's equipment with SCE's electric system shall not cause any reduction in the quality of service being provided to SCE's customers. If complaints result from operation of the generator facility, such equipment shall be disconnected until the problem is resolved.

d) SCE Circuits: Generator facilities are not permitted to energize any de-energized SCE circuit.

e) Operate Prudently: The Producer will be required to operate its facility in accordance with prudent electrical practices.

f) Protection in Service: The generating facility shall be operated with all of required protective apparatus in service whenever the generating facility is connected to, or is operated in parallel with, the SCE electric system. Redundant protective devices may be provided at the Producer's expense if the generator is to be operated in parallel during routine testing of or failure of a protective device. Any deviation for brief periods of emergency may only be by agreement of SCE and is not to be interpreted as permission for subsequent incidents.

g) Added Facilities Documentation: The Producer may not commence parallel operation of generator(s) until final written approval has been given by SCE. As part of the approval process, the Producer shall provide, prior to the commencement of parallel operation, all documents required by SCE to establish the value of any facilities installed by the Producer and deeded to SCE for use as added facilities. SCE reserves the right to inspect the Producer's facility and witness testing of any equipment or devices associated with the interconnection.

5.1 Generating Facility Records and Data

SCE requires generating facility operating records and data from the Producer in order for SCE to plan and reliably operate its electrical system. Some Producers may be subject to similar record and data obligations from the CAISO. If so, the Producer may satisfy many of SCE's operating record and data requirements by giving SCE permission to access the Producer's information held by the CAISO.

Table 5.1 illustrates typical sizes of generating facilities and typical means of communicating generating facility operating records and data to SCE. Typically, medium, and large sized generating facilities are required to install real-time telemetering, but small generating facilities may be excluded from many record and data requirements. Section 7 of this document describes the real-time telemetering[2] hardware requirements. The following two sub-sections describe generating facility operating records and data Producers are required to submit to SCE by real-time telemetering, voice communication or equivalent means.

SCE will require submission of additional records if such records are necessary for SCE to reliably operate and plan its electrical system.

Table 5.1: Typical Communication Requirements Per Generating Facility Size

Aggregate Generation Facility Size	Real Time Telemetering	Voice
Gen. ≥ 1 MW but < 10 MW	*	X
Gen. ≥ 10 MW but < 20 MW	X	X
Gen. ≥ 20 MW	X	X

*Centralized RTU or its equivalent successor

5.2 Operating Records and Data the Producer Must Provide to SCE

a) SCE requires some Producers to maintain operating communications with an SCE designated switching center. These communications provide SCE operating records and data about the Producer's generating facilities for SCE to reliably operate its electric system. Generally, Producers with generating facility capacity of 1 MW or greater will have these requirements, but it may be necessary for SCE to receive generating facility records for smaller generators if needed for reliability. Table 5.2 illustrates typical required generating facility records and data. SCE may require Producers to provide additional records than those shown in Table 5.2.

[2] Generation up to 10 MW may rely on the Public Switched Telephone Network (PSTN) as the primary means of maintaining operating communications. Generation greater than 10 MW should provide an alternate means of communication in addition to the PSTN to insure availability in the event of unplanned outage or emergency.

Table 5.2: Typical Required Generating Facility Records and Data

	Generation Facility Record	Typical Size of Aggregate Generation[3] Facility	Delivery Date or Primary Communication Mode	Delivery Location
1	System Parallel Operation or Separation	> 200 kW	Timely by Voice	Designated SCE Switching Center
2	Scheduled and Unscheduled Outages	> 200 kW	Scheduled Outages Outage Duration Adv. Notice < 1 day 24 Hours 1 day or more 1 Week Major overhaul 6 Months Unscheduled Outages Timely Communication Mode Voice	Designated SCE Switching Center
3	Levels Of Real And Reactive Power	^{3} 1 MW	Real-time Telemetering	SCADA
4	Equipment Clearance	^{3} 10 MW	Timely by Voice	Designated SCE Switching Center
5	Interruption event	> 200 kW	Timely after event by Voice	Designated SCE Switching Center
6	Gen. Circuit Breaker Status	^{3} 10 MW	Real-time Telemetering	SCADA
7	Gen. on/off Status	^{3} 10 MW	Real-time Telemetering	SCADA
8	Generator Terminal Voltage	^{3} 10 MW	Real-time Telemetering	SCADA

b) An interruption event is said to occur on an interconnection circuit when its closed energized circuit breaker has opened or trips and interrupts powerflow to/from SCE facilities. After experiencing an event, the Producer is required to submit the following event information to their Designated Switching Center in order for SCE to assess relay operations and system integrity.

- Date and time of trips by the interconnection circuit breaker
- Generation facility status at time of incident (real & reactive power generation)
- Relay operation indicator (target) operations
- Oscillograph or Sequence of Event recorder records.

[3] Aggregate generation is the total nameplate capacity of generating facilities at the generation site being interconnected or the total generation under one SCE account.

5.3 Operating Data and Records the Producer Must Provide SCE Upon Request

a) The Producer will be required to keep a daily operations log (records) for the generating facility which must include levels of operating voltage, relay operations, information on maintenance outages, maintenance performed, availability, and circuit breaker trip operations requiring a manual reset. Producers with the necessary metering will be required to log fuel consumption, cogeneration fuel efficiency kilowatts, kilovars, and kilowatt-hours generated and settings or adjustments of the generator control equipment and protective devices, and any significant events related to the operation of the generating facility, including but not limited to real and reactive power production; changes in operating status and protective apparatus operations; and any unusual conditions found during inspections. Changes in settings shall also be logged for Producer's generator(s) if it is "block-loaded" to a specific kW capacity.

b) SCE, after giving written notice to the Producer, shall have the right to review and obtain copies of metering records and operations and maintenance logs of the generating facility.

c) If a Producer's generating facility has a Nameplate Rating greater than one (1) megawatt, SCE may require the Producer to report to a designated SCE Switching Center twice a day at agreed upon times for:
   - the current day's operation,
   - the hourly readings in kW of capacity delivered, and
   - the energy in kWh delivered since the last report.

5.4 Calibration of Producer Owned Protective Apparatus

The Producer must test the protective apparatus it owns on a routine basis to provide correct calibration and operation of the devices. Required test intervals of these protective apparatus have been established as shown in Table 5.3.

These test intervals are based on the nominal system voltage at the point of interconnection to SCE. SCE may require the Producer, at the Producer's expense, to demonstrate to SCE's satisfaction the correct calibration and operation of the Producer's protective apparatus at any time SCE reasonably believes that the Producer's protective apparatus may impair the SCE electric system integrity.

Table 5.3: Required Test Intervals for Protective Devices

Interconnection Voltage (Applies For All Voltage Levels)		Test Interval	Delivery Location
1	Microprocessor Protective Relay with Monitoring Microprocessor Protective Relay without monitoring Electromechanical & Solid-State Protective Relays	Every twelve years[1] Every six years[2] Every six years[2]	mail to: Manager, Grid Contracts, P.O. Box 800, 2244 Walnut Grove Avenue, Rosemead, California 91770

1 For Microprocessor relays with self-monitoring (all voltages) if they meet the following:
- Internal self-diagnosis and alarming.
- Voltage and/or current waveform sampling three or more times per power cycle, and conversion of samples to numeric values for measurement calculations by microprocessor electronics.
- Alarming for power supply failure - Alarms are reported within 24 hours of detection to a location where corrective action can be initiated.

2 For any unmonitored protective relay not having all the attributes indicated above, including Sudden Pressure relays.

5.5 Disconnecting Service to a Generation Facility

Applicable agreements and tariffs may state criteria for disconnection of generating facilities which are interconnected to SCE's electric system. In general, generating facilities may be curtailed or disconnected if SCE determines that their operation creates a threat to personnel or the electric system.

5.6 Voltage Variations

a) **Voltage Regulation**: Operation of the Producer's generating facility shall not adversely affect the voltage regulation of that portion of SCE's electric system to which it is connected. Adequate voltage control shall be provided by the Producer to minimize voltage regulation on SCE's electric system caused by changing generator-loading conditions. The step-up transformer ratio must be chosen such that the Producer can meet its voltage regulation obligations over the expected range of SCE system voltages. Step-up transformers must be equipped with no-load taps which provide +5% adjustment of the transformer ratio in 2.5% steps.

b) **Exception**: The tap Requirement will be waived if the Producer submits a study to SCE which demonstrates to SCE's satisfaction that the Producer can meet its voltage regulation obligations over the expected range of system voltages specified by SCE.

Generator voltage schedule and transformer tap settings will be specified by SCE, as necessary, or the CAISO to ensure proper coordination of voltages and regulator action. It is the Producer's responsibility to ensure voltage-VAR schedule compliance. Table 5.4 below identifies whether SCE or the CAISO specifies these schedules.

Table 5.4: Electric System Jurisdiction and Tap-setting Specification

Generating Facility Connected to:	CAISO Controlled Transmission System	SCE Controlled Subtransmission or Distribution
Voltage Schedule	Specified by CAISO	Specified by SCE, as needed
Transformer Tap Settings	Specified by SCE ±5% in 2.5% steps	Specified by SCE ±5% in 2.5% steps

c) **Transmission Voltages**: Expected transmission system operating voltages range from 160 to 164 kV for 161 kV nominal voltage, 220 to 242 kV for 220 kV nominal voltage, and 520 to 540 kV for 500 kV nominal voltage. Voltage regulation at a given location on the transmission system must follow the CAISO and SCE voltage schedules.

d) **Distribution and Subtransmission Voltages**: In order to supply and maintain proper voltages for SCE's customers as required by the CPUC, SCE's primary distribution voltages (2.4 to 34.5 kV) and subtransmission voltages (55 to 115 kV) may fluctuate by as much as +5% from the nominal values (e.g., 12.47 kV +5%; 34.5 kV +5%; etc.). SCE uses various voltage regulation techniques to raise or lower primary distribution and subtransmission voltages to maintain the customer's service voltage at the desired level. Producers interconnected at primary distribution or subtransmission voltage levels must be able to withstand such voltage changes and to respond with proper power factor adjustment not to oppose or interfere with SCE's or the CAISO's voltage regulation processes.

5.7 VAR Correction

VAR correction will normally be planned for light load, heavy load and for system normal and contingency conditions. This is to be accomplished by providing transmission system VAR correction to minimize VAR flow and to maintain proper voltage levels. The planning of transmission system VAR requirements should consider the installation of shunt capacitors, shunt reactors and tertiary shunt reactors, synchronous condensers, FACTS and transformer tap changers. The guidelines for reactive planning are as follows:

5.7.1 Interconnection

SCE shall not be obligated to supply or absorb reactive power for the generator facility when it interferes with operation of SCE's electric system, limits the use of SCE interconnections, or requires the use of generating equipment that would not otherwise be required.

5.7.2 Subtransmission System

VAR correction will normally be planned for connection to 55 kV through 160 kV buses to correct for large customer VAR deficit, subtransmission line VAR deficit, and transformer A-Bank VAR losses, the objective being zero VAR flow at the high side of the A-Banks with VAR flow toward the transmission system on the high side of the A-Banks, if required. Adequate VAR correction shall be provided for maximum coincident customer loads (one-in-five-year heat storm conditions), after adjusting for dependable local generation and loss of the largest local bypass generator.

5.8 Voltage Regulation/Reactive Power Supply Requirements

Operating entities shall ensure that reactive reserves are adequate to maintain minimum acceptable voltage limits under facility outage conditions. Reactive reserves required for acceptable response to contingencies shall be automatically applied when contingencies occur. Operation of static and dynamic reactive devices shall be coordinated such that static devices are switched in or out of service so that the maximum reactive reserves are maintained on generators, synchronous condensers, and other dynamic reactive devices.

To ensure secure and reliable operation of the interconnected power system, reactive supply and reactive generation shall be properly controlled and adequate reactive reserves shall be provided. If power factor correction equipment is necessary, it may be installed by the Producer at the facility, or by SCE at SCE's facilities at the Producer's expense.

Generator VAR schedules, as needed, will be specified by SCE or the CAISO to ensure proper coordination of voltages. It is the Producer's responsibility to ensure voltage-VAR schedule compliance. If power factor correction equipment is necessary, it must be installed by the Producer at its facility at the Producer's expense to ensure the power factor at the point of interconnection meets the criteria in Table 5.5.

Note that the generator power factor capability for Wholesale Distribution Access Tariff (WDAT) service is likely to require equipment capable of operating over the range of 0.9 lag to 0.95 lead to meet the Tariff Point of Delivery requirements.

Table 5.5: Power Factor Criteria

Generating Facility Connected to:	CAISO Controlled Transmission System	SCE Controlled Distribution System*
Power Factor	Synchronous: Generator has the capability of 0.90 lagging to 0.95 leading	Synchronous: Generator has the capability of 0.90 lagging to 0.95 leading at POI
	Asynchronous (FERC Order 827): 0.95 lagging to 0.95 leading at high side of generating station	Asynchronous (FERC Order 827): 0.95 lagging to 0.95 leading at high side of generating station

* For Rule 21 projects, reference the Rule 21 tariff for power factor requirements.

5.8.1 Reactive Power Equipment – Induction Generators (in aggregate)

5.8.1.1 Facility Reactive Power Equipment Design

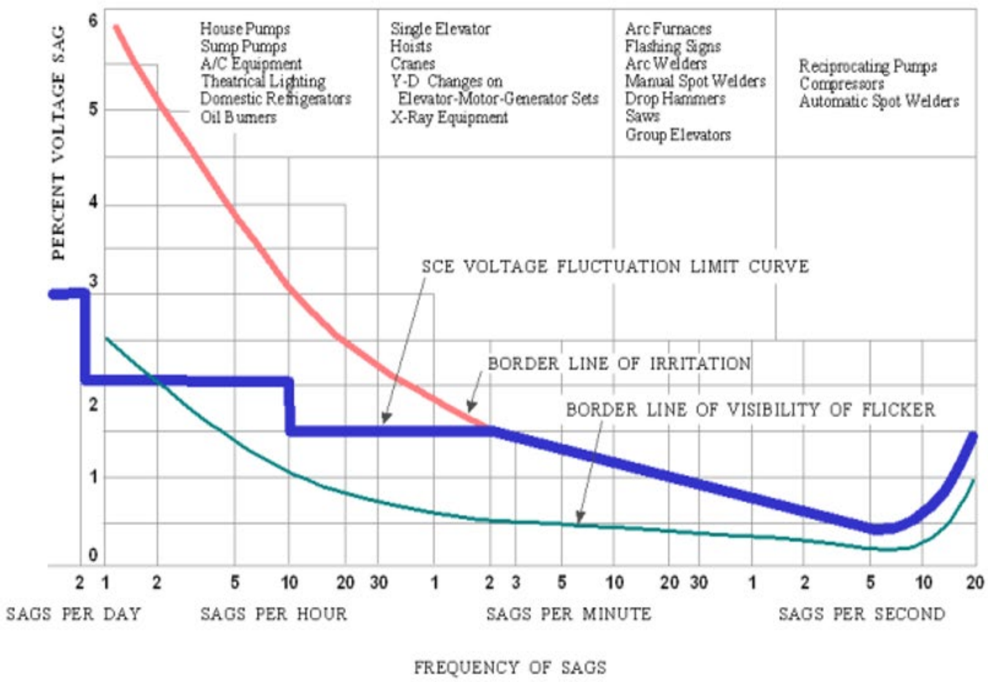
Producers shall provide for the supply of its reactive requirements, including appropriate reactive reserves, and its share of the reactive requirements to support power transfers on interconnecting transmission circuits as they relate to their generator facilities.

Reactive power equipment utilized at a generator facility to meet SCE's requirements must be designed to minimize the exposure of SCE's customers, SCE's electric system, and the electric facilities of others (i.e., other facilities and utilities in the vicinity) to:

a) severe overvoltages that could result from self-excitation of induction generators,
b) transients that result from switching of shunt capacitors,
c) voltage regulation problems associated with switching of inductive and capacitive devices.
d) unacceptable harmonics or voltage waveforms, which may include the effect of power electronic switching, and
e) Voltage flicker exceeding SCE Voltage Flicker limits (See Figure 5.8).

FIGURE 5.8

VOLTAGE FLUCTUATION DESIGN LIMITS



5.8.1.2 Facility Reactive Power Equipment Design - provide variable source

The reactive power equipment utilized at a generator facility to meet SCE's requirements must be designed to provide a variable source of reactive power (either continuously variable or switched in discrete steps). For discrete step changes, the size of any discrete step change in reactive output shall be limited by the following criteria:

a) the maximum allowable voltage rise or drop (measured at the point of interconnection with SCE's electric system) associated with a step change in the output of a generator facility's reactive power equipment must be less than or equal to 1%; and
b) the maximum allowable deviation from a generator facility's reactive power schedule (measured at the point of interconnection with the SCE system) must be less than or equal to 10% of the generator facility's maximum (boost) reactive capability.

5.8.2 Reactive Power Supply Requirements - Synchronous Generators

Producers connected to SCE's electric system and utilizing synchronous generators are required to generate or supply reactive power so that the generating facility does not impose any additional reactive power demand upon SCE other than the demand of loads within the facility. The Producer will not be permitted to deliver excess reactive power to SCE under normal operating conditions unless otherwise agreed to by SCE. Under emergency operating conditions, the Producer is permitted to deliver excess reactive power to SCE to ensure voltage schedule compliance.

Producers connected to the subtransmission system or bulk power system (above 34.5 kV) must have the voltage regulation equipment and generator reactive power capability to maintain a voltage schedule or reactive power schedule prescribed by SCE or, if applicable, the CAISO. Generators must be capable of operation over the power factor ranges designated in Table 5.5.

5.8.3 Reactive Power Supply Requirements - Inverter Systems

Forced-commutated inverters must meet SCE's reactive power supply requirements of synchronous generators in 5.8.2. Line commutated inverters must be corrected to satisfy SCE's reactive power supply requirements of induction generators in 5.8.1.

Inverters must also meet SCE's harmonic load limits based on the latest IEEE Standard 519. For further information on the assessment and mitigation of harmonics due to inverters, refer to "SCE Subtransmission Planning Criteria and Guidelines, Appendix C, HARMONIC LOAD LIMITS, APPLICATION OF IEEE STANDARD 519-1992 TO SUBTRANSMISSION PLANNING".

5.8.3.1 IEEE and UL Standards for Inverter Systems 200 kVA or Less

Inverter systems which conform to the recommended practices in IEEE Standard 929-19 and which have been tested and approved for conformance to UL Subject 1741, are considered to have met all SCE's reactive power supply requirements.

5.8.4 Voltage and Reactive Control

5.8.4.1 Coordination

Operating entities shall coordinate the use of voltage control equipment to maintain transmission voltages and reactive flows at optimum levels for system stability within the operating range of electrical equipment. Operating strategies for distribution capacitors and other reactive control equipment shall be coordinated with transmission system requirements.

5.8.4.2 Transmission Lines

Not Applicable to Generation.

5.8.4.3 Switchable Devices

Not Applicable to Generation.

5.9 Ride Through Requirements

The CAISO is responsible for frequency control and therefore SCE can assume no responsibility for damage that occurs due to off nominal frequency operation. It is possible that the electrical network including SCE's electric system may operate outside of the limits stated above. It is the responsibility of all Producers connected to SCE's electric system to install equipment to protect against damage to Producer owned equipment from off-nominal frequency operation.

Generators that are required to use under-frequency detection for islanding must coordinate frequency threshold settings to ensure conformance with SCE's abnormal frequency operation plan.
SCE's requirements identify three different categories for Producer generating facilities connecting to the SCE electric system each with distinctive protection requirements. These categories are:

5.10 Off Nominal Frequency and Voltage Ride Through

- Category 1: Voltage class 34.5 kV and below
- Category 2: All BES voltage classes
- Category 3: class every other generator not covered by IEEE 1547 or PRC-024-2

5.11 Off Nominal Frequency

5.11.1 Category 1

Producer's generating facilities connecting at 34.5 kV and below are required to comply with IEEE 1547 and/or Rule 21 frequency ride through requirements as applicable.

5.11.2 Category 2

Producer's generating facilities interconnecting to SCE's Bulk Electric System shall set off nominal Frequency Protective Relay settings to meet the NERC Reliability Standard PRC-024-2.

5.11.3 Category 3

Producer's generating facilities that protect for off-nominal frequency operation shall set off nominal Frequency Protective Relay settings to meet at a minimum the time frames in Table 5.6.

Table 5.6: Off Nominal Frequency Limits

Under Frequency Limit	Over Frequency Limit	Minimum Time
> 59.4 Hz	< 60.6 Hz	continuous operating range
≤ 59.4 Hz	≥ 60.6 Hz	3 minutes
≤ 58.4 Hz	≥ 61.6 Hz	30 seconds
≤ 57.8 Hz	N/A	7.5 seconds
≤ 57.3 Hz	N/A	45 cycles
≤ 57.0 Hz	≥ 61.7 Hz	may trip instantaneously if required to protect equipment from damage

Frequency relay settings must not allow less stringent operation of the generating facility than specified in the shown in Table 5.6, unless agreed to in writing by SCE and coordinated with SCE's abnormal frequency operation plan.

5.12 Voltage Ride-Through

5.12.1 Category 1

Producer's generating facilities connecting at 34.5 kV and below are required to comply with IEEE 1547 and/or Rule 21 voltage ride through requirements as applicable.

5.12.2 Category 2

Producer's generating facilities interconnecting to SCE's Bulk Electric System shall set voltage Protective Relay settings to meet the NERC Reliability Standard PRC-024-2.

5.12.3 Category 3

Producer's generating facilities shall set voltage Protective Relay settings to meet at a minimum the time frames in Table 5.7.

Table 5.7: Generator Frequency and Voltage Protective Relay Settings

Low Voltage	High Voltage	Time
≥ .90 (pu)	< 1.10 (pu)	continuous operating range
< .90 (pu)	≥ 1.10 (pu)	3 seconds/1 second
< .75 (pu)	≥ 1.15 (pu)	2 seconds/.5 seconds
< .65 (pu)	≥ 1.175 (pu)	.3 seconds/.2 seconds
< .45 (pu)	N/A	.15 seconds
N/A	≥ 1.20 (pu)	may trip instantaneously if required to protect equipment from damage

5.12.4 Inverter-Based Category 2 and 3

Category 2 and 3 Producers with inverter-based generating facilities interconnecting to SCE's Bulk Electric System shall inject current during a fault if the POI voltage is within NERC Reliability Standard PRC-024-2 bounds, momentarily cease injection only when transient voltages exceed internal component tolerances outside of the NERC IRPTF guideline range and duration, and lastly exhibit the following post-disturbance behavior:

- No intentional delay between active power recovery once voltage recovers within normal IRPTF voltage thresholds
- Recover active power to pre-contingency amount to 100% within 5 seconds excluding any tripped inverters
- Do not allow power plant controller to interfere with post-disturbance recovery requirements or AGC instructions from CAISO

The interconnection study may dictate deviations from this default performance requirement as long as it does not conflict with NERC Reliability Standards or California ISO Planning Standards.

5.13 Voltage Imbalance and Abnormal Voltage or Current Waveforms (harmonics)

Power quality problems are caused when voltage imbalances and harmonic currents result in abnormal voltage and/or current waveforms. Generally, if a generator facility's output degrades power quality to SCE's facilities, other generator or customer facilities, SCE may require the installation of equipment to eliminate the power quality problem.

5.13.1 Voltage Imbalance

The unbalanced voltage level (magnitude and phase), due to a generator facility to be connected at the transmission or subtransmission system level, may not exceed 1% at the Point of Common

Connection[4] (PCC), under steady state system conditions. Under certain conditions (contingency conditions), SCE may allow higher levels of voltage imbalance if justified after a study conducted by SCE. In any event, the unbalanced voltage level created by a generator facility shall not exceed 1.5%.

It is the responsibility of Producers, with a generator facility connected to SCE's electric system to install adequate mitigation devices to protect their own equipment from damage that maybe caused by voltage imbalance condition.

5.13.2 Harmonics

Generator facilities are required to limit harmonic voltage and current distortion produced by static power converters or similar equipment in accordance with good engineering practice used at their facility to comply with the limits set by the current IEEE Standards.

5.13.3 Disconnection

SCE may disconnect any generator facility until the requirements within this section of the Interconnection Handbook are met.

5.13.4 Photovoltaic Inverter Systems

Photovoltaic inverter systems which conform to the recommended practices in IEEE Standard 929-2000 and which have been tested and approved for conformance to UL Subject 1741 are considered to have met SCE's requirements for voltage imbalance and abnormal waveforms.

5.14 Isolating Equipment Requirements and Switching & Tagging Rules

5.14.1 Applicable to Generation Facilities connecting to voltages > 34.5KV

An isolating device must be installed, and specific inter-company rules must be in place to ensure the safety of SCE personnel. The isolating device isolates the Generation Facility from the SCE Electric System and prevents inadvertent energization of the generation tie-line while personnel are performing maintenance and/or repair work on the Interconnection Facilities.

5.14.1.1 Manual Disconnects

The isolating disconnect shall be placed in the LINE disconnect position on the high side of the Producer's generation tie-line. A separate GROUND disconnect shall also be incorporated and placed in the line position on the high side of the Producer's generation tie-line.

For 220 kV and below, the disconnects must be 3-phase, gang-operated disconnects with a common operating handle. For 500 kV, each phase must be equipped with a disconnect having its own operating handle.

[4] The PCC will generally be at the location of the revenue meter or the point of ownership change in the electrical system between SCE and the Producer. For customers served by dedicated facilities, the location of the PCC will be determined by mutual agreement between the Producer and SCE.

The operating handle of the LINE disconnect/disconnects must include a provision for locking the disconnect control handle/handles in the open positions. The operating handle of the GROUND disconnect/disconnects must include a provision for locking the disconnect control handle/handles in the closed positions.

For manual LINE disconnects, the device must:

1. Provide unrestricted, 24-hour access to SCE personnel.
2. Allow visible[5] verification that separation has been accomplished.
3. Be capable of being locked in the open position.
4. Be clearly labeled with permanent signage.

5.14.1.2 Switching and Tagging Rules

SCE and Producer shall provide the other Party a copy of its switching and tagging rules that are applicable to the other Party's activities. In accordance with SCE's switching and tagging rules, the Producer shall allow SCE to place its locks on the Producer's Interconnection Facilities, as may be required (specifically disconnect switches and/or circuit breakers on the Producer's terminus of the generation tie-line). The locking feature of disconnects may be utilized by either party when inter-company clearances are issued on the generation tie-line.

5.14.2 Applicable to Generation Facilities connecting to voltages ≤ 34.5KV

The producer shall furnish and install a ganged, manually-operated isolating device near the Point Of Change of Ownership (POCO) (when SCE and applicant electrical systems connect also referred to as the Point of Common Coupling (PCC)) to isolate the Generating Facility from SCE's Electric System. See Figure 5a.

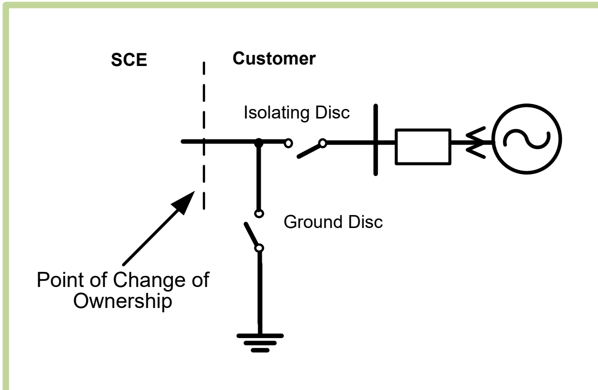
The device must:

1. Allow visible[6] verification that separation has been accomplished.
2. Include marking or signage that clearly indicates open and closed positions.
3. Be capable of being reached quickly and conveniently 24 hours a day by SCE personnel.
4. Be capable of being locked in the open position.
5. Be clearly labeled with permanent signage.

[5] Visible means a visible break when the disconnect is in the open position. Here, visible verification should allow for visual inspection of the device. Typically, this switch should not be enclosed inside of a building or structure.

[6] Visible means a visible break; when the disconnect is in the open position, there is a visible separation between the contacts, and the separation may be observed without disassembling the device. Typically, this switch contains visible blades inside an enclosure.

Figure 5a: Typical Isolating Disconnect Device Configuration



5.15 Grounding Circuits and Substations

The Producers shall follow practices outlined in IEEE 80 "IEEE Guide for Safety in AC Substation Grounding." Substation grounding is necessary to protect personnel and property against dangerous voltage potentials and currents during both normal and abnormal conditions of operation. Also, it provides a path to ground for the discharge of lightning strikes, a path to ground for the neutral currents of grounded neutral circuits and apparatus, the facilities for relaying to clear ground faults, the stability of circuit potentials with respect to ground and a means of discharging current-carrying equipment to be handled by personnel.

Reason for Substation Grounding

Substation grounding practices are outlined in IEEE 80 "IEEE Guide for Safety in AC Substation Grounding."

According to IEEE 80 – 2013 a safe ground grid design has the following two objectives:

- "To provide means to carry electric currents into the earth under normal and fault conditions without exceeding any operating and equipment limits or adversely affecting continuity of service."
- "To reduce the risk of a person in the vicinity of grounded facilities being exposed to the danger of critical electric shock."

"People often assumed that any grounded object can be safely touched. A low substation ground resistance is not, in itself, a guarantee of safety. There is no simple relation between the resistance of the ground system as a whole and the maximum shock current to which a person might be exposed. Therefore, a substation of relatively low ground resistance may be dangerous, while another substation with very high resistance may be safe or can be made safe with careful design." (IEEE 80 – 2013)

Each substation ground grid is a unique design. The conditions at the site: soil type, soil resistivity, fault current, clearing time, size of the substation, and other grounds all factor into the design.

5.15.1 Nominal Voltage and Grounding

SCE's most common primary distribution voltages are 4, 12.47 and 16 kV depending on the geographic area. Other voltages are also used in specific areas. Common subtransmission voltages are nominally 66 kV to 115 kV. Common transmission system voltages are nominally 161 kV, 220 kV, and 500 kV. The majority of the 4, 12.47, and 16 kV circuits are effectively grounded, but some are operated with high impedance or resonant grounding. A substantial number of the effectively grounded circuits are used for four-wire distribution (phase to neutral connected loads). The system grounding may change over time, such as when high impedance grounding is replaced with solid grounding to accommodate four-wire load or solid grounding is replaced with resonant grounding to reduce wildfire risk. SCE will provide the Producer necessary information on the specific circuit serving their generator facility for proper grounding.

5.15.2 Grounding Grid Studies shall be conducted in the following situations:

Grounding calculations will be required for each new substation, and at existing substations, when the ground grid is altered or when major additions are made at a substation. A review of existing substation ground grids will be conducted by Engineering in the following situations, especially if triggered by interconnection requests – these shall be considered in queue order:

- Short Circuit Duty Changes
  1. Circuit breaker replacement for short-circuit duty reasons if a grounding study has not been performed in the last eight years
  2. Addition of transmission or subtransmission line to a substation
  3. System changes causing a substantial change in the substation phase-to-ground short-circuit duty
  4. Addition or replacement of a transformer at a substation. other than a like for like replacement. The replacement of a transformer bank with the same base MVA is considered a like for like replacement. Replacement transformer banks with a lower base MVA than existing will not require a grounding study.
     a. Like for like transformer replacements require a review of the ground grid if a grounding study has not been performed in the last eight years.
  5. Addition of new generation causing a substantial change in the substation phase-to-ground short-circuit duty
- System Protection Changes
  1. Changes in system protection that significantly increases the clearing time for ground faults.
- Grounding Source Changes
  1. Grounding of ungrounded or impedance grounded winding of a transformer
  2. Addition or major change of ground source at a substation
- Substation Changes

1. Alterations to substation fences including additions, movement, and attachments to other fences. The removal of vegetation that blocks access to a substation fence is considered a fence alteration.
2. Alterations to substation ground grids that change their size or increase the effective substation ground grid impedance.
3. Sale or lease of substation property for other uses.

- A grounding review should be conducted any time a grounding problem is reasonably suspected.

5.15.3 Ground Mats

If the generator facility and SCE substation ground mats are tied together, all cables may be landed without any protection. However, if the generator facility and SCE substation ground mats are not tied together, all cables shall have protection at both ends. The design of cable protection, if any, on circuits used for protective relaying purposes shall be such that the operation of the protective relaying is not hampered when the cable protection operates or fails.

All generator facility ground mats shall be designed in accordance with good engineering practice and judgment. Presently the recognized standard for grounding is IEEE 80 "IEEE Guide For Safety in AC Substation Grounding." All ground mat designs should meet or exceed the requirements listed in this standard. If local governmental requirements are more stringent, building codes for example, they shall prevail. All Producers shall perform appropriate tests, including soil resistivity tests, to demonstrate that their ground grid design meets the standard for their generator facilities interconnected to SCE's electric system. Mats shall be tested at regular intervals to ensure their effectiveness.

Grounding studies shall be performed with industry-recognized software. This study will determine the maximum safe fault current for the ground grid design. It is suggested that the grid be designed for the maximum fault currents expected over the life of the facility.

If for any reason the worst-case fault current exceeds the design maximum fault current value due to changes in the Producer's facility or changes on the SCE system, the Producer shall conduct new grounding studies. Any changes required to meet safety limits and protect equipment shall be borne by the Producer.

The Producer is responsible to ensure that the Ground Potential Rise (GPR) of the generator facility's or interconnected mat does not negatively affect nearby structures or buildings. The cost of mitigation for GPR and other grounding problems shall be borne by the Producer. Generator facility and SCE ground grids are typically tied together when they are in close proximity to each other. If it is elected to install separate ground grids for SCE and the generation facility, the Producer shall be responsible to mitigate any transfer voltages and GPR that occur to SCE's grid due to faults on the generation facility.

Any ground grid design, which results in a GPR that exceeds 3,000 volts RMS for the worst-case fault or has a calculated or measured ground grid resistance in excess of 3 ohm, will require special approval by SCE.

5.15.4 Substation Grounding

The Producer shall follow practices outlined in IEEE 80 “IEEE Guide for Safety in AC Substation Grounding.” Substation grounding is necessary to protect personnel and property against dangerous potentials and currents during both normal and abnormal conditions of operation. Also, it provides a path to ground for the discharge of lightning strikes, a path to ground for the neutral currents of grounded neutral circuits and apparatus, the facilities for relaying to clear ground faults, the stability of circuit potentials with respect to ground and a means of discharging current-carrying parts to be handled by personnel.

5.16 Non-SCE Pole Grounding

The Producer shall follow SCE Construction, Operation, and Maintenance requirements. The last Producer -owned structure before the point of interconnection which connects the Producer's generation facility to SCE's electric system shall be designed and constructed to meet SCE grounding requirements.

Generation facilities that will require SCE's crews to climb in order to construct, operate, or maintain SCE facilities shall be built to meet SCE all standards and specifications. Constructing to SCE specifications will ensure that SCE crews can perform work in accordance with internal safety practices identified within SCE's Accident Prevention Manual. This manual stipulates the proper training and equipment to safely climb and work. Examples of safety related requirements that:

- Climbing Steps
- Belt-Off Locations
- Grounding Locations
- Required PPE
- Jumper Cable Ownership

Grounding bolts and bases are the same as step bolts and bases. If SCE personnel will be or could be performing work on a non-SCE owned pole connecting a generator facility directly to SCE's electric system a dead-end structure adhering to SCE's Construction, Operation, and Maintenance standards, is required on that line in close proximity to the generation facility.

Please note that these requirements are for poles only. Non-steel or ungrounded poles will have; project-specific grounding requirements as determined by SCE.

SECTION 6 REVENUE METERING REQUIREMENTS

6.1 General Information

Revenue metering is required to measure the energy, charging capacity, and charging demand consumed, delivered, or stored for later redelivery by a customer. While functionally similar, there are varying metering requirements for customers depending on the nature and purpose of their proposed generating facility along with varying rules established by the authorities having jurisdiction over both SCE and the customer. Metering requirements for customers taking service under a FERC tariff and retail service under CPUC regulations are set forth in Sections 6.2 and 6.3.

In general, all CAISO revenue metering and associated equipment used to measure load shall be provided, owned, and maintained at the Producer's expense.

6.2 Retail Service

The retail metering requirements for retail service will be owned, operated, and maintained by SCE under SCE's Electrical Service Requirements (ESR) and in accordance with SCE approved tariffs.

6.3 SCE Metering Requirements for customers taking interconnection and distribution service, as applicable, specially under a Federal Energy Regulatory Commission ("FERC") tariff.

6.3.1 Customer Metering Arrangement Data

It is the responsibility of the customer to provide detailed one-line diagrams and documentation that clearly shows its proposed generating facility's (or facilities') metering arrangement as early in the interconnection study process as possible, but no later than ten (10) business days following:

- Scoping Meeting;
- Cluster Study Results Meeting;
- System Impact Study Results Meeting; or
- Facility Study Results Meeting, as applicable.

From this documentation SCE must be able to, by way of proper metering, determine the wholesale and retail loads and generating facility characteristics (generator output, charging demand or charging capacity, etc.).

Failure of the customer to provide this information before the start of Cluster Phase II or the Facilities Study, as applicable, may delay the customer's requested in-service and commercial operation date until adequate metering is designed and installed that satisfies SCE metering requirements for retail billing and safe harbor eligibility pursuant to IRS Notice 2016-36.

Customer station light and power, auxiliary loads, cap banks, and metering must be clearly shown on the one-line diagrams.

6.3.2 Non-Battery Storage Generating Facility

6.3.2.1 Non-battery storage generating facilities must be metered in a manner acceptable to SCE.

6.3.2.2 Station light and power and auxiliary loads associated with non-battery storage generation projects are considered retail loads and must be metered in a manner acceptable to SCE.

6.3.2.3 If the station light and power and auxiliary loads associated with non-battery storage generation facilities are located behind the meter solely associated with the non-battery storage generation facility, additional meters may not be required. See example 1 (Figure 6a, Option A or B) one-line below.

6.3.2.4 CAISO Resource ID

6.3.2.4.1 Any non-battery storage generating facility with a CAISO resource ID must be metered separately from other generating facilities that are connected that have a different CAISO resource ID. See example 2 (Figure 6b) one-line below.

6.3.2.4.2 If the generating facility has a CAISO resource ID and the customer desires to add additional non-battery storage generation or a new non-battery storage generating facility under the same resource ID, additional metering may not be required. However, the metering arrangement must be reviewed and approved by SCE.

6.3.2.4.3 If the customer has a generating facility with a CAISO resource ID and desires to add additional non-battery storage generation or a new non-battery storage generation facility under a different CAISO resource ID, alteration of existing metering and/or additional metering may be required.

6.3.2.5 Generating operating characteristics (generator output, etc.) must be metered.

6.3.2.6 If the customer is an SCE retail customer with an SCE retail customer ID and another generator (a different SCE retail customer) desires to interconnect and share interconnection facilities, additional metering may be required (see example 2 (Figure 6b) one-line below).

6.3.3 Battery Energy Storage System (BESS) Generating Facility – Stand Alone systems

6.3.3.1 A BESS generating facility must be metered in a manner acceptable to SCE.

6.3.3.2 Station light and power and auxiliary loads associated with BESS generating facilities are wholesale loads when the BESSs are operating (charging or discharging). When the BESSs are idle (not charging or discharging), station light and power and auxiliary loads are retail loads.

6.3.3.3 If the station light and power and auxiliary loads associated with a BESS generating facility are located behind the meter solely associated with the battery storage generation facility, additional meters may not be required. See example 1 (Figure 6a, Option A or B) one-line below.

6.3.3.4 CAISO Resource ID

6.3.3.4.1 Any BESS generating facility with a CAISO resource ID must be metered separately from other generating facilities that are connected that have a different CAISO resource ID. See example 2 (Figure 6b) one-line below.

6.3.3.4.2 If the generating facility has a CAISO resource ID and the customer desires to add additional BESSs or a new BESS generating facility under the same resource ID, additional metering may not be required. However, the metering arrangement must be reviewed and approved by SCE.

6.3.3.4.3 If the customer has a generating facility with a CAISO resource ID and desires to add additional BESSs or a new BESS generating facility under a different CAISO resource ID, alteration of existing metering and/or additional metering may be required.

6.3.3.5 BESS generating facility operating characteristics (generator output and generator charging, etc.) must be metered.

6.3.3.6 If the customer is an SCE retail customer with an SCE retail customer ID and another generator (a different SCE retail customer) desires to interconnect and share interconnection facilities, additional metering may be required (see example 2 (Figure 6b) one-line below).

6.3.4 Battery Energy Storage System (BESS) Generating Facility – Paired Storage

6.3.4.1 CAISO Resource ID

6.3.4.1.1 Any generating facility with a CAISO resource ID must be metered separately from other generating facilities that are connected that have a different CAISO resource ID. See example 2 (Figure 6b) one-line below.

6.3.4.1.2 If the generating facility has a CAISO resource ID and the customer desires to add additional generation or a new generating facility under the same resource ID, additional metering may not be required. However, the metering arrangement must be reviewed and approved by SCE.

6.3.4.1.3 If the customer has a generating facility with a CAISO resource ID and desires to add additional generation or a new generating facility under a different CAISO resource ID, alteration of existing metering and/or additional metering may be required (see example 2 (Figure 6b) one-line below).

6.3.4.2 SCE Retail Customer

6.3.4.2.1 Any generating facility that is an SCE retail customer must be metered separately from any other generating facility that is or intends to be a different SCE retail customer. See example 2 (Figure 6b) one-line below.

6.4 Metering Instrument Transformers

6.4.1 Revenue metering instrument transformers shall be utilized for revenue metering only, which includes metering by SCE meter(s) and CAISO meter(s). No devices other than SCE and CAISO meters are permitted to be connected to revenue metering instruments.

6.4.2 The revenue metering dedicated PT voltage coils shall be utilized for revenue metering only, which includes metering by SCE meter(s) and CAISO meter(s). If the metering PT has a second set of coils it may be used for protection, monitoring, and/or synching purposes.

6.4.3 The metering PTs shall be 0.3 ANSI accuracy class, or higher, metering devices. The metering CTs shall be 0.15S special extended range ANSI accuracy class metering devices (IEEE C57.13.6 IEEE Standard for High-Accuracy Instrument Transformers). CTs must be guaranteed and tested to accurately measure current down to at least 0.5% of CT rating.

6.4.4 The metering CTs shall be sized in accordance with good metering practices and shall always be within meter accuracy class range during generation cycles and/or auxiliary load cycles. The CTs' preferred rating factor is 4.0 and preferred accuracy range is 0.05% to 400% of rated current.

6.4.5 Metering CTs' and PTs' specifications must be submitted for SCE review and acceptance before ordering.

6.5 SCE Meter Enclosures

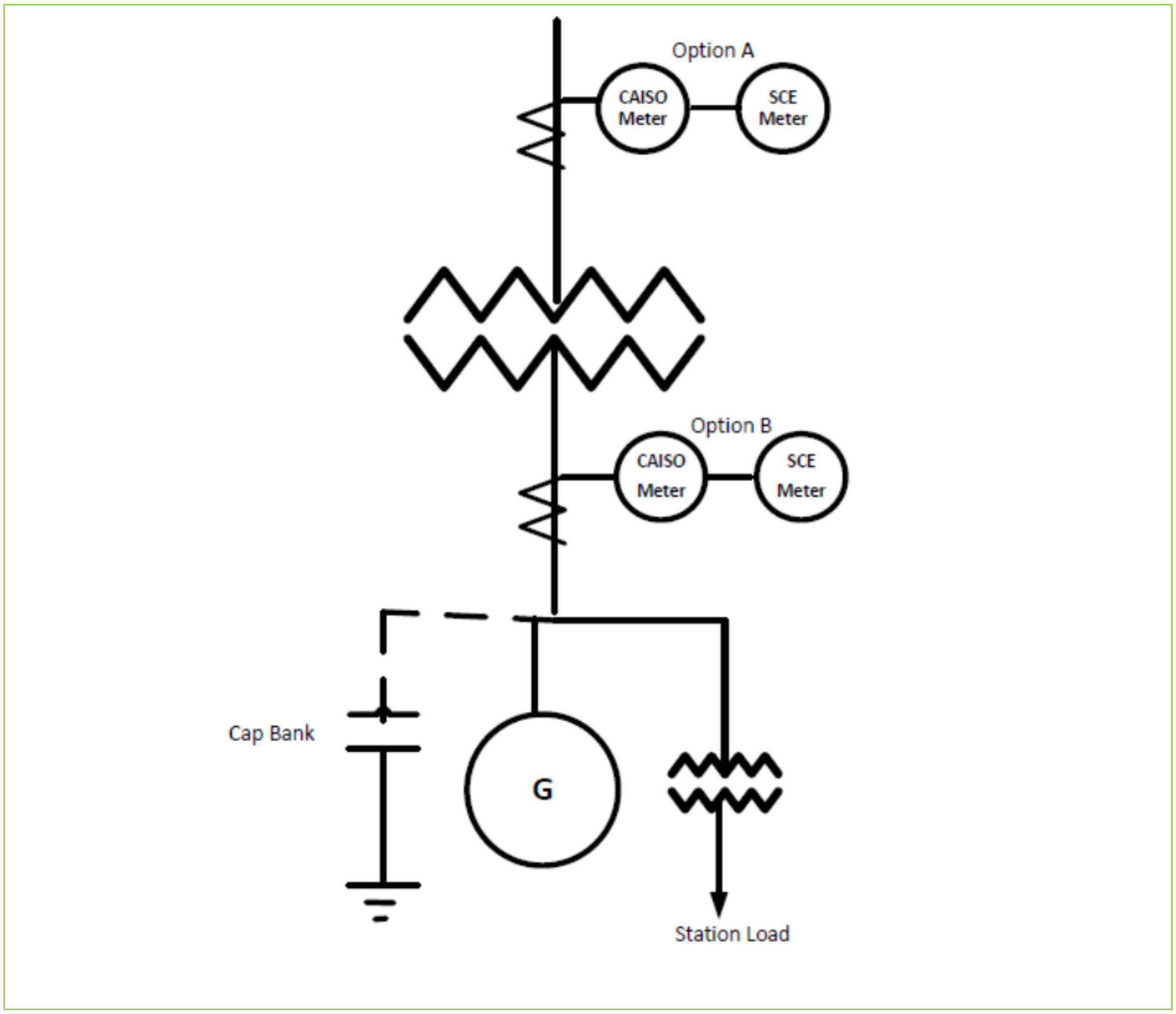
6.5.1 Interconnecting customers shall install and wire up meter enclosures for SCE meters per SCE specifications.

6.5.2 SCE meter enclosure design and location shall meet the SCE Electrical Service Requirements (ESR). The SCE meter enclosure must be located at the fence line of the customer's property, outside and fenced from the switchyard; have separate lockable gate with 24-hour access for SCE personnel to the meter without entering the customer substation (with drive up access); and have a safety working area with a minimum of 3 X 3 feet in front of the meter panel.

Example 1:

Figure 6a: Typical Metering Installation for a single resource Generating Facility

Typical metering configuration for single resource Generators taking service under the CAISO Tariff with CAISO metering installed on Producer's side of the interconnection



Option A- Metering on the high side of transformer

Option B- Metering on the low side of transformer compensated with transformer losses to the high side

6.6 Location/Ownership of CAISO Metering Equipment

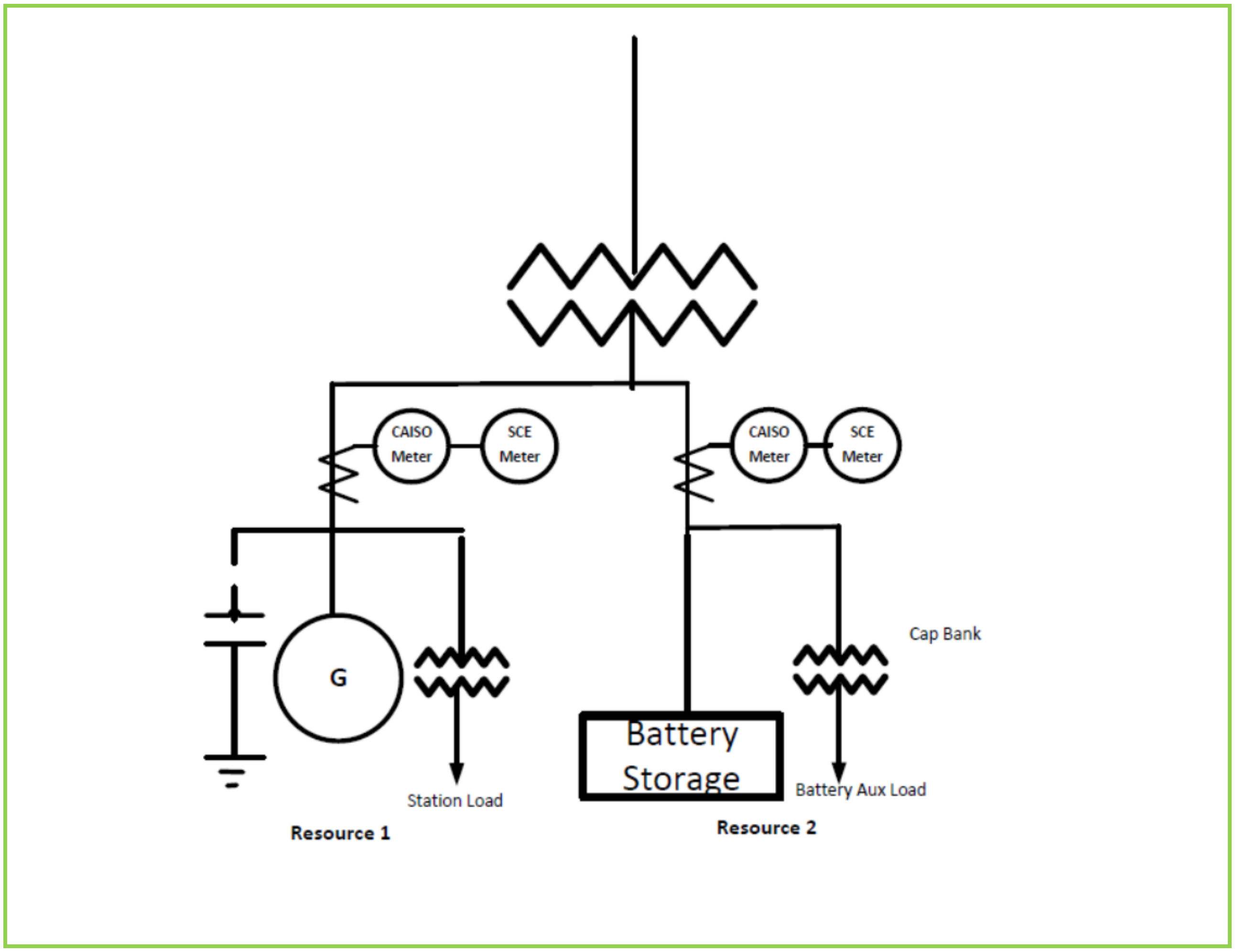
Applicable to Metering Installed on a Producer's Side of Interconnection

A Producer shall, at its expense, install, own, and maintain all CAISO metering equipment, including metering CTs/PTs, meters, routers, and telecommunication's equipment providing such equipment is installed on its assets and located on its side of the point of interconnection with SCE (Figure 6b).

Example 2:

Figure 6b: Typical Metering Installation for multiple resource Generating Facility

Typical metering configuration for multiple resource Generators taking service under the CAISO Tariff with CAISO metering installed on Producer's side of the interconnection



Note: Metering installed on the low side of the transformer is compensated with transformer losses to the high side.

SECTION 7 TELEMETERING REQUIREMENTS (HARDWARE)

7.1 Telemetering Requirements

Applicable to Generation, Transmission, and End-User Facilities

For a high degree of service reliability under normal and emergency operation, it is essential that the INTFAC have adequate and reliable telecommunication facilities.

The INTFAC shall specify the following at the point of connection: the requested voltage level, MW/MVAR capacity, and/or demand.

Applicable to Generation Facilities

Producers with generating facilities 1 MVA nameplate or larger will require telemetering equipment and telecommunications at Producer's expense. For projects equal to or greater than 1 MVA but less than 10 MVA, real time SCADA telemetry of watts and vars only are required for total generation and customer load. For projects 10 MVA and greater, the telemetering equipment must transmit at minimum generator unit gross MW and MVAR, generator status, generator circuit breaker status, and generator terminal voltage. In addition, real time telemetering of project net MW and MVAR is required.

Wind generation facilities equal to or greater than 1 MVA nameplate will require real-time monitoring in most cases. It is the Producer's responsibility to comply with any CAISO telemetry requirements. These telemetry requirements apply to non-exporting-for-sale as well as exporting-for-sale generating facilities; refer to SCE System Operating Bulletin 510 for exemptions to certain non-exporting-for-sale generating facilities.

For generating facilities utilizing photovoltaic inverter-based technology, the nameplate rating is the total aggregate AC nameplate rating of the inverter unit(s). For generating facilities utilizing non-photovoltaic inverter-based technology (i.e. Fuel Cell, Energy Storage, etc.), the total aggregate nameplate rating is either the AC nameplate rating of the inverter unit(s) or the total aggregate nameplate rating of the generator/generating unit(s), as determined by SCE to be the limiting component.

7.2 Total Generation 1 MVA Nameplate or More

Applicable to Generation Facilities

The following is a list of requirements for the installation of Real-Time telemetry at the Producers generating facility. Unless otherwise specified, all the facilities listed below are to be provided by the Producer.

7.2.1 The following specifications are to be used as informational guidelines to facilitate the Centralized Telemetry Method installation at the Generation Facility:

The following apply to a generating facility with 1 MVA $\leq$ Total Generation < 10 MVA interconnected to an SCE (34.5 kV or below) Distribution Circuit. Customer will purchase and install equipment for the Centralized Telemetry Method (CTM) (See Figure 8 for typical installation configuration). The purpose of the CTM is to collect customer facility and generation information for use on the SCE SCADA system to determine system loading, assist in Grid operation, and collect historical data. SCE will provide/approve acceptable solutions for connection to the CTM and program the CTM equipment as necessary. Customer will own, maintain, repair, replace, and upgrade and bring all required telemetry to the CTM.

a) A NEMA 4 enclosure or equivalent for the CTM equipment is required. Other enclosures or mounting shall be evaluated on a case by case basis. The location should be reasonably close to the origin of telemetering signals or data concentrator. A control room or relay house is acceptable as long as the temperature range is within 0° C to 70° C.
b) Provide a 120 VAC 15 Amp power source to the CTM cabinet for CTM power.
c) Provide data communication cables for virtual I/O points directly to the CTM cabinet for termination. Typical data communication cables will be Industrial RS-485 Cables such as Belden 3108A or equivalent. A 4-foot coil is to be left at the CTM location and will be terminated by SCE inside the CTM cabinet.
d) Communication between the producer's Data Concentrator and the CTM shall be ModBus RTU, 16-bit integer, 9600 baud, 8 bits, 1 stop, no parity.
e) Provide Broadband internet service with a Static IP address.
f) Local Network configuration and ISP must support an IPsec VPN connection between the CTM and SCE.
g) Specific Network requirements shall be evaluated on a case by case basis.

7.2.2 The following specifications are to be used as informational guidelines to facilitate the RTU installation at the Generation Facility:

The following apply to a generating facility with 1 MVA ≤ Total Generation ≤ 10 MVA interconnected to an SCE Substation or Total Generation ≥ 10 MVA. The following is a list of requirements for the installation of a Real-Time Remote Terminal Unit (RTU) or equivalent device at the Producer's generating facility. See Figure 7a and Figure 7b for installation configuration. Unless otherwise specified, all the facilities listed below are to be provided by the Producer.

At the customer's expense, SCE will purchase, configure, install, and commission the RTU. The size and point count of the RTU is determined based on the generation nameplate capacity as well as the number of data points to be monitored. SCE will own, operate, maintain, repair, control, alter, replace, and upgrade the RTU. The purpose of the RTU is to collect and concentrate customer facility and generation information for use on the SCE SCADA system to determine system loading, assist in Grid operation, and collect historical data.

a) An interior location suitable for floor or wall mounting the RTU is required. The location should be reasonably close to the origin of telemetering signals or data concentrator. A control room or relay house is acceptable as long as the temperature range is within 0° C to 70° C. The Heating Ventilation and Air Conditioning (HVAC) requirements for fiber optic terminal equipment are more stringent than what is required for RTU equipment. Therefore, the requirements in this Section 7 will match those of Section 8: Telecommunications Requirements, whenever line protection or RAS specifies the use of fiber optic communications and its terminal equipment.

- Cable access can be either through the top or bottom of the RTU cabinet.
- Floor space for standard 8-foot tall, 19" free-standing rack (PREFERRED).
- Wall space for a single door cabinet 24 inches wide by 20 inches deep by 30 inches high. The wall mount cabinet weighs 125 pounds and is mounted with a ½ inch bolt through mounting tabs at each corner.

b) Provide a 120 VAC, 15 Amp convenience power source to the RTU cabinet. This source will utilize a dedicated breaker labeled "SCE-RTU". A 4-foot coil is to be left at the RTU location and will be terminated by SCE inside the RTU cabinet.

c) Station DC power 10 A @ 48 VDC or 5 Amp @ 125 VDC (not shared with other equipment) run to the RTU cabinet for RTU power. The voltage to be supplied to the RTU shall be communicated to SCE PSC in order for SCE to procure the appropriate RTU. The circuit breaker shall label "SCE-RTU". If DC power is not available, a 120 VAC circuit may be used as long as this circuit is sourced from an Uninterruptible Power System with a minimum of 4-hour backup.

d) One stranded AWG #8 conductor will be connected to station ground and run to the RTU cabinet by the customer.

e) The customer will run all data signal cables for physical I/O points to the RTU cabinet or to a near-by (6 feet or less) interface cabinet for termination. Data cables must be shielded with shield grounded at RTU end only. Twisted-pair stranded wire between AWG #16 and AWG #22 or twisted-pair solid wire between AWG #18 and AWG #24 may be used. Cables containing 6, 12, 25 and 32 pairs are typical. A 10-foot coil is to be left at the RTU location and will be terminated by SCE inside the RTU cabinet.

f) All analog quantities will be represented by a + / – 1 milli-Amp or a 4 to 20 milli-Amp current loop. The current loop may be shared as long as there are no grounds and it is not driven beyond the manufacturers specified limits. Physical status points will be presented by a dry contact available at the interface cabinet. All status points will utilize the Normally Open contacts of the customer provided isolation relay. The RTU will provide the contact wetting voltage.

g) The customer shall provide data communication cables for virtual I/O points directly to the RTU cabinet for termination. Typical data communication cables include standard CAT V (Ethernet) cables, Industrial Ethernet Cable, or Industrial RS-485 Cables such as Belden 3108A or equivalent.

h) Communication between the customer data concentrator and the Edison RTU shall be ModBus RTU, 9600 baud, 8 bits, 1 stop, no parity. Other data communication protocols shall be evaluated on a case by case basis.

i) Specific Telemetry Requirements identified in Table 7.1.

Table 7.1: Telemetry Requirements

GENERATOR SIZE AND TYPE	DATA ACQUISITION REQUIREMENT
GF with aggregate generation < 1 MVA	No remote telemetry is required
Non-Wind GF interconnected at ≤ 33 kV with 1 MVA ≤ aggregate generation ≤ 10 MVA	Real-time (SCADA) telemetry required for total generation. Customer load data may be required and shall be evaluated on a case by case basis • Watts • VARs • Voltage
Wind GF ≥ 1 MVA	Real-time (SCADA) telemetry required for total project • Watts • VARs • Voltage • Entire Project CB Status [7]
GF with an aggregate plant ≥ 10 MVA	Real-time (SCADA) telemetry required for 2 of the following 3 parameters: • Total Gross Generation • Customer Load • Net flow to/from utility interface Plus the following: • Watts • VARs • Amps • Volts (Generator Bus) • Interface CB Status [8]
Any single generating unit ≥ 10 MVA	Real-time (SCADA) telemetry required for each individual generating unit: • Watts • VARs • Amps • Volts (Generator Bus) • Unit CB Status [9]
Switchyards ≥ 55 kV	Real-time (SCADA) telemetry required for: • Bus Voltage • Line MW • Line MVARs • Switchyard CB Status [10]

j) SCE's GCC on a site-to-site basis may deem other status, protection alarms, or controls necessary. All ratings are based on the Gross Nameplate Rating.

k) ITBI ITS Network & Telecom Services Grid Projects will determine communications from the RTU to EMS.

l) The RTU cabinet can be delivered to the customer premises for mounting and conveniences to the customer.

m) 24-hour access to the RTU for maintenance by SCE's Power System Controls technicians.

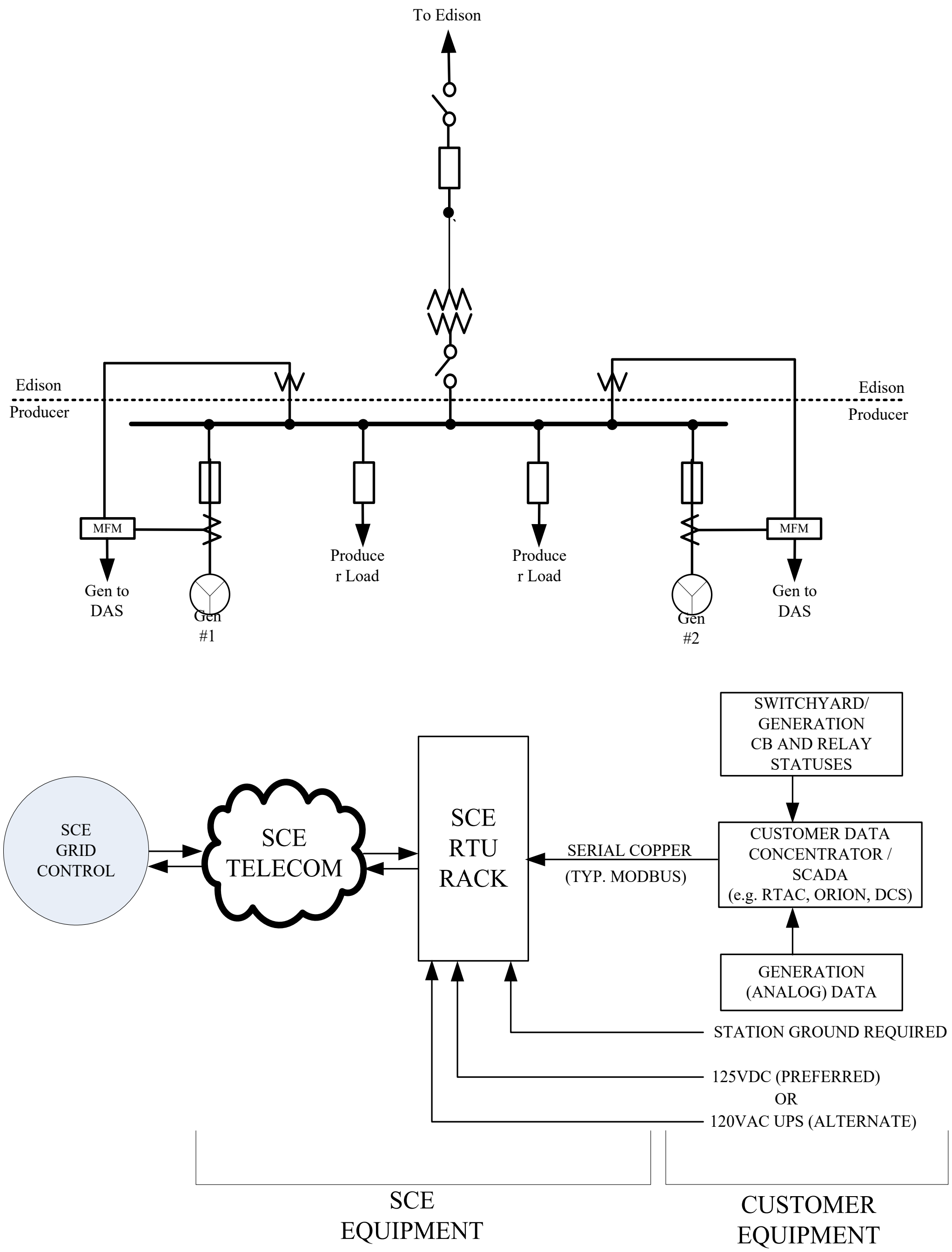
[7] All CB statuses contained in the entire projects

[8] The customer's high side main breaker status

[9] Individual Generating Unit CB Status

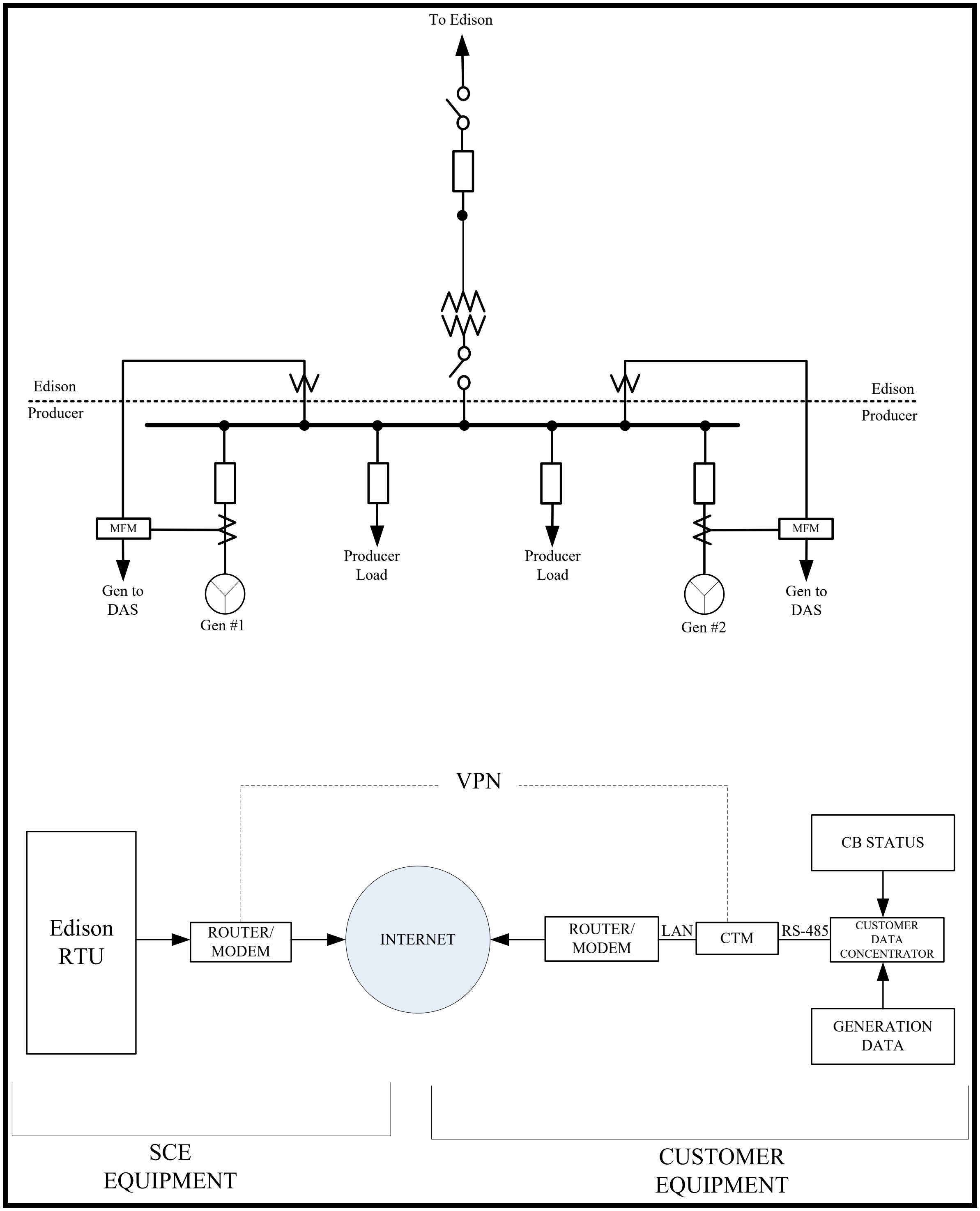
[10] Entire switchyard CB status

Figure 7a: Typical Remote Terminal Unit (RTU) Installation
1 MVA ≤ Total Generation ≤ 10 MVA interconnected to an SCE Substation or Total Generation ≥ 10 MVA



*For generation 1 MVA or more.

Figure 7b: Typical Centralized Telemetry Method (CTM) Installation
1 MVA ≤ Total Generation < 10 MVA interconnected to an SCE (34.5 kV or below) Distribution Circuit



7.3 Exemption for Cold-Iron and Emergency-Backup Generators

Note: These types of generators are not operated in parallel to SCE's electric system except for short times *(typically only several minutes or less)* while performing a "soft-transfer" of customer load between the generator and SCE's electric system. As such, the telemetry requirements of this section **do not apply** to Cold-Iron or Emergency-Backup generators that have selected "Isolated Operation" or "Momentary Parallel" operation.

7.3.1 Cold-Ironing is the action of providing shore-side electrical power to a ship at berth while its on-board generator(s) are shut down.

a) Cold-Iron generator is a generator on board a ship which has the capability of Cold-Ironing.

b) The initial process of Cold-Ironing involves paralleling the ship's electrical system to SCE's electric system for a short duration while the ship's electrical load is transferred between the ship's generator and shore power. A Cold-Iron generator does not parallel to SCE's electric system beyond the initial transferring process.

7.3.2 Emergency-Backup Generation (EBG) is customer-owned generation utilized when disruption of utility power has occurred or is imminent.

a) When utilized, following a disruption, the customer would first disconnect from SCE's electric system prior to starting up the EBG.

b) When utilized prior to a disruption of utility power, the EBG would be started and loaded to carry the entire customer load, and then the customer would disconnect from SCE's electric system.

c) Upon resumption of utility power, the customer would first connect to SCE's electric system and then unload the EBG.

SECTION 8 TELECOMMUNICATIONS REQUIREMENTS

8.1 General Description

The following requirements are to be used as guidelines for typical Telecommunications equipment installation at an Interconnection Facility (INTFAC). Specific design and installation details are addressed during final engineering for each specific INTFAC.

SCE's telecommunications facilities support line clearing in the event of faults in the INTFAC's gen-tie, Supervisory Control and Data Acquisition (SCADA) at the INTFAC's generator (See Section 7), and, if required, a Remedial Action Scheme. As noted in Section 3, the selection of protection devices depends on the INTFAC's generator size and type, number of generators, the composition of the existing protection equipment and the power line characteristics (i.e., voltage, impedance, and ampacity) of its gen-tie and the surrounding area. Identical INTFAC's connected at different locations in SCE's electric system can have widely varying protection requirements and attendant telecommunication costs. For INTFAC's connecting at ≥ 200 kV and above, the primary protection relays are designed to isolate the faulted transmission line within six (6) cycles. Voltage classes as low as 66 kV may have similar time clearing requirement if studies show an electrically faulted transmission line will have severe network impacts if not electrically separated from the grid as quickly as possible. SCE selects high speed relays for these situations.

SCE uses fiber optic (FO) cable for communications between these relays because it is:

1. Fast (speed of light);
2. Resilient (not subject to atmospheric or other interference);
3. Reliable (consistent latency);
4. Available as carrier grade terminal equipment (integral redundancies, design margins, maintenance support); and
5. A best utility practice.
6. Non-conductive (when using All-Dielectric Self-Supporting cable)

SCE does not allow the use of Intermittent and indeterminate communications methods, such as a leased circuits, radios using unlicensed frequencies, and cellular or satellite paths, which defeat the purpose of line current differential relays.

In cases where a second FO telecommunication is required, for protection relay coordination or to support a RAS, the second FO path must comply with WECC guidelines governing diverse routing. The customer will construct the communications path(s) between its end user Facility and the point of interconnection. Primary path can be provided with a FO cable at the end user Facility or as OPGW (fiber Optical Ground Wire). Diverse routing will be required for secondary path. Telemetering data (SCADA) and line protection control signals will be transported on these paths.

If FO is not required for line protection or RAS, a leased circuit may be used for telemetering (SCADA). See Section 8.6.

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8.2 Fiber Optic Cable and Communications Paths:

The C will install the main and diverse FO cables (if needed) from its facility to SCE designated points just outside of the SCE interconnection substation, from which SCE will extend the FO cables into the substation. A minimum of eight (8) strands within each FO cable will be provided to SCE for its exclusive use. SCE follows the WECC Applicable Reliability Standards for space diversity between the -C's main and diverse FO cables. SCE's implementation is the following:

1. Main and a diverse FO cables (i.e. redundant) on two separate paths (i.e. diverse) and spaced such that a single credible event cannot sever both cables. Equipment redundancy is also required. Options within the right-of-way include:
   a) Main path: OPGW or underbuilt FO cable on the gen-tie poles and for the Diverse path: Underground FO cable in the right-of-way; or
   b) Main and diverse (two) direct buried FO cables separated by ≥ 25 feet; or
   c) Main and diverse (two) FO cables in conduits separated by ≥ 10 feet and fully encased in concrete.

Protection Engineering has final approval for fiber architecture.

Fiber Optic Cable at Aggregation (Collector) Substations

If the -C will be connecting to a non SCE aggregation substation (commonly known as a collector substation) that in turn is connected to an SCE substation, the -C is responsible for providing the telecommunication equipment and communications paths between the collector sub and the -C necessary for line protection and RAS participation. The -C is responsible for confirming its telecommunications plan of service meets the WECC Applicable Reliability Standards. An -C that interconnects to a collector substation:

a) Is responsible for the telecom for its line protection between the -C and its collector substation, including any lightwave, channel banks, or related terminal equipment.
b) Is responsible for transport of any RTU data from the -C to the SCE terminal equipment at the collector substation.
c) May elect to install FO cables and equipment that meet WECC's diversity requirement. Sufficient space and facilities must also be provided at both locations (collector substation and -C) to install appropriate equipment to support the RAS.

The provisions of this Handbook for space diversity apply on the -C's side of the collector sub.

8.3 Space Requirements

SCE shall design, operate, and maintain certain telecommunications terminal equipment at the INTFAC to support line protection, telemetering (SCADA), equipment protection, and RAS/CRAS communications applicable to the project. Refer to the respective sections for Protection and Telemetering for their space requirements.

The INTFAC shall provide sufficient floor space within a secure building for SCE to install and operate one communication equipment cabinet for each of the fiber optic cables (corresponding to the Protection requirements for one or two FO cables).

The INTFAC shall procure and install the communication equipment cabinet(s) per SCE's current Telecom Standards. These cabinet(s) shall be secured per current **California Seismic requirements**.

The INTFAC shall provide a working clearance of 36" in front and behind the communication equipment cabinet(s) for the safety of installation and maintenance personnel. The working clearance specified provides a 36" unobstructed space for ladders and/or test equipment carts. Additionally, SCE considers telecommunications equipment cabinets to contain "live electrical equipment," which is consistent with the 36" working clearance specified in the **National Electric Code**.

8.4 HVAC Requirements

The INTFAC shall provide and maintain suitable environmental controls in the equipment room, including an HVAC system to minimize dust, maintain a temperature of 30° C or less, and 5-95% non-condensing relative humidity.

The HVAC requirements for fiber optic lightwave, transport or data equipment are more stringent than what is required for RTU equipment. Therefore, whenever line protection or RAS specifies the use of fiber optic communications and its lightwave, transport or data equipment, the requirements of Section 7: Telemetering Requirements (Hardware) will match those in this Section 8.

8.5 Power and Grounding Requirements

The INTFAC shall provide a connection point to station ground within ten (10) feet of the SCE communication equipment rack(s). SCE will provide and install cabling from the equipment cabinet(s) to the designated station ground termination to protect the communications equipment and service personnel.

The INTFAC shall provide two 15 Amp dedicated branch circuits from the 125 VDC station power to support each required telecommunications equipment rack. The dedicated source breakers shall be labeled "SCE-Telecom A" and "SCE-Telecom B." If DC power is not available, two 15 Amp, 120 VAC circuits may be used as long as the circuits are sourced from an Uninterruptible Power System (UPS) with a minimum of a 4-hour backup. The power source shall not be shared with other equipment.

The INTFAC shall provide a 120 VAC, 15 Amp convenience power source adjacent to the telecommunications equipment cabinet(s). As this source will be utilized for tools and test equipment by installation and maintenance personnel, UPS is not required. The INTFAC shall provide ample lighting for the safety of installation and maintenance personnel.

For RTU power and grounding requirements, refer to Section 7.

8.6 Telemetry and Leased Circuit:

If the INTFAC requires a dedicated RTU but is not required to construct fiber optic cables for line protection or RAS (typical for INTFACs ≥10 MW but < 20 MW), the INTFAC shall:

1. Arrange with the local service provided to deliver a 20 Mb or greater Ethernet circuit from the INTFAC location to a SCE designated SCE service center or similar facility;
2. Technical specifications for circuit are as follows:
    a. Latency Max 20 ms (one-way)
    b. MTU Max 9126 (on Telco side)
    c. CIR Min 25 Mbps
    d. PDR 99.9% (PDR=Packet Delivery Rate)
    e. Availability 99.99% (network availability)
    f. Sync None (We will have to provide our own)
    g. Interface GigE (Multimode preferred)
3. Designate to the service provided that SCE shall be authorized to report trouble and to initiate inquires, troubleshooting and repairs with the service provider on the INTFAC's behalf in the event of an interruption of service on the communication circuit;
4. Incur all make ready and reocurring costs of the leased circuit;
5. Provide high-voltage protection for the service providers communications, if necessary.
6. Provide conduit, raceway, copper cable, fiber optic cable and any miscellaneous equipment or services as necessary for SCE to extend the leased circuit from the Local Exchange Carrier MPOE (Minimum Point of Entry or "demark") to the SCE communications equipment described in Item 6 below. The SCE equipment cabinet(s) shall be no more than 100 feet from the MPOE;
7. Provide conduit, raceway, copper cable, fiber optic cable and any miscellaneous equipment or services as necessary to extend a communications circuit from the RTU to communications equipment and the leased communications circuit in the event the SCE RTU is not located within the same facility as the communications equipment, SCE's RTU and communications equipment shall be no further apart than 100 feet.
8. Provide (1) communications cabinet described in Section 8.3 above.

8.7 Miscellaneous:

1. While SCE may discuss telecommunication connection preferences of the customer's facility, ultimately, SCE has final decision regarding the selection of telecommunication connection equipment. The telecommunication connection equipment must fit within the operating requirements, design parameters, and

communications network architecture of the entire SCE telecommunications network.

2. Use of SCE telecommunications infrastructure (including microwave facilities and fiber optic cables) by a customer is not an option.
3. Leased circuits, radio using unlicensed frequencies, cellular, and satellite are not acceptable options at SCE for high speed protective line relays or C/RAS supporting transmissions lines.
4. SCE telecommunications terminal equipment, being electronic devices, will be periodically refreshed, i.e. replaced, sometime after installation. The time until refresh depends on a number of factors, including its operating environment, repair history, and manufacturer support. A refresh typically occurs around 10 years and could be as early as 5 years or as long as 15 years after installation. The interconnection customer should anticipate for these refreshes to be considered Capital Additions under the terms of the interconnection agreement, with the associated cost being the responsibility of the interconnection customer.
5. The customer shall provide access for SCE employees and approved contractors for planned maintenance and service restoration 24 hours a day, 7 days a week after the communication equipment is installed and in operation.

SECTION 9 PROPERTY REQUIREMENTS

9.1 Right of Way Requirements

The Producer must acquire the necessary Right of Way requirements for its interconnection or transmission line, along with the access requirements to the point of interconnection with SCE's facilities. The use of SCE's Right of Way and/or fee owned property shall not be included in any interconnection proposals.

9.2 Transmission Line Crossing Policy

A "proposed" interconnection transmission line, or Right of Way access, crossing SCE transmission line or access easements or fee owned property must be submitted to SCE's Vegetation & Land Management (V&LM) organization for a separate review by several internal departments for approval/denial. For your reference, below are SCE's Transmission Crossing Policy guidelines:

- A new non-SCE owned transmission line of equal or lower voltage shall not be allowed the superior position and will cross under the existing SCE facilities and/or the new facilities proposed prior to the new line, including facilities needed for queued-or-clustered--ahead generation.
- A new non-SCE owned transmission line, triggered by a generator facility, with higher voltage may be allowed the superior position than an SCE line if it adheres to G.O. 95[11] Grade "A" self-supporting Dead-end construction and has a minimum of double insulator strings on both sides. SCE will regain the superior position if its lower voltage facilities are upgraded and are of equal or higher voltage than the non-SCE owned transmission line. Note: This will apply to all voltages.
- A new non-SCE owned transmission line of higher voltage may be allowed the superior position if it crosses a multiple SCE circuit corridor (two circuits or more). However, this type of crossing needs to be reviewed, and approved by SCE, on a case-by-case basis. All costs incurred by SCE for mitigation measures that are required to accommodate a proposed crossing of SCE facilities shall be at the customer's expense.
- A new non-SCE owned transmission line, regardless of voltage, shall not be allowed the superior position if it crosses a circuit which terminates at a current or former nuclear power plant switchyard.

[11] ***General Order No. 95. (G.O. 95)*** the "Rules for Overhead Line Construction" established by the California Public Utilities Commission is minimum requirements for designing and constructing overhead and underground electrical facilities. In some cases, SCE Practices and Standards may be more stringent. The INTFAC must adhere to the appropriate requirements.

9.3 Infrastructure Property Requirements

Substation: The following approximate land requirements are needed for typical interconnection facilities (SCE owned substation) on the customer's property:

- 66 kV Tap: 80 ft. by 94 ft.
- 66 kV Loop: 135 ft. by 105 ft.
- 115 kV Tap: 112 ft. by 110 ft.
- 115 kV Loop: 170 ft. by 140 ft.

These land requirements assume the customer is installing/owning the transformer and gen-tie line.

Minimum substation land requirements are subject to change according to engineering studies and interaction with SCE is required for final determination. The dimensions above include a required 10 ft. easement bordering the interconnection facility under the assumption that the customer owns the transformer, other facilities; and the land needed for the incoming line(s) is not included.

SECTION 10 GENERATOR SHARING BREAKER AND A HALF

10.1 Summary

Generation[12] projects may request interconnection directly to a bus position on any of SCE's 500 kV, 220 kV, 115 kV, and 66 kV switchracks. The guidelines for generation interconnection bus positions are as follows:

10.1.1 SCE Project[13] Priority

Bus positions reserved for future SCE transformers will not be assigned to generation interconnection projects. Bus positions reserved for any other SCE project with a proposed operating date within 10 years of the execution of the generation project's Generation Interconnection Agreement (GIA), will not be assigned to generation interconnection projects.

10.1.2 Generator Sharing Breaker and a Half

Generation interconnections to SCE's 500 kV, 220 kV, 115 kV, and 66 kV switchracks may share the same breaker-and-a-half (BAAH) position under the following conditions:

a. The remaining switchrack facilities are not overloaded when a bus side breaker is lost
b. Loss of generation projects sharing the breaker and a half position do not exceed the CAISO's 1,150 MW N-1 and 1,400 N-2 tripping limitations
c. No system performance issues result from generation projects sharing the same BAAH position
d. No SCE load is part of the configuration when both bus side breakers are lost

10.1.3 Generator Bus Position Priority

Typically, generation projects requesting interconnection to SCE's 500 kV, 220 kV, 115 kV, and 66 kV switchracks are assigned a bus position on a first come first served basis (i.e. the first customer ready to begin construction will be assigned the position). If multiple eligible generation customers are concurrently ready to begin construction and request the same bus position at a substation where available bus positions are limited, the following guidelines will apply:

10.1.3.1 Generator Bus Position Eligibility Requirements

- Generation customer must have a signed GIA/Engineering, Procurement & Construction Letter Agreement.
- Generation project must be active (not parked/suspended).
- Generation project construction must start within 15-18 months.

[12] Generation refers to Generators or Energy Storage Projects.

[13] SCE Project in this context can be defined as any SCE-built project requiring a bus position, not supporting an SCE/EIX-owned generator.

10.1.3.2 Generator Bus Position Priority Determination

In the event, that multiple generation projects have met all above eligibility requirements and are scheduled to begin construction simultaneously, the following criteria will determine which generator will be assigned the bus position. The generation project that meets the most criteria will be assigned the bus position.

1. Queue Position – The generation project with the earlier queue position will satisfy this criterion.
2. Generation tie-line routing – The generation project with the generation tie-line route that has less transmission line crossing, a shorter route length, less environmental impact, and/or has less licensing challenges will satisfy this criterion.
3. Power Purchase Agreement (PPA) – The generation project that can provide proof of having an executed and regulator-approved PPA will satisfy this criterion.
4. Shortlist Status – The generation project that can provide proof that it is currently included on an active short list, or other commercially recognized method of preferential ranking of power providers by a prospective purchasing Load Serving Entity, will satisfy this criterion.
5. Permitting Status – The generation project that is farther along in the environmental permitting process, will satisfy this criterion.
6. Land Acquisition Status - The generation project that can demonstrate a present legal right to begin construction of the Generating Facility on one hundred percent (100%) of the real property footprint necessary for the entire Generating facility, will satisfy this criterion.

SECTION 11 INVERTER-BASED RESOURCE PERFORMANCE REQUIREMENTS

Applicability: Generators interconnecting below 50 kV shall follow the Rule 21 requirements for Autonomous Functionalities listed below:

1. Autonomous Functionalities
    a) Anti-Islanding Protection
    b) Low/High Voltage Ride Through (L/HVRT)
    c) Low/High Frequency Ride Through (L/HFRT)
    d) Dynamic Volt/Var Operations
    e) Ramp Rates
    f) Fixed Power Factor
    g) Reconnect by "Soft-Start" Methods
    h) I-DER System Parameters and Monitored Points

This section provides a list of interconnection requirements that apply to inverter-based resources interconnecting to SCE's 55 kV or higher voltages. All Producers with inverter-based resources interconnecting must adhere to NERC Reliability Guideline "Improvements to Interconnection Requirements for BS-Connected Inverter-Based Resources[14]"

11.1 Momentary Cessation Voltage Protection Settings

Producers with inverter-based resources interconnecting to SCE's system shall design and operate their settings to eliminate the use of momentary cessation (i.e., where the power electronic firing commands are blocked such that the inverter ceases to inject both active and reactive current and thus produces no active or reactive power). Inverter-based resources shall continue to inject current during a fault if the Point of Interconnection (POI) voltage is within the "No Trip Zone" as defined in the NERC Reliability Standard PRC-024-2. For disturbances that cause voltage to fall outside of the "No Trip Zone" as defined in PRC-024-2, the following design criteria should be used:

- Low Voltage: Set the momentary cessation low voltage threshold to the lowest feasible value.
- High Voltage: Set the momentary cessation high voltage threshold to the PRC-024-2 voltage requirements. The PRC-024-2 voltage requirements are a minimum requirement and the voltage settings should be set as wide as possible while still protecting the facility equipment from damage.
- Recovery Delay: No intentional delay for active power recovery once voltage recovers beyond the momentary cessation voltage threshold.

[14] https://www.nerc.com/comm/OC_Reliability_Guidelines_DL/Reliability_Guideline_IBR_Interconnection_Requirements_Improvements.pdf

- Active Power Ramp Rate: Inverters active power ramp rate must be set at a minimum ramping rate of 100% per second (e.g., return to pre-disturbance active current injection within one second).
- During a disturbance that causes transient low voltage conditions, inverters should be set in reactive power priority to support system voltages.

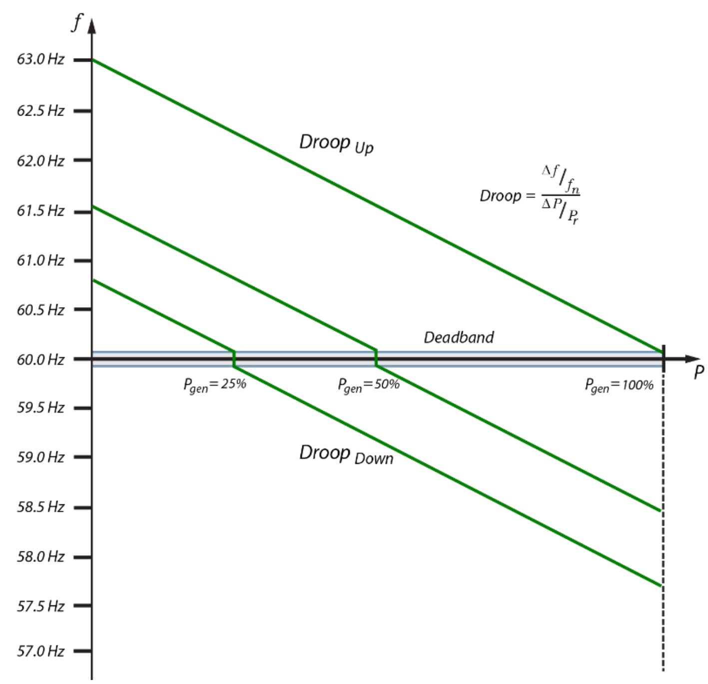
11.2 Ramp Rate Interactions

If a power system disturbance causes plant power output to fall below pre-disturbance levels, the plant level controller must not impede inverter restoration post-disturbance. If the inverter-based resource uses a plant level controller, it must be programmed to allow the inverters to restore current injection to pre-disturbance levels as quickly as possible without delayed ramping.

11.3 Primary Frequency Response Requirements

- Inverter-based resources are required to install a control system that provides active power primary frequency response capability. The response must be timely and sustained with the following response characteristics:
  - Droop: 5% droop with the capability to respond in both the upward (under-frequency) and downward (over-frequency) directions.
  - Deadband: Non-step deadband with a deadband of ±0.036 Hz.
- Figure 11a shows an illustration of the active power-frequency requirement with the droop and non-step characteristics.

Figure 11a Active Power-Frequency Requirement with Droop and Non-Step Characteristics



11.4 Dynamic Active Power Frequency Control Requirements

- For a step change in frequency at the point of measurement (POM)[15], inverter-based resources should have the capability to meet or exceed the dynamic characteristics shown in Table 11.1.
- Producers shall consult with SCE's GCC and Integrated System Planning (ISP) to ensure the system in which their resources are connected does not require more stringent parameters than those specified for the Table 11.1 below.

Table 11.1: Dynamic Active Power-Frequency Performance

Parameter	Description	Performance Target
For a step change in frequency at the POM of the inverter-based resource		
Reaction Time	Time between the step change in frequency and the time when the resource active power output begins responding to the change[16]	< 500 ms
Rise Time	Time in which the resource has reached 90% of the new steady-state (target) active power output command	< 4 sec
Settling Time	Time in which the resource has entered into, and remains within, the settling band of the new steady-state active power output command	< 10 sec
Overshoot	Percentage of rated active power output that the resource can exceed while reaching the settling band	< 5.0%**
Settling Band	Percentage of rated active power output that the resource should settle to within the settling time	< 2.5%**

** Percentage based on final (expected) settling value

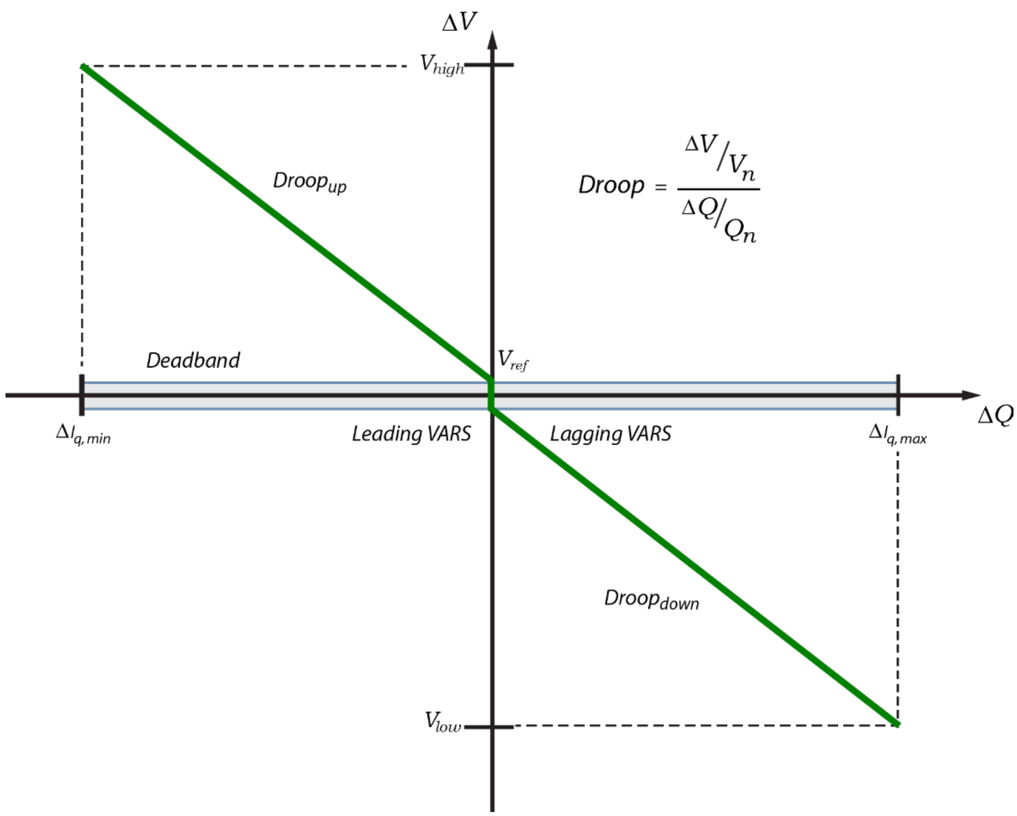
[15] This is the "high-side of the generator main step-up transformer.

[16] Time between step change in frequency and the time to 10 percent of new steady-state value can be used as a proxy for determining this time.

11.5 Reactive Power Control Requirement

- To maintain the scheduled voltage provided by the SCE GCC and to support voltage stability, inverter-based resources shall operate in automatic voltage control mode, unless a different control mode is specified by the SCE GCC and an automatic voltage regulator is installed and in-service.
- To ensure a stable and coordinated voltage control, reactive power droop shall be implemented. The reactive power voltage control requirements (e.g., reactive power droop, deadband, scheduled voltage set point, and the high and low schedule limits) shall be coordinated with the SCE GCC.
- Figure 11b shows an example of reactive power-voltage control characteristic for reference.

Figure 11b: Example of Reactive Power-Voltage Control Characteristic



11.6 Small Disturbance Reactive Power-Voltage Requirement

- Small disturbances occur regularly on the system, ranging from normal switching type events to continuous load and generation changes throughout the day. For small disturbances, the voltage generally remains within the continuous operating range and the plant-level controller maintains the reactive power/voltage control. The reactive power/voltage control characteristic should operate fast enough to mitigate stead-state voltage issues from causing dynamic voltage collapse. Therefore, inverter-based resources that support voltage for small disturbances shall meet the performance characteristics shown in Table 11.2.
- Producers shall consult with SCE's GCC and Integrated System Planning (ISP) to ensure the system in which their resources are connected does not require more stringent parameters than those specified for the Table 11.2 below.

Table 11.2: Disturbance Reactive Power-Voltage Performance

Parameter	Description	Performance Target
For a step change in voltage at the POM of the inverter-based resource		
Reaction Time	Time between the step change in voltage and when the resource reactive power output begins responding to the change	< 500 ms*
Rise Time	Time between a step change in control signal input (reference voltage or POM voltage) and when the reactive power output changes by 90% of its final value	< 1-30 sec**
Overshoot	Percentage of rated reactive power output that the resource can exceed while reaching the settling band	< 5.0%***

* Reactive power response to change in POM voltage should occur with no intentional time delay.
** Depends on whether local inverter terminal voltage control is enabled, any local requirements, and system strength (response should be stable for the lowest possible grid strength). Response time may be modified based on studied system characteristics.
*** Any overshoot in reactive power response should not cause voltages to exceed acceptable voltage limits.

11.7 Large Disturbance Reactive Power-Voltage Performance

- Large disturbances are considered to be fault type of events that cause voltages to fall outside the continuous operating range (e.g. 0.9–1.1 pu). When voltages fall outside the continuous operating range the plant-level control logic may freeze and the inverters may enter into ride-through mode where the individual inverters take over control of the reactive current injection. The local inverter control response should adhere to the following characteristics for large disturbances and be designed to have the performance requirements show in Table 11.3:

- The dynamic performance of each inverter should be tuned to provide a stable response for all expected operating conditions.
- The dynamic response should be programmable to enable changes based on changing grid conditions.
- Current limiters should be coordinated with inverter protection to ensure that the resource is able to respond very quickly while staying within its continuous or short-term overload limits.
- Producer shall coordinate with SCE GCC to tune controls and response times, to make sure the reactive current response does not exacerbate transient overvoltage issues.
- Producers shall consult with SCE's GCC and Integrated System Planning (ISP) to ensure the system in which their resources are connected does not require more stringent parameters than those specified for the Table 11.3 below.

Table 11.3: Large Disturbance Reactive Power-Voltage Performance

Parameter	Description	Performance Target
For a step change in voltage measured at the inverter terminals		
Reaction Time	Time between the step change in voltage and when the resource reactive power output begins responding to the change	< 16 ms*
Rise Time	Time between a step change in control signal input (reference voltage or POM voltage) and when the reactive power output changes by 90% of its final value	< 100 ms**
Overshoot	Percentage of rated reactive power output that the resource can exceed while reaching the settling band	Determined by the SCE GCC or Integrated System Planning (ISP)***

* For very low voltages (i.e. less than around 0.2 pu), the inverter PLL may lose its lock and be unable to track the voltage waveform. In this case, rather than trip or inject a large unknown amount of active and reactive current, the output current of the inverter (s) may be limited or reduced to avoid or mitigate any potentially unstable conditions.
** Varying grid conditions (i.e. grid strength) should be considered and behavior should be stable for the range of plausible driving point impedances. Stable behavior and response should be prioritized over speed of response.
*** Any overshoot in reactive power response should not cause system voltages to exceed acceptable voltage limits. The magnitude of the dynamic response may be requested to be reduced by SCE GCC or Integrated System Planning (ISP) based on stability studies.

11.8 Phase Jump Immunity

Most inverter-based resources follow the external grid reference angle to generate the d-q axis components via the phase-locked loop (PLL) control system. The PLL adjusts the internal phase angle of current injection to remain synchronized with the AC grid; however, nearby faults or line outages can pose challenges for the PLL to track the terminal voltage angle. As a result, Producers shall consult SCE's Transmission Planner to identify the most severe phase jumps at the POI and define the phase jump limits for their facilities. A typical worst-case positive sequence phase jump may exceed 30 degrees.

11.9 Reactive Capability Curve

Producers shall provide a capability curve that includes the overall active and reactive capability of each type of individual inverter as measured at the high-side of the generator substation. This includes a complete P-Q graph (or table of data representing these data points) at nominal voltage. The reactive capability within that curve should be "dynamic" per FERC Order No. 827.

11.10 Inverter Current Injection during Faults (Current Injection Priority)

Producers shall consult with SCE's Integrated System Planning to determine the inverter current injection during fault conditions, which will include the magnitude of the current, the phase relationship of current with respect to voltage, and the timing of current injection. This determination will be based on detailed system studies and system need.

11.11 Fault Ride-Through Capability

Producers shall consult with SCE' Transmission Planner to determine the fault ride-through (FRT) requirements. These requirements will be applicable to all Producers and shall include a performance envelope that must be met by the Producer.

PART 2

Method of Service/End User Facility Interconnection Requirements

CONTENTS

SECTION 1 METHOD OF SERVICE / END USER FACILITY INTERCONNECTION OVERVIEW

The Method of Service study specifies what is necessary to interconnect a customer end user Facility to SCE's electric system and provides these customers with an overview of the requirements to address interconnection requests. It also provides a means to facilitate the communication of technical information to SCE regarding the end user Facilities interconnecting to SCE's electric system.

SECTION 2 PROTECTION REQUIREMENTS

Protective devices (relays, circuit breakers, synchronizing equipment, etc.) must be installed for the protection of SCE's electric system as required by SCE. Generally, the protective devices may differ with the relative electrical capacity of the installation. The larger the installation, the greater the effect it may have on SCE's electric system.

While some protection requirements can be standardized, the detailed protection design highly depends on the type and characteristics of the customer's end user Facility (i.e., voltage, impedance, and ampacity), as well as the existing protection equipment and configuration of SCE's surrounding electric system. Fault duty, existing relay schemes, stability requirements, and other considerations may impact the selection of protection systems. Consequently, identical end user Facilities connected at different locations in SCE's electric system can have widely varying protection requirements and costs. The varying protection requirements will be used to define the corresponding Telecommunications requirements, **(See Section 7.)**

For voltage classes 200 kV and above, primary relay protection for network transmission circuits will be designed to clear transmission line faults within a maximum of 6 cycles. Project stability studies may indicate that faster clearing times are necessary. To ensure the reliability of the electric system, protective relays, and associated equipment require periodic replacement. Typically, the frequency of transmission line relay replacement does not exceed once every fifteen (15) years, but equipment failure, availability of replacement parts, system changes, or other factors may alter the relay system replacement schedule. If equipment does fail, it shall be replaced according to the Interconnection Agreement.

For MOS interconnections utilizing a sub-transmission line interconnection at voltage 66 kV and 115 kV or transmission line at 220 kV and 500 kV, customers shall utilize Protection Requirements as defined in this Interconnection Handbook, Part 3 Transmission Interconnection Requirements Section 2.

2.1 Circuit Breaker Short Circuit Duty and Surge Protection

2.1.1 SCE Short Circuit Duty Analysis

The recognized standard for circuit breakers rated on a symmetrical current basis is IEEE Standard C37.010-1999(R2005), "IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis," and ANSI/IEEE Standard C37.5 for circuit breakers rated on a total current basis. SCE will review circuit breaker short circuit duty capabilities and surge protection to identify any additions required to maintain an acceptable level of SCE system availability, reliability, equipment insulation margins, and safety. Also, the management of increasing short-circuit duty of the transmission system involves selecting the alternative that provides the best balance between cost and capability. System arrangements must be designed so that the interrupting capability of available equipment is not exceeded.

When studies of planned future system arrangements indicate that the short-circuit duty will reach the capability of existing circuit breakers, consideration should be given to the following factors:

a) Methods of limiting duty to below the circuit breaker capability:
   1. De-looping or rearranging transmission lines at substations;
   2. Split bus arrangements.
b) Magnitude of short circuit duty.
c) The effect of future projects on the short circuit duty.
d) Increasing the interrupting capability of equipment.
e) The ability of a particular circuit breaker to interrupt short circuit currents considering applicable operating experience and prior test data.

Please note that SCE performs an annual short circuit duty analysis, which may include reevaluation of the facility circuit breakers.

2.1.2 Customer Owned Duty/Surge Protection Equipment

In compliance with Good Utility Practice and, if applicable, the requirements of SCE's Interconnection Handbook, the owner shall provide, install, own, and maintain relays, circuit breakers and all other devices necessary to remove any fault contribution of its end-user Facilities to any short circuit occurring on SCE's electric system not otherwise isolated by SCE's equipment, such that the removal of the fault contribution shall be coordinated with the protective requirements of SCE's electric system. Such protective equipment shall include, but not limited to, a disconnecting device and a fault current-interrupting device located between the customer's end-user Facilities and the SCE electric system at a site selected upon mutual agreement (not to be unreasonably withheld, conditioned or delayed) of the Parties. The owner shall be responsible for protection of the end-user Facilities and other equipment from such conditions as negative sequence currents, over- or under-frequency, sudden load rejection, over- or under-voltage, and generator loss-of-field. The owner shall be solely responsible to disconnect their facility if conditions on SCE's electric system are impacted by the customer's end-user Facilities.

SECTION 3 MISCELLANEOUS REQUIREMENTS:

3.1 Overhead & Underground Facilities Requirements

The customer shall ensure that its overhead facilities are constructed to a minimum of General Order 95 **Rules for** Overhead **Electric Line Construction** standards when facilities are built within California and to **National Electric Safety Code** standards when facilities are built outside of California. The customer shall ensure that its underground facilities are constructed to a minimum of General Order 128 **Rules for Construction of Underground Electric Supply and Communication Systems** when facilities are built within California and to **National Electric Safety Code** standards when facilities are built outside of California. Where facilities are intended to be owned by SCE, additional design requirements apply and must be consistent with SCE's design standards.

3.2 Automatic Voltage Regulators (AVR)

Automatic voltage control equipment on end user Facilities, synchronous condensers, and Flexible Alternating Current Transmission System (FACTS) shall be kept in service to the maximum extent possible with outages coordinated to minimize the number out of service at any one time. Such voltage control equipment shall operate at voltages specified by the balancing authority operator which is the CAISO.

3.3 Underfrequency Relays

Since the facilities of SCE's electric system may be vital to the secure operation of the Interconnection, the CAISO and SCE shall make every effort to remain connected to the Interconnection. However, if the system or control area determines that it is endangered by remaining interconnected, it may take such action as it deems necessary to protect the system.

Intentional tripping of tie lines due to underfrequency is permitted at the discretion of SCE's electric system, providing that the separation frequency is no higher than 57.9 Hz with a one-second time delay. While acknowledging the right to trip tie lines at 57.9 Hz, the preference is that intentional tripping shall not be implemented.

3.4 Insulation Coordination

Insulation coordination is the selection of insulation strength and practice of correlating insulation levels of equipment and circuits with the characteristics of surge-protective devices such that the insulation is protected from excessive over-voltages. Insulation coordination must be done properly to ensure electrical system reliability and personnel safety.

The customer shall be responsible for an insulation coordination study to determine appropriate surge arrester class and rating on the end user Facilities equipment. In addition, the customer is responsible for the proper selection of substation equipment and their arrangements from an insulation coordination standpoint.

Basic Surge Level (BSLs), surge arrester, conductor spacing and gap application, substation and transmission line insulation strength, protection, and shielding shall be documented and submitted for evaluation as part of the interconnection plan.

3.5 Ratings

3.5.1 Facility Ratings

The ratings of facilities are the responsibility of the owner of those facilities. Ratings of facilities must conform to NERC Standard governing Facility Ratings.

3.5.2 Ratings Provided by Equipment Manufacturers

Equipment installed on SCE's electric system is rated according to the manufacturer's nameplate or certifications, and ANSI/IEEE standards. The manufacturer's nameplate rating is the normal rating of the equipment. ANSI/IEEE standards may allow for emergency overloads above the normal rating under specified conditions and often according to an engineering calculation. Emergency loading may impact the service life of the equipment. In some cases, the manufacturer has certified equipment for operation at different normal or emergency loads based on site-specific operation conditions. Older technology equipment is rated according to the standards under which it was built unless the manufacturer, ANSI/IEEE standards, or SCE's determination indicates that a reduced rating is prudent or an increase rating is justified.

3.5.3 Rating Practice

The normal and emergency ratings of transmission lines or the transformation facilities shall equal the least rated component in the path of power flow.

3.5.4 Ambient Conditions

Since SCE's territory is in a year-round moderate climate, SCE does not establish equipment ratings based on seasonal temperatures. That is, SCE standard ratings for normal and emergency ratings are the same throughout the year and reflect summer ambient temperatures coincident with ANSI/IEEE standards, i.e., 40°C (104°F). However, in some cases SCE may calculate site-specific ratings that consider the local ambient conditions based on ANSI/IEEE rating methods.

3.5.5 Transmission Lines

The transmission circuit rating is determined according to the least rated component in the path of power flow. This comprises of the transmission line conductor/cable, the series devices in the line, the allowable current that will not cause the conductors to sag below allowable clearance limits, the allowable current that will not cause the cables to operate above the designed temperature limit, and the termination equipment.

3.5.6 Overhead Conductors

The transmission line conductor ratings are calculated in accordance with ANSI/IEEE 738-1993. For Aluminum Conductor Steel Reinforced (ACSR) conductor the normal conductor rating allows a total temperature of 90°C and the emergency rating allows 135°C. Similarly, for aluminum and copper conductors, SCE permits 85°C and 130°C. For Aluminum Conductor Steel Supported (ACSS), SCE base the normal rating at 120°C, and 200°C for the emergency rating. Higher or lower temperature limits may be permitted as appropriate depending on engineering justification.

3.5.7 Underground Cable

The transmission line cable ratings are calculated in accordance with IEC 60287. For cross-linked polyethylene (XLPE) insulated cable, the normal cable rating allows a total temperature of 90°C and the emergency rating allows 105°C for 4 hours. Higher or lower temperature limits may be permitted as appropriate depending on engineering justification and/or component tested data.

3.5.8 Series and Shunt Compensation Devices

Series capacitor and reactors are only permitted to be loaded to ANSI/IEEE limits or as specified by the manufacturer. VAR compensators shall be rated according to the ANSI/IEEE standards where applicable and according to the manufacturer's limitations. These ratings are reported to CAISO Transmission Register. Shunt capacitors and reactors are not in the path of power flow, so they are not directly a "limiting component." However, their reactive power capacity is reported to CAISO Transmission Register.

3.5.9 Terminal Equipment

Terminal equipment comprises of the following: circuit breakers, disconnect switches, jumpers, drops, conductors, buses, and wave-traps, i.e., all equipment in the path of power flow that might limit the capacity of the transmission line or transformer bank to which it is connected. The normal and emergency ampere rating for each termination device is reported to CAISO in its Transmission Register.

3.5.10 Transformer Bays

The rating of a transformer bay is determined by the least rated device in the path of power flow. This comprises ratings of the transformer, the transformer leads, the termination equipment, and reduced parallel capacity where applicable. The transformer rating is compared to the termination equipment ratings and lead conductors to establish the final transformation rating based on the least rated component. All the above ratings are reported to the CAISO Transmission Register.

3.5.11 Transformer Normal Ratings

The "normal" rating is the transformer's highest continuous nameplate rating with all its cooling equipment operating. The only exception is when a special "load capability study" has been performed showing that a specific transformer is capable of higher than nameplate loading and for which the test data or calculations are available.

3.5.12 Transformer Emergency Ratings

A transformer's emergency rating is arrived at by one of two methods. First, if no overload tests are available then a 10% overload is allowed. Second, if a factory heat-run or a load capability study has been performed, the emergency rating may be as high as 20% above normal as revealed by the test. For transformers on the transmission system, i.e., primary voltage of 500 kV, the allowed duration of the emergency loading is 24-hours. For transformers with primary voltage of 161 kV to 220 kV, the allowed duration is 30 days.

3.5.13 Parallel Operation of Transformers

When two or more transformers are operated in parallel, consideration is given to load split due to their relative impedances such that full parallel capacity is not usually realized. The permissible parallel loading is calculated according to ANSI/IEEE standards.

3.5.14 Relay Protective Setting Limits

In cases where protection systems constitute a loading limit on a facility, this limit is the rating for that facility. These limiting factors are reported to the CAISO Transmission Register and are so noted as to the specific reason, e.g., "limited to 725 A by relay setting."

3.5.15 Path Ratings

As stated in Section 2 of the WECC Procedures for Project Rating Review, new facilities and facility modifications should not adversely impact accepted or existing ratings regardless of whether the facility is being rated. New or modified facilities can include transmission lines, end user Facilities, substations, series capacitor stations, remedial action schemes or any other facilities affecting the capacity or use of the interconnected electric system.

3.6 Synchronizing of Facilities

Testing and synchronizing of a customer's end user Facility may be required depending on SCE's electric system conditions, ownership, or policy, and will be determined based on facility operating parameters. Such procedures should provide for alternative action to be taken if lack of information or loss of communication channels would affect synchronization.

Appropriate operating procedures and equipment designs are needed to guard against out-of-sync closure or uncontrolled energization. (Note: SCE's transmission lines utilize ACB phase rotation, which is different than the national standard phase rotation). The owner of the end user Facilities is responsible to know and follow all applicable regulations, industry guidelines, safety requirements, and accepted practice for the design, operation and maintenance of their facility.

Synchronizing locations shall be determined ahead of time; required procedures shall be in place and be coordinated with SCE. SCE and the owner of the end user Facility shall mutually agree and select the initial synchronization date. The initial synchronization date shall mean the date upon which a facility is initially synchronized to the SCE transmission system and upon which trial operation begins.

3.7 Maintenance Coordination and Inspection

The security and reliability of the interconnected power system depends upon periodic inspection and adequate maintenance of the customer's end user Facilities and associated equipment, including but not limited to control equipment, communication equipment, relaying equipment, and other system facilities. Entities and coordinated groups of entities shall follow CAISO procedures and are responsible for disseminating information on scheduled outages and for coordinating scheduled outages of major facilities which affect the security and reliability of the interconnected power system.

3.8 Abnormal Frequency and Voltages

3.8.1 Joint Reliability Procedures

Where specific transmission issues have been identified, those entities affected by and those entities contributing to the problem shall develop joint procedures for maintaining reliability.

3.8.2 Voltage and Reactive Flows

CAISO shall coordinate the control of voltage levels and reactive flows during normal and emergency conditions on the CAISO controlled system. All operating entities shall assist with the CAISO's coordination efforts.

3.8.3 Transfer Limits Under Outage and Abnormal System Conditions

In addition to establishing total transfer capability limits under normal system conditions, transmission providers and balancing authority shall establish total transfer capability limits for facility outages and any other conditions such as unusual loads and resource patterns or power flows that affect the transfer capability limits.

3.9 Communications and Procedures

3.9.1 Use of Communication System

It is essential to establish and maintain communications with the SCE Grid Control Center (GCC), the Alternate Grid Control Center (AGCC) or a jurisdictional Switching Center should a temporarily attended station or area of jurisdiction become involved in a case of system trouble. It is equally important that communication services be kept clear of nonessential use during times of system trouble to facilitate system restoration or other emergency operations.

3.9.2 Remedial Action Schemes Communication Equipment Requirements

Customer end use Facilities will require the necessary communication equipment for the implementation of Remedial Action Schemes (RAS). This equipment provides line monitoring and high-speed communications between customer's breaker and the central control facility, utilizing applicable protocols. RASs may also be applied to end user Facilities that may be required to trip in order to relieve congestion on transmission facilities. Thus, allowing a RAS to incorporate disconnection into automatic control algorithms under contingency conditions, as needed.

RASs are fully redundant systems. The following paragraph is an excerpt from the WECC Remedial Action Scheme Design Guide that specifies the Philosophy and General Design Criteria for RAS redundancy.

> *"Redundancy is intended to allow removing one scheme following a failure or for maintenance while keeping full scheme capability in service with a separate scheme. Redundancy requirements cover all aspects of the scheme design including detection, arming, power, supplies, telecommunications facilities and equipment, logic controllers (when applicable), and RAS trip/close circuits." Excerpt from: WECC Remedial Action Scheme Design Guide (11/28/2006)*

3.9.3 Critical System Voltage Operation

Voltage control during abnormal system configurations requires close attention with consideration given to what operations will be necessary following loss of the next component. Voltages approaching 10% above or below the normal value are considered critical with rate of change being of principal importance.

SECTION 4 GENERAL OPERATING REQUIREMENTS:

a) **System Operating Bulletins:** An end user Facility connecting into SCE's electric system may be subject to operating requirements established by SCE, the CAISO or both. SCE's general operating requirements are discussed in the sections below. SCE may also require additional operating requirements specific to an end user Facility. If so, these requirements will be documented in SCE's System Operating Bulletins (SOB), Substation Standard Instructions (SSI), and/or interconnection and power purchase agreements. SCE's SOBs and/or SSIs specific to the end user Facility and any subsequent revisions will be provided by SCE to the customer as they are made available.

b) **Responsibility for the Owner of an end user Facility:** The owner of an end user Facility is responsible for complying with all applicable operating requirements. Operating procedures are subject to change as system conditions and system needs change. Therefore, it is advisable for the customer to regularly monitor operating procedures that apply to its end user Facility. The CAISO publishes its operating procedures on its internet site, but it is prudent for the customer to contact the CAISO for specific requirements.

c) **Quality of Service:** The interconnection of the customer's equipment with SCE's electric system shall not cause any reduction in the quality of service being provided to SCE's customers. If complaints result from operation of the customer's end use Facility, such equipment shall be disconnected until the problem is resolved.

d) **SCE Circuits:** Only SCE is permitted to energize any de-energized SCE circuit.

e) **Operate Prudently:** The owner of an end user Facility will be required to operate its facility in accordance with prudent electrical practices.

f) **Protection in Service:** An end user Facility shall be operated with all of required protective apparatus in service whenever the end user Facility is connected to, or is operated in parallel with, the SCE electric system. Redundant protective devices may be provided at the customer's discretion. Any deviation for brief periods of emergency may only be by agreement of SCE and is not to be interpreted as permission for subsequent incidents.

g) **Added Facilities Documentation:** The customer may not commence parallel operation of its end user Facility until final written approval has been given by SCE. As part of the approval process, the customer shall provide, prior to the commencement of parallel operation, all documents required by SCE to establish the value of any facilities installed by the customer and deeded to SCE for use as added facilities. SCE reserves the right to inspect the customer's end user Facility and witness testing of any equipment or devices associated with the interconnection.

4.1 VAR Correction

VAR correction will normally be planned for light load, heavy load and for system normal and contingency conditions. This is to be accomplished by providing transmission system VAR correction to minimize VAR flow and to maintain proper voltage levels. The planning of transmission system VAR requirements should consider the installation of shunt capacitors, shunt reactors and tertiary shunt reactors, synchronous condensers, FACTS and transformer tap changers. The guidelines for reactive planning are as follows:

4.1.1 Interconnection

Interconnection with other utilities will normally be designed with the capability of maintaining near-zero VAR exchange between systems. Entities interconnecting their electric system with SCE's electric system shall endeavor to supply the reactive power required on their own system, except as otherwise mutually agreed. SCE shall not be obligated to supply or absorb reactive power for the customer's end user Facility when it interferes with operation of the SCE electric system, limits the use of SCE interconnections, or requires the use of generating equipment that would not otherwise be required.

4.1.2 Subtransmission System

VAR correction will normally be planned for connection to 55 kV through 160 kV buses to correct for large customer VAR deficit, subtransmission line VAR deficit, and transformer A-Bank VAR losses, the objective being zero VAR flow at the high side of the A-Banks with VAR flow toward the transmission system on the high side of the A-Banks, if required. Adequate VAR correction shall be provided for maximum coincident customer loads (one-in-five-year heat storm conditions), after adjusting for dependable local generation and loss of the largest local bypass generator.

4.2 Voltage Regulation/Reactive Power Supply Requirements

Operating entities shall ensure that reactive reserves are adequate to maintain minimum acceptable voltage limits under facility outage conditions. Reactive reserves required for acceptable response to contingencies shall be automatically applied when contingencies occur. Operation of static and dynamic reactive devices shall be coordinated such that static devices are switched in or out of service so that the maximum reactive reserves are maintained on generators, synchronous condensers, and other dynamic reactive devices.

To ensure secure and reliable operation of the interconnected power system, reactive supply and reactive generation shall be properly controlled and adequate reactive reserves shall be provided. If power factor correction equipment is necessary, it may be installed by the customer at its end use Facility, or by SCE at SCE's facilities at the customer's expense.

4.2.1 Facility Reactive Power Equipment Design

Customers shall provide for the supply of its reactive requirements, including appropriate reactive reserves, and its share of the reactive requirements to support power transfers on interconnecting transmission circuits.

The reactive power equipment utilized by the interconnecting customer to meet SCE's requirements must be designed to minimize the exposure of SCE's customers, SCE's electric system, and the electric facilities of others (i.e., other facilities and utilities in the vicinity) to:

a) severe over-voltages that could result from self-excitation- of induction generators,

b) transients that result from switching of shunt capacitors,

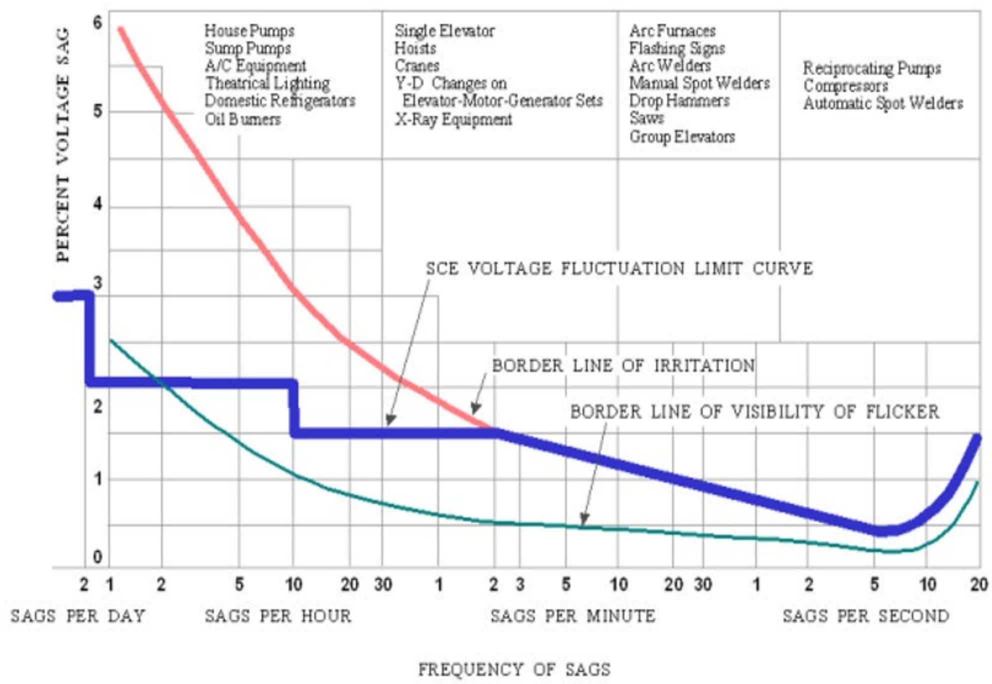
c) voltage regulation problems associated with switching of inductive and capacitive devices.

d) unacceptable harmonics or voltage waveforms, which may include the effect of power electronic switching, and

e) Voltage flicker exceeding SCE Voltage Flicker limits (See Figure 5.8).

FIGURE 5.8

VOLTAGE FLUCTUATION DESIGN LIMITS



4.2.2 Facility Reactive Power Equipment Design - provide variable source

The reactive power equipment utilized by the interconnecting customer to meet SCE's requirements must be designed to provide a variable source of reactive power (either continuously variable or switched in discrete steps). For discrete step changes, the size of any discrete step change in reactive output shall be limited by the following criteria:

a) the maximum allowable voltage rise or drop (measured at the point of interconnection with SCE's electric system) associated with a step change in the output of the customer's reactive power equipment must be less than or equal to 1%; and

b) the maximum allowable deviation from the customer's reactive power schedule (measured at the point of interconnection with the SCE system) must be less than or equal to 10% of the customer's maximum (boost) reactive capability.

4.2.3 Voltage and Reactive Control

4.2.3.1 Coordination

Operating entities shall coordinate the use of voltage control equipment to maintain transmission voltages and reactive flows at optimum levels for system stability within the operating range of electrical equipment. Operating strategies for distribution capacitors and other reactive control equipment shall be coordinated with transmission system requirements.

4.2.3.2 Transmission Lines

Although transmission lines should be kept in service as much as possible, during over-voltage system conditions a customer's transmission line(s) may be subject to removal from operation as a means to mitigate voltage problems in the local area. SCE will notify CAISO when removing such facilities from and returning them back to service.

4.2.3.3 **Switchable Devices**

Devices frequently switched to regulate transmission voltage and reactive flow shall be switchable without de-energizing other facilities.

4.3 Voltage Imbalance and Abnormal Voltage or Current Waveforms (harmonics)

Power quality problems are caused when voltage imbalances and harmonic currents result in abnormal voltage and/or current waveforms. Generally, if an end user Facility degrades power quality to other SCE customer facilities or SCE's own facilities, SCE may require the owner of that end user Facility to install equipment to eliminate the power quality problem.

4.3.1 Voltage Imbalance

The unbalanced voltage level (magnitude and phase), due to a customer's end use Facility connected to SCE at the transmission or subtransmission system level, may not exceed 1% at the Point of Common Connection[1] (PCC), under steady state system conditions. Under certain conditions (contingency conditions), SCE may allow higher levels of voltage imbalance if justified after a study conducted by SCE. In any event, the unbalanced voltage level created by a customer's end use Facility shall not exceed 1.5%.

It is the responsibility of the owner of an end use Facility, connected to SCE's electric system, to install the adequate mitigation devices to protect their own equipment from damage that maybe caused by voltage imbalance condition.

4.3.2 Harmonics

Customers interconnecting to SCE's electric system are required to limit harmonic voltage and current distortion produced by static power converters or similar equipment in accordance to good engineering practice used at their facility to comply with the limits set by the current IEEE Standards.

4.3.3 Disconnection

SCE may disconnect any Facility connected to its system until the above requirements are met.

4.3.4 Photovoltaic Inverter Systems

Photovoltaic inverter systems which conform to the recommended practices in the latest IEEE Standard 929 "IEEE Recommended Practice for Utility Interface of Photovoltaic (PV) Systems" and which have been tested and approved for conformance to UL Subject 1741 are considered to have met SCE's requirements for voltage imbalance and abnormal waveforms.

4.4 Grounding Circuits and Substations

A customer interconnecting its end user Facility to SCE's system shall follow practices outlined in IEEE 80 "IEEE Guide for Safety in AC Substation Grounding." Substation grounding is necessary to protect personnel and property against dangerous voltage potentials and currents during both normal and

[1] The PCC will generally be at the location of the revenue meter or the point of ownership change in the electrical system between SCE and the Producer. For customers served by dedicated facilities, the location of the PCC will be determined by mutual agreement between the Producer and SCE.

abnormal conditions of operation. Also, it provides a path to ground for the discharge of lightning strikes, a path to ground for the neutral currents of grounded neutral circuits and apparatus, the facilities for relaying to clear ground faults, the stability of circuit potentials with respect to ground and a means of discharging current-carrying equipment to be handled by personnel.

Reason for Substation Grounding

Substation grounding practices are outlined in the latest IEEE 80 "IEEE Guide for Safety in AC Substation Grounding."

According to IEEE 80 – 2013 a safe ground grid design has the following two objectives:

- "To provide means to carry electric currents into the earth under normal and fault conditions without exceeding any operating and equipment limits or adversely affecting continuity of service."
- "To reduce the risk of a person in the vicinity of grounded facilities being exposed to the danger of critical electric shock."

"People often assumed that any grounded object can be safely touched. A low substation ground resistance is not, in itself, a guarantee of safety. There is no simple relation between the resistance of the ground system as a whole and the maximum shock current to which a person might be exposed. Therefore, a substation of relatively low ground resistance may be dangerous, while another substation with very high resistance may be safe or can be made safe with careful design." (IEEE 80 –2013)

Each substation ground grid is a unique design. The conditions at the site: soil type, soil resistivity, fault current, clearing time, size of the substation, and other grounds all factor into the design.

4.4.1 Nominal Voltage and Grounding

SCE's most common primary distribution voltages are 4 kV, 12.47 kV and 16 kV depending on the geographic area. Other voltages are also used in specific areas. Common subtransmission voltages are nominally 66 kV to 115 kV. Common transmission system voltages are nominally 161 kV, 220 kV, and 500 kV. The majority of the 4, 12.47, and 16 kV circuits are effectively grounded, but some are operated with high impedance or resonant grounding. A substantial number of the effectively grounded circuits are used for four-wire- distribution (phase to neutral connected loads). The system grounding may change over time, such as when high impedance grounding is replaced with solid grounding to accommodate four-wire load or solid grounding is replaced with resonant grounding to reduce wildfire risk. SCE will provide the customer necessary information on the specific circuit serving its end user Facility for proper grounding.

4.4.2 Grounding Grid Studies shall be conducted in the following situations:

Grounding calculations will be required for each new substation, and at existing substations, when the ground grid is altered or when major additions are made at a substation. A review of existing substation ground grids will be conducted by Engineering in the following situations, especially if triggered by interconnection requests – these shall be considered in queue order:

- Short Circuit Duty Changes
    1. Circuit breaker replacement for short-circuit duty reasons if a grounding study has not been performed in the last eight years

2. Addition of a transmission or subtransmission line to a substation
3. System changes causing a substantial change in the substation phase-to-ground short-circuit duty
1. Addition or replacement of a transformer at a substation other than a like for like replacement. The replacement of a transformer bank with the same base MVA is considered a like for like replacement. Replacement transformer banks with a lower base MVA than existing will not require a grounding study.
    a. Like for like transformer replacements require a review of the ground grid if a grounding study has not been performed in the last eight years.
2. Addition of new generation causing a substantial change in the substation phase-to-ground short-circuit duty

- System Protection Changes
    1. Changes in system protection that significantly increases the clearing time for ground faults.
- Grounding Source Changes
    2. Grounding of ungrounded or impedance grounded winding of a transformer
    3. Addition or major change of ground source at a substation
- Substation Changes
    1. Alterations to substation fences including additions, movement, and attachments to other fences. The removal of vegetation that blocks access to a substation fence is considered a fence alteration.
    2. Alterations to substation ground grids that change their size or increase the effective substation ground grid impedance.
    3. Sale or lease of substation property for other uses.
- A grounding review should be conducted any time a grounding problem is reasonably suspected.

4.4.3 Ground Mats

If the customer's end user Facility and SCE substation ground mats are tied together, all cables may be landed without any protection. If the customer's end user Facility and SCE substation ground mats are not tied together, all cables shall have protection at both ends. The design of cable protection, if any, on circuits used for protective relaying purposes shall be such that the operation of the protective relaying is not hampered when the cable protection operates or fails.

All ground mats shall be designed in accordance with good engineering practice and judgment. Presently, the recognized standard for grounding is IEEE 80 "IEEE Guide For Safety in AC Substation Grounding." All ground mat designs should meet or exceed the requirements listed in this standard. If local governmental requirements are more stringent, building codes for example, they shall prevail. All customers shall perform appropriate tests, including soil resistivity tests, to demonstrate that their ground grid design meets the standard. Mats shall be tested at regular intervals to ensure their effectiveness.

Grounding studies shall be performed with industry-recognized software. This study will determine the maximum safe fault current for the ground grid design. It is suggested that the grid be designed for the maximum fault currents expected over the life of the facility.

If for any reason the worst-case fault current exceeds the design maximum fault current value due to changes in the customer's end user Facility or changes on the SCE system, the customer shall conduct new grounding studies. Any changes required to meet safety limits and protect equipment shall be borne by the customer.

The customer is responsible to ensure that the Ground Potential Rise (GPR) of its or interconnected mat does not negatively affect nearby structures or buildings. The cost of mitigation for GPR and other grounding problems shall be borne by the customer. End user facility and SCE ground grids are typically tied together when they are in close proximity to each other. If it is elected to install separate ground grids for SCE and the customer, the facility shall be responsible to mitigate any transfer voltages and GPR that occur to SCE's grid due to faults on the customer's end user Facility.

Any ground grid design, which results in a GPR that exceeds 3,000 Volts (RMS) for the worst-case fault or has a calculated or measured ground grid resistance in excess of 3 ohm, will require special approval by SCE.

4.4.4 Substation Grounding

A customer connecting and end user Facility to SCE's system shall follow practices outlined in IEEE 80 "IEEE Guide for Safety in AC Substation Grounding." Substation grounding is necessary to protect personnel and property against dangerous potentials and currents during both normal and abnormal conditions of operation. Also, it provides a path to ground for the discharge of lightning strikes, a path to ground for the neutral currents of grounded neutral circuits and apparatus, the facilities for relaying to clear ground faults, the stability of circuit potentials with respect to ground and a means of discharging current-carrying parts to be handled by personnel.

4.5 Non-SCE Pole Grounding

A customer connecting its end user Facility to SCE's system shall follow SCE Construction, Operation, and Maintenance requirements. The last customer-owned structure shall be designed and constructed to meet SCE grounding requirements.

Customer facilities that will require SCE's crews to climb in order to construct, operate, or maintain SCE facilities shall be constructed so as to meet SCE standards and specifications. Constructing to SCE specifications will ensure that SCE crews can safely perform and complete the jobs at hand in accordance with SCE's Accident Prevention Manual that stipulate the proper training and equipment to safely climb and work. Examples of safety related requirements that:

- Climbing Steps
- Belt-Off Locations
- Grounding Locations
- Required PPE

- Jumper Cable Ownership

Grounding bolts and bases are the same as step bolts and bases. If there is the potential need to have SCE personnel work on non-SCE owned poles connecting the customer's end user Facility directly to SCE's electric system a dead-end structure adhering to SCE's Construction, Operation, and Maintenance standards, is required

Please note that these requirements are for poles only. Non-steel or ungrounded poles will have; project-specific grounding requirements as determined by SCE.

SECTION 5 REVENUE METERING REQUIREMENTS

5.1 General Information

Revenue metering is required to measure the energy and capacity delivered and consumed by a customer. While functionally similar, there are varying requirements for customers depending on the nature and purpose of their end user Facility along with varying rules established by the authorities having jurisdiction over both SCE and the customer. Metering Requirements for customers taking service under a FERC tariff, and retail service under CPUC regulations are set forth in Section 6.2.

In general, all CAISO revenue metering and associated equipment used to measure load shall be provided, owned, and maintained at the customer's expense.

5.1.1 Retail Service

The retail metering requirements for retail service will be owned, operated, and maintained by SCE under SCE's Electrical Service Requirements (ESR) and in accordance with SCE approved tariffs.

SECTION 6 TELEMETERING REQUIREMENTS (HARDWARE)

6.1 Telemetering Requirements

For a high degree of service reliability under normal and emergency operation, it is essential that the customer's end user Facility have adequate and reliable telecommunication facilities.

The customer shall specify the following at the point of connection: the requested voltage level, MW/MVAR capacity, and/or demand.

6.2 Exemption for Cold-Iron and Emergency-Backup Generators

Note: These types of generators are not operated in parallel to SCE's electric system except for short times *(typically only several* minutes*)* while performing a "soft-transfer" of customer load between the generator and SCE's electric system. As such, the telemetry requirements of this section **do not apply** to Cold-Iron or Emergency-Backup generators.

6.2.1 Cold-Ironing is the action of providing shore-side electrical power to a ship at berth while its on-board generator(s) are shut down.

a) Cold-Iron generator is a generator on board a ship which has the capability of Cold-Ironing.

b) The initial process of Cold-Ironing involves paralleling the ship's electrical system to SCE's electric system for a short duration while the ship's electrical load is transferred between the ship's generator and shore power. A Cold-Iron generator does not parallel to SCE's electric system beyond the initial transferring process.

6.2.2 Emergency-Backup Generation (EBG) is customer-owned generation utilized when disruption of utility power has occurred or is imminent.

a) When utilized, **following** a disruption, the customer would first disconnect from SCE's electric system prior to starting up the EBG.

b) When utilized **prior to** a disruption of utility power, the EBG would be started and loaded to carry the entire customer load, and then the customer would disconnect from SCE's electric system.

c) Upon resumption of utility power, the customer would first connect to SCE's electric system and then unload the EBG.

SECTION 7 TELECOMMUNICATIONS REQUIREMENTS

7.1 General Description

The following requirements are to be used as guidelines for typical Telecommunications equipment installation at an INTFAC. Specific design and installation details are addressed during final engineering for each specific INTFAC.

SCE's telecommunications facilities support line clearing in the event of faults in the INTFAC's customer tie line, Supervisory Control and Data Acquisition (SCADA) at the INTFAC's end user Facility (See Section 6), and, if required, a Remedial Action Scheme. As noted in Section 2, the selection of protection devices depends on the INTFAC's end user Facility size and type, number of end user Facilities, the composition of the existing protection equipment and the power line characteristics (i.e., voltage, impedance, and ampacity) of its customer tie line and the surrounding area. Identical INTFACs connected at different locations in SCE's electric system can have widely varying protection requirements and attendant telecommunication costs. For INTFACs connecting at ≥ 200 kV and above, the primary protection relays are designed to isolate the faulted transmission line within six (6) cycles. Voltage classes as low as 66 kV may have similar time clearing requirement if studies show an electrically faulted transmission line will have severe network impacts if not electrically separated from the grid as quickly as possible. SCE selects high speed relays for these situations.

SCE uses fiber optic (FO) cable for communications between these relays because it is:

1. Fast;
2. Resilient (not subject to atmospheric or other interference);
3. Reliable (consistent latency);
4. Available as carrier grade terminal equipment (integral redundancies, design margins, maintenance support); and
5. A best utility practice.
6. Non-conductive (when using All-Dielectric Self-Supporting cable)

SCE does not allow the use of Intermittent and indeterminate communications methods, such as a leased circuits, radios using unlicensed frequencies, and cellular or satellite paths, which defeat the purpose of line current differential relays.

In cases where a second FO telecommunication is required, for protection relay coordination or to support a RAS, the second FO path must comply with WECC guidelines governing diverse routing. The customer will construct the communications path(s) between its end user Facility and the point of interconnection. Primary path can be provided with a FO cable at the end user Facility or as OPGW (fiber Optical Ground Wire). Diverse routing will be required for secondary path. Telemetering data (SCADA) and line protection control signals will be transported on these paths.

If FO is not required for line protection or RAS, a leased circuit may be used for telemetering (SCADA). See Section 7.6.

7.2 Fiber Optic Communications Paths:

The INTFAC will install the main and diverse FO cables (if needed) from its facility to SCE designated points just outside of the SCE interconnection substation, from which SCE will extend the FO cables into the substation. A minimum of eight (8) strands within each FO cable will be provided to SCE for its exclusive use. SCE follows the WECC Applicable Reliability Standards for space diversity between the INTFAC's main and diverse FO cables. SCE's implementation is the following:

7. Main and a diverse FO cables (i.e. redundant) on two separate paths (i.e. diverse) and spaced such that a single credible event cannot sever both cables. Equipment redundancy is also required. Options within the right-of-way include:
    a) Main path: OPGW or underbuilt FO cable on the gen-tie poles and for the Diverse path: Underground FO cable in the right-of-way; or
    b) Main and diverse (two) direct buried FO cables separated by ≥ 25 feet; or
    c) Main and diverse (two) FO cables in conduits separated by ≥ 10 feet and fully encased in concrete.

Protection Engineering has final approval for fiber architecture.

<u>Fiber Optic Cable at Aggregation (Collector) Substations</u>

If the INTFAC will be connecting to a non SCE aggregation substation (commonly known as a collector substation) that in turn is connected to an SCE substation, the INTFAC is responsible for providing the telecommunication equipment and communications paths between the collector sub and the INTFAC necessary for line protection and RAS participation. The INFAC is responsible for confirming its telecommunications plan of service meets the WECC Applicable Reliability Standards. An INTFAC that interconnects to a collector substation:

a) Is responsible for the telecom for its line protection between the INTFAC and its collector substation, including any lightwave, channel banks, or related terminal equipment.
b) Is responsible for transport of any RTU data from the INTFAC to the SCE terminal equipment at the collector substation.
c) May elect to install FO cables and equipment that meet WECC's diversity requirement. Sufficient space and facilities must also be provided at both locations (collector substation and INTFAC) to install appropriate equipment to support the RAS.

The provisions of this Handbook for space diversity apply on the INTFAC's side of the collector sub.

7.3 Space Requirements

SCE shall design, operate, and maintain certain telecommunications terminal equipment at the INTFAC to support line protection, telemetering (SCADA), equipment protection, and RAS communications applicable to the project. Refer to the respective sections for Protection and Telemetering for their space requirements.

The INTFAC shall provide sufficient floor space within a secure building for SCE to install and operate one communication equipment cabinet for each of the fiber optic cables (corresponding to the Protection requirements for one or two FO cables).

The INTFAC shall procure and install the communication equipment cabinet(s) per SCE's current Telecom Standards. These cabinet(s) shall be secured per current **California Seismic requirements**.

The INTFAC shall provide a working clearance of 36" in front and behind the communication equipment cabinet(s) for the safety of installation and maintenance personnel. The working clearance specified provides a 36" unobstructed space for ladders and/or test equipment carts. Additionally, SCE considers telecommunications equipment cabinets to contain "live electrical equipment," which is consistent with the 36" working clearance specified in the **National Electric Code**.

7.4 HVAC Requirements

The INTFAC shall provide and maintain suitable environmental controls in the equipment room, including an HVAC system to minimize dust, maintain a temperature of 30° C or less, and 5-95% non-condensing relative humidity.

The HVAC requirements for fiber optic lightwave, transport or data equipment are more stringent than what is required for RTU equipment. Therefore, whenever line protection or C/RAS specifies the use of fiber optic communications and its lightwave, transport or data equipment, the requirements of Section 6: Telemetering Requirements (Hardware) will match those in this Section 7.

7.5 Power and Grounding Requirements

The INTFAC shall provide a connection point to station ground within ten (10) feet of the SCE communication equipment rack(s). SCE will provide and install cabling from the equipment cabinet(s) to the designated station ground termination to protect the communications equipment and service personnel.

The INTFAC shall provide two 15 Amp dedicated branch circuits from the 125 VDC station power to support each required telecommunications equipment rack. The dedicated source breakers shall be labeled "SCE-Telecom A" and "SCE-Telecom B." If DC power is not available, two 15 Amp, 120 VAC circuits may be used as long as the circuits are sourced from an Uninterruptible Power System (UPS) with a minimum of a 4-hour backup. The power source shall not be shared with other equipment.

The INTFAC shall provide a 120 VAC, 15 Amp convenience power source adjacent to the telecommunications equipment cabinet(s). As this source will be utilized for tools and test equipment by installation and maintenance personnel, UPS is not required. The INTFAC shall provide ample lighting for the safety of installation and maintenance personnel.

For RTU power and grounding requirements, refer to Section 6

7.6 Telemetry and Leased Circuit:

If the INTFAC requires a dedicated RTU but is not required to construct fiber optic cables for line protection or C/RAS (typical for INTFACs ≥10 MW but < 20 MW), the INTFAC shall:

8. Arrange with the local service provided to deliver a 25Mb or greater Ethernet circuit from the INTFAC location to a SCE designated SCE service center or similar facility.
9. Technical specifications for circuit are as follows:
   a. Latency Max 20 ms (one-way)
   b. MTU Max 9126 (on Telco side)
   c. CIR Min 20 Mbps
   d. PDR 99.9% (PDR=Packet Delivery Rate)
   e. Availability 99.99% (network availability)
   f. Sync None (We will have to provide our own)
   g. Interface GigE (Multimode preferred)
10. Designate to the service provided that SCE shall be authorized to report trouble and to initiate inquires, troubleshooting and repairs with the service provider on the INTFAC's behalf in the event of an interruption of service on the communication circuit;
11. Incur all make ready and reoccurring costs of the leased circuit;
12. Provide high-voltage protection for the service providers communications, if necessary.
13. Provide conduit, raceway, copper cable, fiber optic cable and any miscellaneous equipment or services as necessary for SCE to extend the leased circuit from the Local Exchange Carrier MPOE (Minimum Point of Entry or "demark") to the SCE communications equipment described in Item 6 below. The SCE equipment cabinet(s) shall be no more than 100 feet from the MPOE;
14. Provide conduit, raceway, copper cable, fiber optic cable and any miscellaneous equipment or services as necessary to extend a communications circuit from the RTU to communications equipment and the leased communications circuit in the event the SCE RTU is not located within the same facility as the communications equipment, SCE's RTU and communications equipment shall be no further apart than 100 feet.
15. Provide (1) communications cabinet described in Section 7.3 above.

7.7 Miscellaneous:

1. While SCE may discuss telecommunication connection preferences of the customer's facility, ultimately, SCE has final discretion regarding the selection of telecommunication connection equipment. The telecommunication connection must fit within the operating requirements, design parameters, and communications network architecture of the entire SCE telecommunications network.
2. Use of SCE telecommunications infrastructure (including microwave facilities and fiber optic cables) by a customer is not an option.

3. Leased circuits, radio using unlicensed frequencies, cellular, and satellite are not acceptable options at SCE for high speed protective line relays or C/RAS supporting transmissions lines.
4. SCE telecommunications terminal equipment, being electronic devices, will be periodically refreshed, i.e. replaced, sometime after installation. The time until refresh depends on a number of factors, including its operating environment, repair history, and manufacturer support. A refresh typically occurs around 10 years and could be as early as 5 years or as long as 15 years after installation. The interconnection customer should anticipate for these refreshes to be considered Capital Additions under the terms of the interconnection agreement, with the associated cost being the responsibility of the interconnection customer.
5. The customer shall provide access for SCE employees and approved contractors for planned maintenance and service restoration 24 hours a day, 7 days a week after the communication equipment is installed and in operation.

SECTION 8 PROPERTY REQUIREMENTS

The customer must acquire the necessary Right of Way requirements for their end use Facility along with the access requirements to the point of interconnection with SCE's facilities. The use of SCE Right of Way and/or fee owned property shall not be included in any interconnection proposals.

8.1 Transmission Line Crossing Policy

The Interconnection Transmission line or access Right of Way that are proposed to cross SCE transmission line or access easements or fee owned property must be submitted to SCE's Vegetation & Land Management (V&LM)organization for a separate review request for approval/denial. For your reference, below are SCE's Transmission Crossing Policy guidelines:

- A new customer transmission line of equal or lower voltage shall not be allowed the superior position and will cross under the existing SCE facilities and/or the new facilities proposed prior to the new line.
- A new customer transmission line, triggered by a customer's end user Facility, with higher voltage may be allowed the superior position with G.O. 95[2] Grade "A" self-supporting Dead-end construction with minimum of double insulator strings on both sides. This will apply to all voltages. SCE will regain the superior position should SCE lower voltage facilities be upgraded in the future of equal or higher voltage than the customer's end user facilities.
- A new customer transmission line of higher voltage may be allowed the superior position if it is crossing a SCE multiple circuits corridor (two circuits or more), but this type of crossing will need to be reviewed on a case-by-case basis.
- A new customer transmission line, regardless of voltage, shall not be allowed the superior position if it is crossing a circuit which terminates at the switchyard for a nuclear power plant.

8.2 Infrastructure Property Requirements

Substation: The following approximate land requirements are needed for typical interconnection facilities (SCE owned substation) on the customer's property:

- SCE owned Transformers:
    - 66 kV Tap: 105 ft. by 115 ft.
    - 66 kV Loop: 135 ft. by 160 ft.
    - 115 kV Tap: 115 ft. by 130 ft.
    - 115 kV Loop: 170 ft. by 205 ft.

[2] ***General Order No. 95. (G.O.* 95)** the "Rules for Overhead Line Construction" established by the California Public Utilities Commission is minimum requirements for designing and constructing overhead and underground electrical facilities. In some cases, SCE Practices and Standards may be more stringent. The interconnecting customer must adhere to the appropriate requirements.

- Customer owned Transformers:
  - 66 kV Tap: 80 ft. by 80 ft.
  - 66 kV Loop: 135 ft. by 105 ft.
  - 115 kV Tap: 115 ft. by 110 ft.
  - 115 kV Loop: 170 ft. by 140 ft.

Minimum substation land requirements are subject to change according to engineering studies and interaction with SCE is required for final determination. The dimensions above include a required 10 ft. easement bordering the interconnection facility under the assumption that the customer owns the transformer, other facilities; and the land needed for the incoming line(s) is not included.

PART 3

Transmission Interconnection Requirements

CONTENTS

SECTION 1 TRANSMISSION INTERCONNECTION OVERVIEW

The Transmission Interconnection Section specifies what is necessary to interconnect non-SCE owned Transmission Facilities to SCE's electric system and provides these customers with an overview of the Requirements to address interconnection requests. It also provides a means to facilitate the communication of technical information to SCE regarding the generation facilities interconnecting to SCE's electric system.

SECTION 2 PROTECTION REQUIREMENTS

Protective devices (relays, circuit breakers, synchronizing equipment, etc.) must be installed for the protection of SCE's electric system as required by SCE. Generally, the protective devices may differ with the relative electrical capacity of the installation. The larger the installation, the greater the effect it may have on SCE's electric system.

While some protection requirements can be standardized, the detailed protection design highly depends on the type and characteristics of the interconnecting Transmission Facilities, (i.e., voltage, impedance, and ampacity), and the existing protection equipment and configuration of SCE's electric system in the vicinity of the point of interconnection. Fault duty, existing relay schemes, stability requirements, and other considerations may impact the selection of protection systems. Consequently, identical transmission interconnection customers connected at different locations in SCE's electric system can have widely varying protection requirements and costs. The varying protection requirements will be used to define the corresponding Telecommunications requirements, (See Section 6 Telecommunications Requirements.)

For voltage classes 200 kV and above, primary relay protection for network transmission circuits will be designed to clear transmission line faults within a maximum of 6 cycles. Project stability studies may indicate that faster clearing times are necessary. To ensure the reliability of the electric system, protective relays, and associated equipment require periodic replacement. Typically, the frequency of transmission line relay replacement does not exceed once every 15 years, but equipment failure, availability of replacement parts, system changes, or other factors may alter the relay system replacement schedule.

Protection Categories: SCE classifies Transmission Facilities connecting to SCE electric system into three distinct categories each having their own distinctive protection requirements.

The categories are:

1. Interconnection voltage 66 kV and 115 kV
2. Interconnection voltage 220 kV
3. Interconnection voltage 500 kV (Protection requirements of these categories are described in Sections 2.1 to 2.3.)

Disclaimer: These Protection Categories were established for convenience and are based on urban/suburban circuits with normal load density. The final decision as to the specific requirements for each installation will be made by SCE.

The following is a legend of device numbers referred to in Sections 2.1 through 2.3:

Legend

Protective Device Numbers and Description

4	Master Contactor
21	Distance/Impedance
25	Synchronizing or Synchronism Check
27	Under-voltage
32	Power Direction
40	Loss of Field Detection
46	Current Balance
47	Voltage Phase Sequence
50	Breaker Failure
51	Time Over-current
51G	Ground Time Over-current
51N	Neutral Time Over-current
51V	Voltage Restrained/Controlled Time Over-current
59	Over-voltage
59G	Over-voltage Type Ground Detector
67V	Voltage Restrained/Controlled Directional Time Over-current
78	Loss of Synchronism (Out-of-Step)
79	Reclosing Relay
810	Over-frequency
81U	Under-frequency
87	Current Differential

NOTE: For additional information on device numbers, refer to ANSI C37.2.

2.1 Category 1: Voltage 66 kV and 115 kV

2-terminal or 3-terminal lines: Dual pilot

Source substation (SCE):

(1) Primary relay that provides communication based high-speed protection (87L); backup Phase distance (21) or directional phase overcurrent (67) and directional ground overcurrent (67G) protection. Example SEL-311L

(1) Duplicate relay that provides communication based high-speed protection (87L); backup Phase distance (21) or directional phase overcurrent (67) and directional ground overcurrent (67G) protection. Example L90

(2) Fiber interface and two redundant and diverse digital communication path

Interconnection substation: (looking towards the line)

(1) Primary relay that provides communication based high-speed protection (87L); backup Phase distance (21) or directional phase overcurrent (67) and directional ground overcurrent (67G) protection. Example SEL-311L

(1) Duplicate relay that provides communication based high-speed protection (87L); backup Phase distance (21) or directional phase overcurrent (67) and directional ground overcurrent (67G) protection. Example L90

(2) Fiber interface and two redundant and diverse digital communication path

2.2 Category 2: Voltage 220 kV

2-terminal line: Dual pilot

Source substation (SCE):

(1) Primary relay that provides communication based high-speed protection (87L); backup Phase distance (21) or directional phase overcurrent (67) and directional ground overcurrent (67G) protection. Example SEL-311L

(1) Duplicate relay that provides communication based high-speed protection (87L); backup Phase distance (21) or directional phase overcurrent (67) and directional ground overcurrent (67G) protection. Example L90

(2) Fiber interface and two redundant and diverse digital communication paths

Interconnection substation: (looking towards the line)

(1) Primary relay that provides communication based high-speed protection (87L); backup Phase distance (21) or directional phase overcurrent (67) and directional ground overcurrent (67G) protection. Example SEL-311L

(1) Duplicate relay that provides communication based high-speed protection (87L); backup Phase distance (21) or directional phase overcurrent (67) and directional ground overcurrent (67G) protection. Example L90

(2) Fiber interface and two redundant and diverse digital communication paths

2.3 Category 3: Voltage 500 kV

Source substation (SCE):

(2) Communication based high-speed relays that provides high-speed protection (87L or POTT); backup Phase distance (21) or directional phase overcurrent (67) and directional ground overcurrent (67G) protection. Example L90, SEL-411L

(1) Communication based high speed relay that provides Permissive Over-Reaching Transfer Trip Scheme (POTT) and Direct Transfer Trip (DTT); backup Phase distance (21) or directional phase overcurrent (67) and directional ground overcurrent (67G) protection. Example SEL-421

(2) Direct Transfer Trip Relays. Example RFL-9745's

(3) Fiber interfaces and two redundant and diverse digital communication paths.

<u>Interconnection substation: (looking towards the line)</u>

(2) Communication based high-speed relays that provides high-speed protection (87L or POTT); backup Phase distance (21) or directional phase overcurrent (67) and directional ground overcurrent (67G) protection. Example L90, SEL-411L

(1) Communication based high speed relay that provides Permissive Over-Reaching Transfer Trip Scheme (POTT) and Direct Transfer Trip (DTT); backup Phase distance (21) or directional phase overcurrent (67) and directional ground overcurrent (67G) protection. Example SEL-421

(2) Direct Transfer Trip Relays. Example RFL-9745's

(3) Fiber interfaces and two redundant and diverse digital communication paths.

2.4 Circuit Breaker Short Circuit Duty Ratings and Surge Protection

2.4.1 SCE Duty Analysis

The recognized standard for circuit breakers rated on a symmetrical current basis is IEEE Standard C37.010-1999(R2005), "IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis," and ANSI/IEEE Standard C37.5 for circuit breakers rated on a total current basis. SCE will review circuit breaker short circuit duty ratings and surge protection to identify any additions required to maintain an acceptable level of SCE system availability, reliability, equipment insulation margins, and safety. Also, the management of increasing short circuit duty of the transmission system involves selecting the alternative that provides the best balance between cost and capability. System arrangements must be designed so that the interrupting capability of available equipment is not exceeded.

When studies of planned future system arrangements indicate that the short-circuit duty will reach the capability of existing circuit breakers, consideration should be given to the following factors:

Methods of limiting short circuit duty to under the circuit breaker capability, or less:

1. De-looping or rearranging transmission lines at substations;
2. Split bus arrangements.
    - Magnitude of short circuit duty.
    - The effect of future projects on the short circuit duty.
    - Increasing the interrupting capability of equipment.

- The ability of a particular circuit breaker to interrupt short circuit currents considering applicable operating experience and prior test data.

Please note that SCE performs an annual short circuit duty analysis, which may include re-evaluation of the facility circuit breakers.

2.4.2 Customer Owned Duty/Surge Protection Equipment

In compliance with Good Utility Practice and, if applicable, the Requirements within the Handbook, the owner of the Transmission Facilities being interconnected shall provide, install, own, and maintain relays, circuit breakers and all other devices necessary to remove any fault contribution those facilities may have related to any short circuit occurring on SCE's electric system, not otherwise isolated by SCE's equipment, such that the removal of the fault contribution shall be coordinated with the protective requirements of SCE's electric system. Such protective equipment shall include, but not limited to, a disconnecting device and a fault current-interrupting device located between the customer's Transmission Facilities and SCE electric system at a site selected upon mutual agreement (not to be unreasonably withheld, conditioned or delayed) of the Parties. The owner of the Transmission Facilities shall be responsible for protection of their equipment and other equipment from such conditions as negative sequence currents, over- or under-frequency, sudden load rejection, over- or under-voltage, and generator loss-of-field. The interconnecting Transmission Facilities owner shall be solely responsible to disconnect their facility if conditions on SCE's electric system are impacted by them.

2.5 RAS and CRAS

A RAS (Remedial Action Scheme) is an automatic system designed to 1) detect predetermined system conditions by RAS monitoring relays; 2) take corrective actions by logic processors and mitigation relays for the grid to meet requirements identified in the NERC Reliability Standards. A CRAS (Centralized Remedial Action Scheme) has the same functionality as a standalone RAS but offers a Centralized platform which coordinates & optimizes the various RASs. CRAS platform has been specified as the standard moving forward.

A RAS/CRAS has three basic components:

1. Line or Bank outage monitor relay ("Line Monitor" or "Bank Monitor"): typically installed at SCE substations, occasionally installed also at the Interconnection substations as required.
2. Mitigation/Tripping relay: typically installed at both SCE and Interconnection substations.
3. Logic Processor and arming program: SCE substations and/or centralized locations.

A typical RAS/CRAS has two redundant systems (system A and system B) with full diverse digital communications paths. The two systems are typically identical.

CRAS is the standard for all new RAS installations.

- Exception for the use of CRAS would be in areas where anticipated Generation-interconnection growth is slow to minimal

For existing standalone RASs with new generation being added, the RAS-to-CRAS Scoring Matrix (maintained by Protection Engineering) is to be utilized to determine when RAS should be transitioned to CRAS.

SECTION 3 MISCELLANEOUS REQUIREMENTS:

3.1 Transmission Facilities Requirements

The customer shall ensure that its transmission facilities are constructed to a minimum of General Order 95 **Rules for Overhead Electric Line Construction** standards when facilities are built within California and to **National Electric Safety Code** standards when facilities are built outside of California. The customer shall ensure that its underground transmission facilities are constructed to a minimum of General Order 128 **Rules for Construction of Underground Electric Supply and Communication Systems** when facilities are built within California and to **National Electric Safety Code** standards when facilities are built outside of California. Where facilities are intended to be owned by SCE, additional design requirements apply and must be consistent with SCE's design standards

3.2 Sub-Synchronous Interaction Evaluations

Transmission lines with series capacitors or Flexible Alternating Current Transmission Systems (FACTS) interconnected within electrical proximity of generating facilities are susceptible to Subsynchronous Interaction (SSI) conditions which must be evaluated. Sub-Synchronous Interaction evaluations include Sub-Synchronous Resonance (SSR) and Subsynchronous Torsional Interactions (SSTI) for conventional generation units, and Subsynchronous Control Instability (SSCI) for inverter-based generators using power electronic devices (e.g. Solar PV and Wind Turbines).

A study must be performed to evaluate the SSI between transmission lines with series capacitor banks and/or FACTS devises projects interconnecting in close electrical proximity of generating facilities to ensure that the transmission projects does not damage SCE's control systems. The SSI study may require that the INTFAC provide a detailed PSCAD model of its series capacitor banks and/or FACTS and associated control systems, along with the manufacturer representative's contact information. The study will identify any mitigation(s) that will be required prior to initial energization of the transmission project. The study and the proposed mitigation(s) shall be at the expense of the INTFAC.

The Interconnection Customer is 100% responsible for the cost associated with SSI studies and mitigations. It is the INTFAC's responsibility to select, purchase, and install equipment that are compatible with the existing system.

3.2.1 Sub-Synchronous Resonance Studies

SSR occurs when the network natural frequencies (below fundamental frequencies) coincide with the turbine-generator torsional-mode frequencies causing the turbine-generator to stress that may result in shaft failure. The turbine-generator and the system may interact with SSR into two main ways: Torsional Interaction (TI) and Torque Amplification (TA). In order to evaluate a potential SSR condition on a new series capacitors and / or FACTS devises installation near generation facilities a screening study needs to be conducted to identify any TA or TI impact on the series compensation level or FACTS devices controls. If a case is identified by the initial screening process (Frequency Scanning Study) a more detailed time domain study is required to quantify the potential damage and provide with mitigation measures.

3.2.2 Sub-Synchronous Control Interaction Studies

SSCI risk occurs on zero-crossing reactance when going from negative (capacitive) to positive (inductive) reactance. In order to evaluate a potential SSCI condition on a new series capacitors and / or FACTS devises installation near generation facilities a screening is performed through impedance scans looking out into the system from the inverter-based plant, with the plant disconnected. If a case is identified by the initial screening process, a more detailed study is required to quantify the potential damage and provide with mitigation measures.

3.3 Automatic Voltage Regulators (AVR)

Automatic voltage control equipment, synchronous condensers, and Flexible Alternating Current Transmission System (FACTS) shall be kept in service to the maximum extent possible with outages coordinated to minimize the number out of service at any one time. Such voltage control equipment shall operate at voltages specified by the CAISO.

3.4 Underfrequency Relays

Since the facilities of SCE's electric system may be vital to the secure operation of the Interconnection, CAISO and SCE shall make every effort to remain connected to the Interconnection. However, if the system or control area determines that it is endangered by remaining interconnected, it may take such action as it deems necessary to protect the system.

Intentional tripping of tie lines due to underfrequency is permitted at the discretion of SCE's electric system, providing that the separation frequency is no higher than 57.9 Hz with a one-second time delay. While acknowledging the right to trip tie lines at 57.9 Hz, the preference is that intentional tripping shall not be implemented.

3.5 Insulation Coordination

Insulation coordination is the selection of insulation strength and practice of correlating insulation levels of equipment and circuits with the characteristics of surge-protective devices such that the insulation is protected from excessive over-voltages. Insulation coordination must be done properly to ensure electrical system reliability and personnel safety.

The customer shall be responsible for an insulation coordination study to determine appropriate surge arrester class and rating on their Transmission Facilities interconnecting into SCE's system. In addition, the customer is responsible for the proper selection of substation equipment and their arrangements from an insulation coordination standpoint.

Basic Surge Level (BSLs), surge arrester, conductor spacing and gap application, substation and transmission line insulation strength, protection, and shielding shall be documented and submitted for evaluation as part of the interconnection plan.

3.6 Ratings

3.6.1 Facility Ratings

The ratings of facilities are the responsibility of the owner of those facilities. Ratings of facilities must conform to the current NERC Reliability Standard governing Facility Ratings.

3.6.2 Ratings Provided by Equipment Manufacturers

Equipment installed on SCE's electric system is rated according to the manufacturer's nameplate or certifications, and ANSI/IEEE standards. The manufacturer's nameplate rating is the normal rating of the equipment. ANSI/IEEE standards may allow for emergency overloads above the normal rating under specified conditions and often according to an engineering calculation. Emergency loading may impact the service life of the equipment. In some cases, the manufacturer has certified equipment for operation at different normal or emergency loads based on site-specific operation conditions. Older technology equipment is rated according to the standards under which it was built unless the manufacturer, ANSI/IEEE standards, or SCE's determination indicates that a reduced rating is prudent, or an increase rating is justified.

3.6.3 Rating Practice

The normal and emergency ratings of transmission lines or the transformation facilities shall equal the least rated component in the path of power flow.

3.6.4 Ambient Conditions

Since SCE's territory is in a year-round moderate climate, SCE does not establish equipment ratings based on seasonal temperatures. That is, SCE standard ratings for normal and emergency ratings are the same throughout the year and reflect summer ambient temperatures coincident with ANSI/IEEE standards, i.e., 40°C (104°F). However, in some cases SCE may calculate site-specific ratings that consider the local ambient conditions based on ANSI/IEEE rating methods.

3.6.5 Transmission Lines

The transmission circuit rating is determined according to the least rated component in the path of power flow. This is comprised of the transmission line conductor/cable, the series devices in the line, the allowable current that will not cause the conductors to sag below allowable clearance limits, the allowable current that will not cause the cables to operate above the designed temperature limit, and the termination equipment.

3.6.6 Overhead Conductors

The transmission line conductor ratings are calculated in accordance with ANSI/IEEE 738-1993. For Aluminum Conductor Steel Reinforced (ACSR) conductor the normal conductor, rating allows a total temperature of 90°C, and the emergency rating allows 135°C. Similarly, for aluminum and copper conductors, SCE permits 85°C and 130°C. For Aluminum Conductor Steel Supported (ACSS), SCE base the normal rating at 120°C, and 200°C for the emergency rating. Higher or lower temperature limits may be permitted as appropriate, depending on engineering justification.

3.6.7 Underground Cable

The transmission line cable ratings are calculated in accordance with IEC 60287. For XLPE insulated cable, the normal cable rating allows a total temperature of 90° C, and the emergency rating allows 105° C for 4 hours. Higher or lower temperature limits may be permitted as appropriate depending on engineering justification and/or component tested data.

3.6.8 Series and Shunt Compensation Devices

Series capacitor and reactors are only permitted to be loaded to ANSI/IEEE limits or as specified by the manufacturer. VAR compensators shall be rated according to the ANSI/IEEE standards where applicable and according to the manufacturer's limitations. These ratings are reported to CAISO Transmission Register. Shunt capacitors and reactors are not in the path of power flow, so they are not directly a "limiting component." However, their reactive power capacity is reported to CAISO Transmission Register.

3.6.9 Terminal Equipment

Terminal equipment are comprised of the following components: circuit breakers, disconnect switches, jumpers, drops, conductors, buses, and wave-traps, i.e., all equipment in the path of power flow that might limit the capacity of the transmission line or transformer bank to which it is connected. The normal and emergency ampere rating for each termination device is reported to CAISO in its Transmission Register.

3.6.10 Transformer Bays

The rating of a transformer bay is determined by the least rated device in the path of power flow. This comprises ratings of the transformer, the transformer leads, the termination equipment, and reduced parallel capacity where applicable. The transformer rating is compared to the termination equipment ratings and lead conductors to establish the final transformation rating based on the least rated component. All the above ratings are reported to the CAISO Transmission Register.

3.6.11 Transformer Normal Ratings

The "normal" rating is the transformer's highest continuous nameplate rating with all of its cooling equipment operating. The only exception is when a special "load capability study" has been performed showing that a specific transformer is capable of higher than nameplate loading and for which the test data or calculations are available.

3.6.12 Transformer Emergency Ratings

A transformer's emergency rating is arrived at by one of two methods. First, if no overload tests are available, then a 10% overload is allowed. Second, if a factory heat-run or a load capability study has been performed, the emergency rating may be as high as 20% above normal, as revealed by the test. For transformers on the transmission system, (i.e., primary voltage of 500 kV), the allowed duration of the emergency loading is 24-hours. For transformers with a primary voltage of 161 kV to 220 kV, the allowed duration is 30 days.

3.6.13 Parallel Operation of Transformers

When two or more transformers are operated in parallel, consideration is given to load split due to their relative impedances such that full parallel capacity is not usually realized. The permissible parallel loading is calculated according to ANSI/IEEE standards.

3.6.14 Relays Protective Devices

In cases where protection systems constitute a loading limit on a facility, this limit is the rating for that facility. These limiting factors are reported to the CAISO Transmission Register and are so noted as to the specific reason, e.g., "limited to 725 A by relay setting."

3.6.15 Path Ratings

As stated in Section 2.2.2 of the Path Rating Process of the Project Coordination and Path Rating Processes[1], new facilities and facility modifications should not adversely impact accepted or existing ratings regardless of whether the facility is being rated. New or modified facilities can include transmission lines, generating plants, substations, series capacitor stations, remedial action schemes or any other facilities affecting the capacity or use of the interconnected electric system.

3.7 Synchronizing of Facilities

Testing and synchronizing of a customer's Transmission Facilities may be required depending on SCE's electric system conditions, ownership, or policy, and will be determined based on facility operating parameters. Such procedures should provide for alternative action to be taken if lack of information or loss of communication channels would affect synchronization.

Appropriate operating procedures and equipment designs are needed to guard against out-of-sync closure or uncontrolled energization. (Note: SCE's transmission lines utilize ACB phase rotation, which is different than the national standard phase rotation). The owner of the Transmission Facilities is responsible to know and follow all applicable regulations, industry guidelines, safety requirements, and accepted practice for the design, operation and maintenance of the facility.

Synchronizing locations shall be determined ahead of time; required procedures shall be in place and be coordinated with SCE. SCE and the owner of the Transmission Facilities shall mutually agree and select the initial synchronization date. The initial synchronization date shall mean the date upon which a facility is initially synchronized to SCE's electric system and upon which trial operation begins.

3.8 Maintenance Coordination and Inspection

The security and reliability of the interconnected power system depends upon periodic inspection and adequate maintenance of the customer's Transmission Facilities and associated equipment, including but not limited to control equipment, communication equipment, relaying equipment, and other system facilities. Entities and coordinated groups of entities shall follow CAISO procedures and are responsible for disseminating information on scheduled outages and for coordinating scheduled outages of major facilities which affect the security and reliability of the interconnected power system.

3.9 Abnormal Frequency and Voltages

3.9.1 Joint Reliability Procedures

Where specific transmission issues have been identified, those entities affected by and those entities contributing to the problem shall develop joint procedures for maintaining reliability.

3.9.2 Voltage and Reactive Flows

CAISO shall coordinate the control of voltage levels and reactive flows during normal and Emergency Conditions. All operating entities shall assist with the CAISO's coordination efforts.

[1] https://www.wecc.org/Reliability/Project_Coordination_Path_Rating_and_Progress_Report_Processes_20170316.pdf

3.9.3 Transfer Limits Under Outage and Abnormal System Conditions

In addition to establishing total transfer capability limits under normal system conditions, transmission providers and balancing authority shall establish total transfer capability limits for facility outages and any other conditions such as unusual loads and resource patterns or power flows that affect the transfer capability limits.

3.10 Communications and Procedures

3.10.1 Use of Communication System

It is essential to establish and maintain communications with the SCE Grid Control Center (GCC), the Alternate Grid Control Center (AGCC) or a jurisdictional Switching Center should a temporarily attended station or area of jurisdiction become involved in a case of system trouble. It is equally important that communication services be kept clear of nonessential use during times of system trouble to facilitate system restoration or other emergency operations.

3.10.2 Remedial Action Schemes Communication Equipment Requirements

Customer Transmission Facilities will require the necessary communication equipment for the implementation of RAS. This equipment provides line monitoring and high-speed communications between the customer's breaker and the central control facility, utilizing applicable protocols. RASs may also be applied to individual transmission lines to relieve congestion on much larger portion of SCE's electric system. Thus, allowing a RAS to incorporate disconnection into automatic control algorithms under contingency conditions, as needed.

RASs are fully redundant systems. The following paragraph is an excerpt from the "WECC Remedial Action Scheme Design Guide that specifies the Philosophy and General Design Criteria" for RAS redundancy. *"Redundancy is intended to allow removing one scheme following a failure or for maintenance while keeping full scheme capability in service with a separate scheme. Redundancy requirements cover all aspects of the scheme design including detection, arming, power, supplies, telecommunications* facilities *and equipment, logic controllers (when applicable), and RAS trip/close circuits.* Excerpt from: WECC Remedial Action Scheme Design Guide (11/28/2006)

3.10.3 Critical System Voltage Operation

Voltage control during abnormal system configurations requires close attention with consideration given to what operations will be necessary following loss of the next component. Voltages approaching 10% above or below the normal value are considered critical with rate of change being of principal importance.

SECTION 4 GENERAL OPERATING REQUIREMENTS:

- **System Operating Bulletins:** The Transmission Facilities connecting into SCE's electric system may be subject to operating requirements established by SCE, the CAISO or both. SCE's general operating requirements are discussed in the sections below. SCE may also require additional operating requirements specific to a specific set of Transmission Facilities. If so, these requirements will be documented in SCE's System Operating Bulletins (SOB), Substation Standard Instructions (SSI), and/or interconnection and power purchase agreements. SCE's SOBs and/or SSIs specific to a set of Transmission Facilities, and any subsequent revisions will be provided by SCE to the customer as they are made available.
- **Owner of the Interconnecting Transmission Facilities' Responsibility:** The owner of the Transmission Facilities is responsible for complying with all applicable operating requirements. Operating procedures are subject to change as system conditions and system needs change. Therefore, it is advisable for the owner to regularly monitor operating procedures that apply to its generating facilities. The CAISO publishes its operating procedures on its internet site, but it is prudent for the owner to contact the CAISO for specific requirements.
- **Quality of Service:** The interconnection of the customer's Transmission Facilities with SCE's electric system shall not cause any reduction in the quality of service being provided to SCE's customers. If complaints result from operation of the customer's Transmission Facilities, such equipment shall be disconnected until the problem is resolved.
- **SCE Circuits:** Only SCE is permitted to energize any de-energized SCE circuit.
- **Operate Prudently:** The owner of the Transmission Facilities will be required to operate its equipment in accordance with prudent electrical practices.
- **Protection in Service:** The Transmission Facilities shall be operated with all of required protective apparatus. Redundant protective devices may be provided at the Interconnection customer's expense. Any deviation for brief periods of emergency may only be by agreement of SCE and is not to be interpreted as permission for subsequent incidents.

4.1 VAR Correction

VAR correction will normally be planned for light load, heavy load and for system normal and contingency conditions. This is to be accomplished by providing transmission system VAR correction to minimize VAR flow and to maintain proper voltage levels. The planning of transmission system VAR requirements should consider the installation of shunt capacitors, shunt reactors and tertiary shunt reactors, synchronous condensers, FACTS and transformer tap changers. The guidelines for reactive planning are as follows:

4.1.1 Interconnection

Interconnection with other utilities will normally be designed with the capability of maintaining near-zero VAR exchange between systems. Entities interconnecting their transmission system with SCE's e system shall endeavor to supply the reactive power required on their own system, except as otherwise mutually agreed. SCE shall not be obligated to supply or absorb reactive power for the customer's Transmission Facilities when it interferes with operation of SCE's electric system, limits the use of SCE interconnections, or requires the use of generating equipment that would not otherwise be required.

4.1.2 Subtransmission System

VAR correction will normally be planned for connection to 55 kV through 160 kV buses to correct for large customer VAR deficit, subtransmission line VAR deficit, and transformer A-Bank VAR losses, the objective being zero VAR flow at the high side of the A-Banks with VAR flow toward the transmission system on the high side of the A-Banks, if required. Adequate VAR correction shall be provided for maximum coincident customer loads (one-in-five year heat storm conditions), after adjusting for dependable local generation and loss of the largest local bypass generator.

4.2 Voltage Regulation/Reactive Power Supply Requirements

Operating entities shall ensure that reactive reserves are adequate to maintain minimum acceptable voltage limits under facility outage conditions. Reactive reserves required for acceptable response to contingencies shall be automatically applied when contingencies occur. Operation of static and dynamic reactive devices shall be coordinated such that static devices are switched in or out of service so that the maximum reactive reserves are maintained on generators, synchronous condensers, and other dynamic reactive devices.

To ensure secure and reliable operation of the interconnected power system, reactive supply and reactive generation shall be properly controlled and adequate reactive reserves shall be provided. If power factor correction equipment is necessary, it may be installed by the customer on its Transmission Facilities, or by SCE at SCE's facilities at the customer's expense.

4.2.1 Reactive Power Equipment – Induction Generators (in aggregate)

4.2.1.1 Facility Reactive Power Equipment Design

The owner of the interconnecting Transmission Facilities shall provide for the supply of its reactive requirements, including appropriate reactive reserves, and its share of the reactive requirements to support power transfers on interconnecting transmission circuits.

The reactive power equipment utilized by the interconnecting customer to meet SCE's Requirements must be designed to minimize the exposure of SCE's customers, SCE's electric system, and the electric facilities of others (i.e., other facilities and utilities in the vicinity) to:

- severe over-voltages that could result from self--excitation of induction generators,

transients that result from switching of shunt capacitors,

voltage regulation problems associated with switching of inductive and capacitive devices.

unacceptable harmonics or voltage waveforms, which may include the effect of power electronic switching, and

voltage flicker exceeding SCE Voltage Flicker limits as indicated in SCE Transmission Planning Criteria and Guidelines Figure 4-1 “VOLTAGE FLUCTUATION DESIGN LIMITS”.

4.2.1.2 Facility Reactive Power Equipment Design - provide variable source

The reactive power equipment utilized by customer’s Transmission Facilities connecting to SCE’s system to meet SCE’s Requirements must be designed to provide a variable source of reactive power (either continuously variable or switched in discrete steps). For discrete step changes, the size of any discrete step change in reactive output shall be limited by the following criteria:

- the maximum allowable voltage rise or drop (measured at the point of interconnection with SCE’s electric system) associated with a step change in the output of the Transmission Facilities’ reactive power equipment must be less than or equal to 1%; and
- the maximum allowable deviation from an Interconnection customer’s reactive power schedule (measured at the point of interconnection with the SCE system) must be less than or equal to 10% of the Interconnection customer’s maximum (boost) reactive capability.

4.2.2 Voltage and Reactive Control

4.2.2.1 Coordination

Operating entities shall coordinate the use of voltage control equipment to maintain transmission voltages and reactive flows at optimum levels for system stability within the operating range of electrical equipment. Operating strategies for distribution capacitors and other reactive control equipment shall be coordinated with transmission system requirements.

4.2.2.2 Transmission Lines

Although transmission lines should be kept in service as much as possible, during over-voltage system conditions a customer’s transmission line(s) may be subject to removal from operation as a means to mitigate voltage problems in the local area. SCE will notify CAISO when removing such facilities from and returning them back to service.

4.2.2.3 Switchable Devices

Devices frequently switched to regulate transmission voltage and reactive flow shall be switchable without de-energizing other facilities.

4.3 Voltage Imbalance and Abnormal Voltage or Current Waveforms (harmonics)

Power quality problems are caused when voltage imbalances and harmonic currents result in abnormal voltage and/or current waveforms. Generally, if a customer's Transmission Facilities connecting to SCE's system degrades power quality to SCE's facilities, or other SCE customer facilities, SCE may require the installation of equipment to eliminate the power quality problem.

4.3.1 Voltage Imbalance

The unbalanced voltage level (magnitude and phase), due to a customer's Transmission Facilities connecting to SCE's system, may not exceed 1% at the Point of Common Connection[2] (PCC), under steady state system conditions. Under certain conditions (contingency conditions), SCE may allow higher levels of voltage imbalance if justified after a study conducted by SCE. In any event, the unbalanced voltage level created by facilities interconnecting to SCE's system shall not exceed 1.5%.

It is the responsibility of customers connected to SCE's electric system to install adequate mitigation devices to protect their own equipment from damage that may be caused by voltage imbalance condition.

4.3.2 Harmonics

Facilities interconnecting to SCE's system are required to limit harmonic voltage and current distortion produced by static power converters or similar equipment in accordance to good engineering practice used at their facility to comply with the limits set by the current IEEE Standards.

4.3.3 Disconnection

SCE may disconnect any Facility connected to its system until the above requirements are met.

4.4 Grounding Circuits and Substations

Substation Grounding

Customers connecting Transmission Facilities to SCE's system shall follow practices outlined in IEEE 80 "IEEE Guide for Safety in AC Substation Grounding." Substation grounding is necessary to protect personnel and property against dangerous voltage potentials and currents during both normal and abnormal conditions of operation. Also, it provides a path to ground for the discharge of lightning strikes, a path to ground for the neutral currents of grounded neutral circuits and apparatus, the facilities for relaying to clear ground faults, the stability of circuit potentials with respect to ground and a means of discharging current-carrying equipment to be handled by personnel.

[2] The PCC will generally be at the location of the revenue meter or the point of ownership change in the electrical system between SCE and the Interconnection customer. For customers served by dedicated facilities, the location of the PCC will be determined by mutual agreement between the Interconnection customer and SCE.

Reason for Substation Grounding

Substation grounding practices are outlined in the latest IEEE 80 "IEEE Guide for Safety in AC Substation Grounding."

According to IEEE 80 – 2013 a safe ground grid design has the following two objectives:

1. "To provide means to carry electric currents into the earth under normal and fault conditions without exceeding any operating and equipment limits or adversely affecting continuity of service."
2. "To reduce the risk of a person in the vicinity of grounded facilities being exposed to the danger of critical electric shock."

"People often assumed that any grounded object can be safely touched. A low substation ground resistance is not, in itself, a guarantee of safety. There is no simple relation between the resistance of the ground system as a whole and the maximum shock current to which a person might be exposed. Therefore, a substation of relatively low ground resistance may be dangerous, while another substation with very high resistance may be safe or can be made safe with careful design." (IEEE 80 – 2013)

Each substation ground grid is a unique design. The conditions at the site: soil type, soil resistivity, fault current, clearing time, size of the substation, and other grounds all factor into the design.

4.4.1 Nominal Voltage and Grounding

SCE's most common primary distribution voltages are 4 kV, 12.47 kV, and 16 kV depending on the geographic area. Other voltages are also used in specific areas. Common subtransmission voltages are nominally 66 kV to 115 kV. Common transmission system voltages are nominally 161 kV, 220 kV, and 500 kV. The majority of the 4 kV, 12.47 kV, and 16 kV circuits are effectively grounded, but some are operated with high impedance or resonant grounding. A substantial number of the effectively grounded circuits are used for four-wire- distribution (phase to neutral connected loads). The system grounding may change over time, such as when high impedance grounding is replaced with solid grounding to accommodate four-wire load or solid grounding is replaced with resonant grounding to reduce wildfire risk. SCE will provide the customer the necessary information on the specific circuit serving its Transmission Facilities for proper grounding.

4.4.2 Grounding Grid Studies shall be conducted in the following situations:

Grounding calculations will be required for each new substation, and at existing substations, when the ground grid is altered or when major additions are made at a substation. A review of existing substation ground grids will be conducted by Engineering in the following situations, especially if triggered by interconnection requests – these shall be considered in queue order:

3. Short Circuit Duty Changes
    1. Circuit breaker replacement for short-circuit duty reasons if a grounding study has not been performed in the last eight years
    2. Addition of a transmission or subtransmission line into a substation

3. System changes causing a substantial change in the substation phase-to-ground short-circuit duty
4. Addition or replacement of a transformer at a substation other than a like for like replacement. The replacement of a transformer bank with the same base MVA is considered a like for like replacement. Replacement transformer banks with a lower base MVA than existing will not require a grounding study.
   a. Like for like transformer replacements require a review of the ground grid if a grounding study has not been performed in the last eight years.
5. Addition of new generation causing a substantial change in the substation phase-to-ground short-circuit duty

4. System Protection Changes
   1. Changes in system protection that significantly increases the clearing time for ground faults.
5. Grounding Source Changes
   1. Grounding of ungrounded or impedance grounded winding of a transformer
   2. Addition or major change of ground source at a substation
6. Substation Changes
   1. Alterations to substation fences including additions, movement, and attachments to other fences. The removal of vegetation that blocks access to a substation fence is considered a fence alteration.
   2. Alterations to substation ground grids that change their size or increase the effective substation ground grid impedance.
   3. Sale or lease of substation property for other uses.
7. A grounding review should be conducted any time a grounding problem is reasonably suspected.

4.4.3 Ground Mats

If the customer and SCE substation ground mats are tied together, all cables may be landed without any protection. However, if the customer and SCE substation ground mats are not tied together, all cables shall have protection at both ends. The design of cable protection, if any, on circuits used for protective relaying purposes shall be such that the operation of the protective relaying is not hampered when the cable protection operates or fails.

All customer ground mats shall be designed in accordance with good engineering practice and judgment. Presently the recognized standard for grounding is IEEE 80 "IEEE Guide For Safety in AC Substation Grounding." All ground mat designs should meet or exceed the requirements listed in this standard. If local governmental requirements are more stringent, building codes for example, they shall prevail. All customers shall perform appropriate tests, including soil resistivity tests, to demonstrate that their ground grid design meets the standard. Mats shall be tested at regular intervals to ensure their effectiveness.

Grounding studies shall be performed with industry-recognized software. This study will determine the maximum safe fault current for the ground grid design. It is suggested that the grid be designed for the maximum fault currents expected over the life of the facility.

If for any reason the worst-case fault current exceeds the design maximum fault current value due to changes in the interconnection customer's facility or changes on the SCE system, the customer shall conduct new grounding studies. Any changes required to meet safety limits and protect equipment shall be borne by the customer.

The customer is responsible to ensure that the GPR (Ground Potential Rise) of its interconnected mat does not negatively affect nearby structures or buildings. The cost of mitigation for GPR and other grounding problems shall be borne by the customer. Generator facility and SCE ground grids are typically tied together when they are in close proximity to each other. If it is elected to install separate ground grids for SCE and the customer, they shall be responsible to mitigate any transfer voltages and GPR that occur to SCE's grid due to faults on the customer's Transmission Facilities connecting to SCE's system.

Any ground grid design, which results in a GPR that exceeds 3,000 Volts (RMS) for the worst-case fault or has a calculated or measured ground grid resistance in excess of 3 ohm, will require special approval by SCE.

4.4.4 Substation Grounding

The customer connecting Transmission facilities to SCE's system shall follow practices outlined in IEEE 80 "IEEE Guide for Safety in AC Substation Grounding." Substation grounding is necessary to protect personnel and property against dangerous potentials and currents during both normal and abnormal conditions of operation. Also, it provides a path to ground for the discharge of lightning strikes, a path to ground for the neutral currents of grounded neutral circuits and apparatus, the facilities for relaying to clear ground faults, the stability of circuit potentials with respect to ground and a means of discharging current-carrying parts to be handled by personnel.

4.5 Non-SCE Pole Grounding

A customer connecting Transmission facilities to SCE's system shall follow SCE Construction, Operation, and Maintenance requirements. The last customer-owned structure shall be designed and constructed to meet SCE grounding requirements.

Customer facilities that will require SCE's crews to climb in order to construct, operate, or maintain SCE facilities shall be constructed so as to meet SCE standards and specifications. Constructing to SCE specifications will ensure that SCE crews can safely perform and complete the jobs at hand in accordance with SCE's Accident Prevention Manual that stipulate the proper training and equipment to safely climb and work. Examples of safety related requirements that:

8. Climbing Steps
9. Belt-Off Locations
10. Grounding Locations
11. Required PPE
12. Jumper Cable Ownership

Grounding bolts and bases are the same as step bolts and bases. If there is the potential need to have SCE personnel work on non-SCE owned poles connecting the customer's Transmission Facilities directly to SCE's electric system a dead-end structure adhering to SCE's Construction, Operation, and Maintenance standards, is required.

Please note that these requirements are for poles only. Non-steel or ungrounded poles will have; project-specific grounding requirements as determined by SCE.

SECTION 5 TELEMETERING REQUIREMENTS (HARDWARE)

5.1 Telemetering Requirements

For a high degree of service reliability under normal and emergency operation, it is essential that the customer's Transmission Facilities connecting to SCE's system have adequate and reliable telecommunication facilities.

The customer shall specify the following at the point of connection: the requested voltage level, MW/MVAR capacity, and/or demand.

SECTION 6 TELECOMMUNICATIONS REQUIREMENTS

6.1 General Description

The following requirements are to be used as guidelines for typical Telecommunications equipment installation at an Interconnection Facility (INTFAC). Specific design and installation details are addressed during final engineering for each specific INTFAC.

SCE's telecommunications facilities support line clearing in the event of faults in the INTFAC's gen-tie, Supervisory Control and Data Acquisition (SCADA) at the INTFAC's generator (See Section 7), and, if required, a Remedial Action Scheme. As noted in Section 2, the selection of protection devices depends on the INTFAC's generator size and type, number of generators, the composition of the existing protection equipment and the power line characteristics (i.e., voltage, impedance, and ampacity) of its gen-tie and the surrounding area. Identical INTFACs connected at different locations in SCE's electric system can have widely varying protection requirements and attendant telecommunication costs. For INTFACs connecting at ≥ 200 kV and above, the primary protection relays are designed to isolate the faulted transmission line within six (6) cycles. Voltage classes as low as 66 kV may have similar time clearing requirement if studies show an electrically faulted transmission line will have severe network impacts if not electrically separated from the grid as quickly as possible. SCE selects high speed relays for these situations.

SCE uses fiber optic (FO) cable for communications between these relays because it is:

1. Fast (speed of light);
2. Resilient (not subject to atmospheric or other interference);
3. Reliable (consistent latency);
4. Available as carrier grade terminal equipment (integral redundancies, design margins, maintenance support); and
5. A best utility practice.
6. Non-conductive (when using All-Dielectric Self-Supporting cable)

SCE does not allow the use of Intermittent and indeterminate communications methods, such as a leased circuits, radios using unlicensed frequencies, and cellular or satellite paths, which defeat the purpose of the line current differential relays.

In cases where a second FO telecommunication is required, for protection relay coordination or to support a RAS, the second FO path must comply with WECC guidelines governing diverse routing. The customer will construct the communications path(s) between its end user Facility and the point of interconnection. Primary path can be provided with a FO cable at the end user Facility or as OPGW (fiber Optical Ground Wire). Diverse routing will be required for secondary path. Telemetering data (SCADA) and line protection control signals will be transported on these paths.

If FO is not required for line protection or RAS, a leased circuit may be used for telemetering (SCADA). See Section 6.6.

6.2 Fiber Optic Communications Paths:

The INTFAC will install the main and diverse FO cables (if needed) from its facility to SCE designated points just outside of the SCE interconnection substation, from which SCE will extend the FO cables into the substation. A minimum of eight (8) strands within each FO cable will be provided to SCE for its exclusive use. SCE follows the WECC Applicable Reliability Standards for space diversity between the INTFAC's main and diverse FO cables. SCE's implementation is the following:

1. Main and a diverse FO cables (i.e. redundant) on two separate paths (i.e. diverse) and spaced such that a single credible event cannot sever both cables. Equipment redundancy is also required. Options within the right-of-way include:
   a. Main path: OPGW or underbuilt FO cable on the gen-tie poles and for the Diverse path: Underground FO cable in the right-of-way; or
   b. Main and diverse (two) direct buried FO cables separated by ≥ 25 feet; or
   c. Main and diverse (two) FO cables in conduits separated by ≥ 10 feet and fully encased in concrete.

Protection Engineering has final approval for fiber architecture.

<u>Fiber Optic Cable at Aggregation (Collector) Substations</u>

If the INTFAC will be connecting to a non SCE aggregation substation (commonly known as a collector substation) that in turn is connected to an SCE substation, the INTFAC is responsible for providing the telecommunication equipment and communications paths between the collector sub and the INTFAC necessary for line protection and RAS participation. The INTFAC is responsible for confirming its telecommunications plan of service meets the WECC Applicable Reliability Standards. An INTFAC that interconnects to a collector substation:

a. Is responsible for the telecom for its line protection between the INTFAC and its collector substation, including any lightwave, channel banks, or related terminal equipment.
b. Is responsible for transport of any RTU data from the INTFAC to the SCE terminal equipment at the collector substation.
c. May elect to install FO cables and equipment that meet WECC's diversity requirement. Sufficient space and facilities must also be provided at both locations (collector substation and INTFAC) to install appropriate equipment to support the RAS.

The provisions of this Handbook for space diversity apply on the INTFAC's side of the collector sub.

6.3 Space Requirements

SCE shall design, operate, and maintain certain telecommunications terminal equipment at the INTFAC to support line protection, telemetering (SCADA), equipment protection, and RAS communications applicable to the project. Refer to the respective sections for Protection and Telemetering for their space requirements.

The INTFAC shall provide sufficient floor space within a secure building for SCE to install and operate one communication equipment cabinet for each of the fiber optic cables (corresponding to the Protection requirements for one or two FO cables).

The INTFAC shall procure and install the communication equipment cabinet(s) per SCE's current Telecom Standards. These cabinet(s) shall be secured per current **California Seismic requirements**.

The INTFAC shall provide a working clearance of 36" in front and behind the communication equipment cabinet(s) for the safety of installation and maintenance personnel. The working clearance specified provides a 36" unobstructed space for ladders and/or test equipment carts. Additionally, SCE considers telecommunications equipment cabinets to contain "live electrical equipment," which is consistent with the 36" working clearance specified in the **National Electric Code**.

6.4 HVAC Requirements

The INTFAC shall provide and maintain suitable environmental controls in the equipment room, including an HVAC system to minimize dust, maintain a temperature of 30° C or less, and 5-95% non-condensing relative humidity.

The HVAC requirements for fiber optic lightwave, transport or data equipment are more stringent than what is required for RTU equipment. Therefore, whenever line protection or C/RAS specifies the use of fiber optic communications and its lightwave, transport or data equipment, the requirements of Section 5: Telemetering Requirements (Hardware) will match those in this Section 6.

6.5 Power and Grounding Requirements

The INTFAC shall provide a connection point to station ground within ten (10) feet of the SCE communication equipment rack(s). SCE will provide and install cabling from the equipment cabinet(s) to the designated station ground termination to protect the communications equipment and service personnel.

The INTFAC shall provide two 15 Amp dedicated branch circuits from the 125 VDC station power to support each required telecommunications equipment rack. The dedicated source breakers shall be labeled "SCE-Telecom A" and "SCE-Telecom B." If DC power is not available, two 15 Amp, 120 VAC circuits may be used as long as the circuits are sourced from an Uninterruptible Power System (UPS) with a minimum of a 4-hour backup. The power source shall not be shared with other equipment.

The INTFAC shall provide a 120 VAC, 15 Amp convenience power source adjacent to the telecommunications equipment cabinet(s). As this source will be utilized for tools and test equipment by installation and maintenance personnel, UPS is not required. The INTFAC shall provide ample lighting for the safety of installation and maintenance personnel.

For RTU power and grounding requirements, refer to Section 5

6.6 Telemetry and Leased Circuit:

If the INTFAC requires a dedicated RTU but is not required to construct fiber optic cables for line protection or C/RAS (typical for INTFACs ≥10 MW but < 20 MW), the INTFAC shall:

1. Arrange with the local service provider to deliver a 25Mb or greater Ethernet circuit from the INTFAC location to a SCE designated SCE service center or similar facility;
2. Technical specifications for circuit are as follows:
    a. Latency Max 20 ms (one-way)
    b. MTU Max 9126 (on Telco side)
    c. CIR Min 25 Mbps
    d. PDR 99.9% (PDR=Packet Delivery Rate)
    e. Availability 99.99% (network availability)
    f. Sync None (We will have to provide our own)
    g. Interface GigE (Multimode preferred)
3. Designate to the service provider that SCE shall be authorized to report trouble and to initiate inquires, troubleshooting and repairs with the service provider on the INTFAC's behalf in the event of an interruption of service on the communication circuit;

7. Incur all make ready and reoccurring costs of the leased circuit;
8. Provide high-voltage protection for the service provider communications, if necessary.
9. Provide conduit, raceway, copper cable, fiber optic cable and any miscellaneous equipment or services as necessary for SCE to extend the leased circuit from the Local Exchange Carrier MPOE (Minimum Point of Entry or "demark") to the SCE communications equipment described in Item 6 below. The SCE equipment cabinet(s) shall be no more than 100 feet from the MPOE;
10. Provide conduit, raceway, copper cable, fiber optic cable and any miscellaneous equipment or services as necessary to extend a communications circuit from the RTU to communications equipment and the leased communications circuit in the event the SCE RTU is not located within the same facility as the communications equipment, SCE's RTU and communications equipment shall be no further apart than 100 feet.
11. Provide (1) communications cabinet described in Section 5.3 above.

6.7 Miscellaneous:

1. While SCE may discuss telecommunication connection preferences of the customer's facilities, ultimately, SCE has final discretion regarding the selection of telecommunication connection equipment. The telecommunication connection must fit within the operating requirements, design parameters, and communications network architecture of the entire SCE telecommunications network.

13. Use of SCE telecommunications infrastructure (including microwave facilities and fiber optic cables) by a customer is not an option.
14. Leased circuits, radio using unlicensed frequencies, cellular, and satellite are not acceptable options at SCE for high speed protective line relays or C/RAS supporting transmissions lines.
15. SCE telecommunications terminal equipment, being electronic devices, will be periodically refreshed, i.e. replaced, sometime after installation. The time until refresh depends on a number of factors, including its operating environment, repair history, and manufacturer support. A refresh typically occurs around 10 years and could be as early as 5 years or as long as 15 years after installation. The interconnection customer should anticipate for these refreshes to be considered Capital Additions under the terms of the interconnection agreement, with the associated cost being the responsibility of the interconnection customer.
16. The customer shall provide access for SCE employees and approved contractors for planned maintenance and service restoration 24 hours a day, 7 days a week after the communication equipment is installed and in operation.

SECTION 7 PROPERTY REQUIREMENTS

7.1 Right of Way Requirements

The customer must acquire the necessary Right of Way requirements for its transmission line, along with the access requirements to the point of interconnection with SCE's facilities. The use of SCE's Right of Way and/or free owned property shall not be included in any interconnection proposals.

7.2 Transmission Line Crossing Policy

The interconnection transmission line or Access Right of Way that are proposed to cross SCE transmission line or access easements or fee owned property must be submitted to SCE's Vegetation & Land Management (V&LM) organization for a separate review request for approval. For your reference, below are SCE's Transmission Crossing Policy guidelines:

17. A new customer transmission line of equal or lower voltage shall not be allowed the superior position and will cross under the existing SCE facilities and/or the new facilities proposed prior to the new line.
18. A new customer transmission line, triggered by an INTFAC, with higher voltage may be allowed the superior position with G.O. 95[3] Grade "A" self-supporting Dead-end construction with minimum of double insulator strings on both sides. This will apply to all voltages. SCE will regain the superior position should SCE lower voltage facilities be upgraded in the future of equal or higher voltage than the customer's Transmission Facilities.
19. A new customer transmission line of higher voltage may be allowed the superior position if it is crossing a SCE multiple circuits corridor (two circuits or more), but this type of crossing will need to be reviewed on a case-by-case basis.
20. A new customer transmission line, regardless of voltage, shall not be allowed the superior position if it is crossing a circuit which terminates at the switchyard for a nuclear power plant.

7.3 Infrastructure Property Requirements

Substation: The following approximate land requirements are needed for typical interconnection facilities (SCE owned substation) on the customer's property:

21. 66 kV Tap: 90 ft. by 120 ft.
22. 66 kV Loop: 150 ft. by 120 ft.
23. 115 kV Tap: 110 ft. by 120 ft.
24. 115 kV Loop: 170 ft. by 200 ft.

Minimum substation land requirements are subject to change according to engineering studies and interaction with SCE is required for final determination. The dimensions above include a required 10 ft. easement bordering the interconnection facility under the assumption that the customer owns the transformer, other facilities; and the land needed for the incoming line(s) is not included.

[3] ***General Order No. 95. (G.O. 95)*** the "Rules for Overhead Line Construction" established by the California Public Utilities Commission is minimum requirements for designing and constructing overhead and underground electrical facilities. In some cases, SCE Practices and Standards may be more stringent. The INTFAC must adhere to the appropriate requirements.

PART 4

Affected Systems Overview

CONTENTS

SECTION 1 AFFECTED SYSTEMS COORDINATION AND NOTIFICATION

SCE's recognizes the affect an interconnecting generation Facility, end-user Facility or transmission Facility could have on a neighboring system, and firmly believes any mitigation must jointly be developed by all parties involved. To ensure this concept is understood by each of the three types of interconnecting facilities Part 1 Section 4.13, Part 2 Section 3.8 and Part 3 Section 3.9 of the Interconnection Handbook all specify:

> *"Where specific transmission issues have been identified, those entities affected by and those entities contributing to the problem shall develop joint procedures for maintaining reliability".*

The language identified above binds SCE to assist in working toward a solution. However, as SCE is a Transmission Owner with its BES assets under CAISO operational control these facilities must adhere the CAISO 5th Replacement FERC Electric Tariff (CAISO Tariff) and their associated Transmission Planning Process. These documents clearly identify the responsibility for the study of and coordination with affected systems as belonging to the CAISO. Below is a brief summarization of this documentation:

- **CAISO Tariff, Section 24.10 Operational Review and Impact Analysis**

  Section 24.10 of the document clearly states that CAISO will perform an analysis on all Regional Transmission Facilities that are a part of, proposed to be connected to, or made part of, the CAISO Controlled Grid as part of its Transmission Planning Process. This includes analysis identifying the impacts of these facilities on neighboring systems. The CAISO will also coordinate with the affected system to ensure the appropriate mitigation is in place.

- **CAISO Tariff, APPENDIX U Standard Large Generator Interconnection Procedures (LGIP)**
  Sections 3.2 and 3.7 of this document describes the responsibilities and procedures for coordination of studies and notification between affected systems for both new and modified generation facilities that are not assigned to a Queue Cluster Window. The CAISO coordinates the conduct of any studies required to determine the impact of the Interconnection Request on affected systems with affected system operators, to the extent possible, and, if possible, the CAISO will include those results (if available) in its applicable Interconnection Study, as described in the LGIP.

- **CAISO Tariff, APPENDIX Y GIP For Interconnection Requests Generator Interconnection Procedures (GIP)**
  Section 3.2 and 3.7 of this document describes the responsibilities and procedures for coordination of studies and notification between affected systems for both new and modified generation facilities that are either: (i) assigned to a Queue Cluster, (ii) included in the Independent Study Process, or (iii) included in the Fast Track Process. The CAISO coordinates the conduct of any studies required to determine the impact of the Interconnection Request on affected systems with affected system operators, to the extent possible, and, if possible, the

CAISO will include those results (if available) in its applicable Interconnection Study, as described in the GIP.

- **CAISO Business Practice Manual for the Transmission Planning Process**

  This document describes coordination with affected systems for both new and modified transmission and end-user facilities. The CAISO's Transmission Planning Process (TPP) utilizes a Request Window (Section 4.4) to provide TPP Participants with the opportunity to propose economic or reliability-driven transmission upgrades or additions (projects), requests for Economic Planning Studies, resource alternatives, i.e., Demand management programs or Generation, or otherwise submit additional relevant data to the CAISO for inclusion in the following year's annual Transmission Planning Process. The Request Window opens August 15th and closes October 15th of each planning cycle. The CAISO will post a summary of valid project proposals and study requests it receives from the Request Window on the CAISO website. Reliability transmission projects proposed by SCE shall be submitted by September 15 of each year to allow sufficient time for TPP Participants to review these projects. SCE shall also provide the CAISO the final study reports that document their NERC compliance, updates on the status of transmission projects previously approved by CAISO but not yet in-service and newly proposed transmission additions and upgrades. The CAISO will incorporate relevant planning information from these reports into the annual CAISO Transmission Plan.

  Section 7 of this document identifies that through the TPP the CAISO will act as the: (1) initiator; (2) organizer; and (3) participant in relevant forums for sub-regional and regional transmission planning. The TPP is the CAISO's procedure to coordinate joint studies and notify others of new and modified transmission and end user facilities.

SECTION 2 COORDINATION WITHIN BALANCING AUTHORITY'S METERED BOUNDARIES

It is the responsibility of the INTFAC to make appropriate arrangements with the appropriate BA to ensure its Facilities are within the BA's metered boundaries. SCE as the Transmission Owner is responsible for confirming that the INTFAC interconnecting has made appropriate provisions with a Balancing Authority to operate within its metered boundaries. SCE will coordinate with each of the three types of interconnections referred to in this Handbook as INTFAC as follows:

- **Transmission Coordination**
  Section 11.1.7 of the Transmission Interconnection Procedure defines how SCE confirms coordination amongst the Transmission Interconnection customer and the appropriate BA.
- **Generation Coordination**
  Sections 6.1.4 and 6.1.4.2 of CAISO's Generation Interconnection Deliverability Allocation Procedure (GIDAP) defines the coordination process SCE shall follow when the INTFAC is within the CAISO metered boundaries. In instances where the metered boundaries are outside the CAISO footprint, SCE shall:
  - Inform the INTFAC to coordinate with the appropriate BA during the results meeting.
  - Request appropriate documentation to confirm coordination amongst the INTFAC and the BA has occurred, prior to execution of the IA.
- **End-User Facility Coordination**
  SCE shall inform that End-User/MOS customer to coordinate with the appropriate BA and affected systems. Prior to execution of the MOS, SCE shall confirm that coordination amongst the End-User/MOS customer and the BA has occurred.

GLOSSARY

ACSR - Aluminum Conductor Steel Reinforced

ACSS - Aluminum Conductor Steel Supported

Adverse (System) Effect/Impact – The negative effects due to technical or operational limits on conductors or equipment being exceeded that may compromise the safety and reliability of the electric system.

AGCC - Alternate Grid Control Center

ANSI – American National Standards Institute

Applicable Reliability Standards – The requirements and guidelines of NERC, the Applicable Reliability Council, and the Balancing Authority Area of the Participating TO's Transmission System to which the Generating Facility is directly connected, including requirements adopted pursuant to Section 215 of the Federal Power Act.

AWG – American Wire Gauge

CAISO – California Independent System Operator.

CAISO Controlled Grid – The system of transmission lines and associated facilities of the parties to the Transmission Control Agreement that have been placed under the CAISO's Operational Control.

CAISO Tariff – The CAISO's tariff, as filed with FERC, and as amended or supplemented from time to time, or any successor tariff.

CPUC - California Public Utilities Commission

CTM - Centralized Telemetry Method

Direct Access (DA) – A service option where the customer obtains its electric power and ancillary services from Electric Service Provider (ESP), who is registered with the California Public Utilities Commission (CPUC). See SCE Tariff Books Rule 22 for more information.

Distribution System – Those non-CAISO-controlled transmission, subtransmission, and distribution facilities owned by the Participating TO's.

EBG - Emergency-Backup Generation

Effective Date – The date the Interconnection Handbook is published.

Element – Any electrical device with terminals that may be connected to other electrical devices such as a generator, transformer, circuit breaker, bus section, or transmission line. An element may be comprised of one or more components.

Emergency-Backup Generation (EBG) – Customer-owned generation utilized when disruption of utility power has occurred or is imminent.

Emergency Condition – A condition or situation: (1) that is imminently likely to endanger life or property; or (2) that, in the case of the CAISO, is imminently likely to cause a material adverse effect on the security of, or damage to, the CAISO Controlled Grid or the electric systems of others to which the CAISO Controlled Grid is directly connected; (3) that, in the case of the Participating TO, is imminently likely to cause a material adverse effect on the security of, or damage to, the Participating TO's Transmission System, Participating TO's Interconnection Facilities, Distribution System, or the electric systems of others to which the Participating TO's electric system is directly connected; or (4) that, in the case of the Interconnection Customer, is imminently likely to cause a material adverse effect on the security of, or damage to, the Generating Facility or Interconnection Customer's Interconnection Facilities.

ESR - Electrical Service Requirements

Facility – A set of electrical equipment that operates as a single electric system Element (e.g., a line, a generator, a shunt compensator, transformer, etc.)

FACTS – Flexible Alternating Current Transmission System

Federal Power Act – The Federal Power Act, as amended, 16 U.S.C. §§ 791a et seq.

FERC – The Federal Energy Regulatory Commission or its successor.

FO – Fiber Optic.

FRT - Fault Ride-Through

GCC - Grid Control Center

Generating Facility Capacity – The total capacity of the Generating Facility and the aggregate net capacity of the Generating Facility where it includes multiple energy production devices.

GIA - Generation Interconnection Agreement

Good Utility Practice – Any of the practices, methods and acts engaged in or approved by a significant portion of the electric industry during the relevant time period, or any of the practices, methods and acts which, in the exercise of reasonable judgment in light of the facts known at the time the decision was made, could have been expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety and expedition. Good Utility Practice is not intended to be limited to the optimum practice, method, or act to the exclusion of all others, but rather to be acceptable practices, methods, or acts generally accepted in the region.

GPR - Ground Potential Rise

Ground Potential Rise (GPR) – The voltage rise of a substation-grounding grid relative to a remote point. GPR is equal to maximum earth current into or out of the grid times the grid resistance. (The Earth current can vary from 0 to 100 percent of the fault current depending on fault location and neutral connections to the substation.) The interconnecting customer is responsible to ascertain that the GPR of the Producer's or interconnected mat does not negatively affect nearby structures or buildings. The cost of mitigation for GPR and other grounding problems shall be borne by the interconnecting customer. If it is elected to install separate ground grids for SCE and the interconnecting facility, the customer shall be responsible to mitigate any transfer voltages and GPR that occur to SCE's grid due to faults on the interconnecting customer's facilities.

HVAC - Heating Ventilation and Air Conditioning

IEEE - Institute of Electrical and Electronics Engineers

Initial Synchronization Date – The date upon which an Electric Generating Unit is initially synchronized and upon which Trial Operation begins.

Interconnection Handbook (Handbook)– A handbook, developed by the SCE and posted its website for customer use which describing the technical and operational requirements necessary for generators, transmission facilities, and end use Facilities to connect to SCE's electrical system. These requirements outlined in the Handbook provide for safe and reliable operation of SCE's electric system, and may be modified or superseded from time to time.

INTFAC – Short for "Interconnection Facility" which refers to all applicable facilities, such as generation, transmission, and end-user facilities.

ISP - Integrated System Planning

L/HFRT - Low/High Frequency Ride Through

L/HVRT - Low/High Voltage Ride Through

LELL - Long Term Emergency Load Limit

Metering Equipment – All metering equipment installed or to be installed for measuring the output of the Generating Facility, including but not limited to instrument transformers, MWh-meters, data acquisition equipment, transducers, remote terminal unit, communications equipment, phone lines, and fiber optics.

ModBus – A serial communications protocol published by Modicon in 1979 for use with its programmable logic controllers (PLCs). Simple and robust, it has since become a *de facto* standard communication protocol, and it is now amongst the most commonly available means of connecting industrial electronic devices.

Monitor - Observe the routine in-service operation of the Component.

MOS – Method of Service

NERC – The North American Electric Reliability Corporation or its successor organization.

Operating Requirements – Any operating and technical requirements that may be applicable due to Regional Transmission Organization, the California Independent System Operator Corporation, control area, or the Distribution Provider's requirements, including those set forth in Generation Interconnection Agreement.

OPGW – Fiber Optical Ground Wire.

Party or Parties – The Participating TO, CAISO, Interconnection Customer, or the applicable combination of the above.

PLL - Phase-Locked Loop

Point of Change of Ownership (POCO) – The point where the Interconnection Customer's Interconnection Facilities connect to the Participating TO's Interconnection Facilities.

Point of Interconnection (POI) – The point where the Interconnection Facilities connect with the Distribution Provider's Distribution System.

POM - Point of Measurement

PPA - Power Purchase Agreement

PSS – Power System Stabilizers

PV - Photovoltaic

RAS - Remedial Action Schemes

RTU – A **remote terminal unit (RTU)** is a microprocessor-controlled electronic device that interfaces objects in the physical world to a distributed control system or SCADA (supervisory control and data acquisition system) by transmitting telemetry data to the system, and by using messages from the supervisory system to control connected objects.

SCADA – (**supervisory control and data acquisition**) generally refers to industrial control systems (ICS): computer systems that monitor and control industrial, infrastructure, or facility-based processes such as electrical power transmission and distribution.

SCE's Electric System – Locations where SCE is owner and/or operating agent.

SOB - System Operating Bulletins

SSCI – Subsynchronous Control Instability

SSI – Subsynchronous Interaction

SSI - Substation Standard Instructions

SSR – Subsynchronous Resonance

SSTI – Subsynchronous Torsional Interactions

STELL - Short Term Emergency Load Limit

TA – Torque Amplification

TI – Torsional Interaction

TO – Transmission Owner

TOP – Transmission Operator

Transmission Control Agreement (TCA) – As defined by the CAISO California Independent Fifth Replacement Electronic Tariff.

Transmission System – Those facilities owned by the Distribution Provider that have been placed under the CAISO's operational control and are part of the CAISO Grid.

UL - Underwriters Laboratories

UPS - Uninterruptible Power System

V&LM - Vegetation & Land Management

WDAT - Wholesale Distribution Access Tariff

XLPE - Cross-Linked Polyethylene

APPENDIX A

Following is a list of the technical standards and criteria referenced within SCE's Interconnection Technical Requirements.

- NERC/WECC Planning Standards
- WECC Coordinated Off-Nominal Frequency Load Shedding and Restoration Plan
- IEEE 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems
- IEEE 80 Guide for Safety in AC Substation Grounding
- IEEE 929 Recommended Practice for Utility Interface of Residential and Intermediate Photovoltaic (PV) Systems
- IEEE 519 IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems
- IEEE C37.010-1999 IEEE Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
- UL 1741 Inverters, Converters, and Controllers for Use in Independent Power Systems
- ANSI C84.1 Voltage Ratings for Electric Power Systems and Equipment
- Voltage Fluctuation Design Limits - SCE Company Criteria
- WECC Minimum Operating Reliability Criteria
- Overview of Policies and Procedures for Regional Planning Project Review, Project Rating Review, and Progress Reports
- IEEE C57.13 Standard Requirements for Instrument Transformers
- IEEE C57.13.6 Standard for High-Accuracy Instrument Transformers
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NEXT REVIEW DATE

This document shall be reviewed upon a change in the referenced documents that may impact this document.

DATA RETENTION

This document shall be retained a minimum of 4 years from last WECC on-site audit and is stored in/on the Compliance Integration Group SharePoint site.

APPROVAL

T&D Organization	Signature	Date
Integrated System Planning	Original Copy signed by Robert Tucker	12/18/21

REVISION HISTORY

Rev. No.	Date	Description of Revision	By	Next Review Date
1		Revised the Interconnection Handbook, Generators to incorporate interconnection requirements for new Generation, Transmission, and End User facilities	---	---
2	3/19/2009	Replaces all remaining referenced documents in Version 1, so that, this Interconnection Handbook will be used for new Generation, Transmission, and End User facilities	---	---
3	10/2/2009	Revised to incorporate new SCE approved wind turbines set-back criteria.	---	---
4	8/2/2010	Incorporated the new SCE approved Transmission Line Crossing Policy. This update resulted in a reconfiguration of Section 9 and added an additional page to the document.	---	----
5	10/5/2011	Sec# 3: Incorporated new diagrams for inverter based interconnections. Incorporated Third Party Protection Equipment Maintenance Responsibility Statement. Sec# 4.15.2: Removal of C-RAS reference from section. Sec# 7: Incorporated exemption of telemetry requirements for Cold Ironing Ships and Emergency back-up generators. And clarification of 1 MVA size definition. Sec# 8: Describe the necessary telecommunications requirements.	---	----
6	10/3/2012	Section 5.11: Isolating Equipment & Switching and Tagging Rules. Re-designed to clarify the need for Isolating Equipment, Inter-Company and Switching and Tagging Rules. Delineating the different voltage classes: (NEW Section) For Generation Facilities (GF's) connecting to voltages >34.5 kV. (NEW Section) For GF's connecting to voltages ≤ 34.5kV. Section 5.12: Grounding Circuit & Substation. Introducing the need for Grounding Studies at the POI for generation interconnection customers. Section 5.13: Non-SCE Pole Grounding. Introducing grounding requirements when Connecting to Customer-Owned Facilities for Generation Interconnections Sections 3: Protection. Updated the Introduction paragraph. Incorporated new Protection diagram for Inverter-based Technology >34.5kV. Section 7: Telemetering. Updated to include the purpose & definition of an RTU. Updated the HVAC Section to align with Telecom. Engineering's Temperature Requirements. Harmonized the Telemetry Requirements with SOB510. Put Telemetry Requirements in a Table format. Added provisions to how to handle "virtual IO." Section 8: Telecommunications. Updated the 3rd paragraph to align with the updates made in Section 3: Identical projects connected at different locations in SCE's electric system can have widely varying protection requirements and attendant telecommunication costs. Updated the HVAC section, stipulating more stringent temperature requirements and pointing to the PSC Section. Included new fiber optic section to align with WECC standards and clarified miscellaneous options Section 9: Property Requirements. Removed the footprints for the building 220kV or 500kV Looping Stations. Increased the 66kV and 115kV Looping Station Footprints consistent with new Substation Standards. Introduced New Glossary Section. Section 8: Telecommunications. Updated the 3rd paragraph to align with the updates made in Section 3: Identical projects connected at different locations in SCE's electric system can have widely varying protection requirements and attendant telecommunication	---	----

		costs. Updated the HVAC section, stipulating more stringent temperature requirements and pointing to the PSC Section. Included new fiber optic section to align with WECC standards and clarified miscellaneous options Section 9: Property Requirements. Removed the footprints for the building 220kV or 500kV Looping Stations. Increased the 66kV and 115kV Looping Station Footprints consistent with new Substation Standards. Introduced New Glossary Section.		
7	12/29/16	Handbook split into 3 major components based on interconnection type for customer ease of use. Introduction/ Summary rewritten to clearly articulate the new format for the Handbook. Transmission Interconnection Requirements revised to more clearly articulate Protection needs. Glossary of terms revised to identify only terminology used in the Handbook.	---	----
8	12/13/2017	Introduction and Summary includes new language to address adverse impact on affected systems and reference to a new fourth section. The Generator Part 1 was revised for clarity and also added several new sections which include: Sub-Sychronous Interaction Evaluation, Voltage Control, Ride Through Requirements and Underground Cable. Method Of Service/End User Facility Part 2 was revised for clarity and added a new section for Underground Cable. Transmission Part 3 was revised for clarity and added several news sections which include: 2-terminal or 3-terminal lines for Dual Pilot, Sub-Synchronous Interaction Evaluations, Sub-Synchronous Resonance Studies, Underground Cable. Updated all sections which references to SPS to RAS to align with NERC's Glossary of Terms. Added a new Affected Systems Part 4 to add clarity. Updated all instances Transmission and Interconnection Planning to Electric System Planning.		
9	12/13/2018	For the Generator Part 1, a new section 5.12.4 Inverter-Based Category 2 and 3 was added. Part 4 Affected Systems Overview was revised to include a new section Coordination Within Balancing Authority's Metered Boundaries. Minor edits were made for clarity.		As needed
10	12/13/2019	The Generator Part 1 was revised for clarity and updated the following sections to align with current SCE practices and/or regulatory bodies: Section 3 – Protection Requirements – updated to reflect current SCE practices; Section 9 – Property Requirements – updated for clarity; Section 11 – Inverter-Based Resource Performance Requirements – This section was updated to align with existing NERC guidelines. Method Of Service/End User Facility Part 2 was revised for clarity. Transmission Part 3 was revised for clarity. Updated all instances Electric System Planning to Integrated System Strategy.		As needed

11	12/13/2020	The Generator Part 1 - updated the following sections to align with current SCE practices and/or regulatory bodies: Section 8 – Telecommunications Requirements – updated to reflect current SCE practices; Section 9 – Property Requirements – updated for clarity; Section 10 – Generator Sharing Breaker and Half – This section was updated to include guidelines on how SCE will prioritize Generators interconnecting to the same bus position. Method Of Service/End User Facility Part 2 – updated the following section to align with SCE current practices and/or regulatory bodies: Section 7 – Telecommunications Requirements – updated to reflect current SCE practices; Section 8 – Property Requirements – updated for clarity. Transmission Part 3 - updated the following section to align with SCE current practices and/or regulatory bodies: Section 6 – Telecommunications Requirements – updated to reflect current SCE practices; Section 7 – Property Requirements – updated for clarity. Updated Glossary of terms to include definitions of terms referenced.		As needed
12	12/13/2021	The Generator Part 1 - updated the following sections to align with current SCE practices and/or regulatory bodies: Sub-section 5.4 – Table 5.3 was revamped. Sub-section 5.8.1 a new Figure 5.8 was added. Section 8 – Telecommunication was completely redone. Method Of Service/End User Facility Part 2 – updated the following section to align with SCE current practices and/or regulatory bodies: Section 7 – Telecommunications Requirements – updated to reflect current SCE practices; Section 8 – Property Requirements – updated for clarity. Transmission Part 3 - updated the following section to align with SCE current practices and/or regulatory bodies: Section 2 – Protection Requirement – added a new sub-section 2.5 RAS & CRAS; Section 6 – Telecommunications Requirements – updated to reflect current SCE practices; Section 7 – Property Requirements – updated for clarity. Updated Glossary of terms to include definitions of terms referenced. Appendix A was updated as well.		As needed

ATTACHMENTS

None

DISTRIBUTION

Integrated System Planning