TECHNICAL SPECIFICATIONS

AND

OPERATING PROTOCOLS AND PROCEDURES

FOR

INTERCONNECTION OF GENERATION FACILITIES

NOT SUBJECT TO FERC JURISDICTION

Document 9022

Puget Sound Energy, Inc.

PSE-TC-160.70

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1. INTRODUCTION

1.1 GENERAL POLICY

For the purposes of this document, “Interconnection Customer” means or refers to any customer-owned generator that does not generate power for sale at wholesale or for transmission in interstate commerce, and accordingly is not subject to the jurisdiction of the Federal Energy Regulatory Commission (FERC); or is a “qualifying facility” whose interconnection is not subject to the jurisdiction of FERC. “PSE” means Puget Sound Energy, Inc., the Transmission Provider.

This document is referred to in Section 8 of the Parallel Operation Agreement between the Interconnection Customer and PSE. In the case of any conflict between the terms and conditions of this document and the terms and conditions of the Parallel Operation Agreement, the terms of the Parallel Operation Agreement shall control.

The requirements stated in this document are intended to minimize adverse conditions on the PSE system and to enable the Interconnection Customer to operate its generating equipment in parallel with PSE’s system in a safe and reliable manner. The requirements cover the necessary interconnection equipment (relays, breaker, etc.) to be installed, owned, and maintained by the Interconnection Customer. The interconnection equipment is needed to disconnect the parallel generation from the system whenever a fault or abnormality occurs. PSE will also identify any additional enhancements needed on the PSE system to provide the capacity and protection systems needed to successfully integrate the generation into the system. PSE’s interconnection requirements are designed and intended to protect PSE’s system only. The Interconnection Customer is solely responsible for protecting its generation and interconnection equipment. It is emphasized that these requirements are general and may not cover all details in specific cases. Interconnection Customers are advised to discuss project plans with PSE before purchasing or installing any equipment.

If the Interconnection Customer should cause harmonics, unusual fluctuation or disturbance on, or inductive interference with PSE’s system or PSE’s other customers, then PSE shall have the right to require the Interconnection Customer to install suitable apparatus to reasonably correct or limit such abnormalities at no expense to PSE or PSE’s other customers. PSE retains the right to disconnect the Interconnection Customer’s equipment until such requirements are met.

Interconnection Customers and PSE personnel shall apply this document and the system reliability performance requirements of the North American Electric Reliability Corporation (NERC), Western Electricity Coordinating Council (WECC), Northwest Power Pool (NWPP), and PSE when planning installations of independently owned or controlled generation throughout the planning horizon.

1.2 COMPLIANCE WITH NERC STANDARDS

This section is applicable for those generators which PSE determines are interconnected to the Bulk Electric System.
This document provides PSE interconnection requirements for generation Facilities, addressing NERC Standard FAC-001-3 Facility Interconnection Requirements, requirement R1 and R1.1. Requirement R1 states that each Transmission Owner shall document, maintain, and publish and make available Facility interconnection requirements. These PSE Facility interconnection requirements shall be maintained and updated from time to time as required. They shall be made available to the users of the transmission system, to WECC, and to NERC on request, and they are posted on.

NERC Standard FAC-001-3, requirement R3 states the Transmission Owner shall, “address the following items in its Facility interconnection requirements”. R3.1 in FAC-001-3, under requirement R3, requires “Procedures for coordinated studies of new or materially modified existing interconnections and their impacts on affected systems(s)”. The studies of new or materially modified existing interconnections and their impacts on affected system(s) will be coordinated through phone calls and conference calls, meetings, possible site visits. WECC policies, procedures and guidelines governing the coordination of plans include “WECC Progress Report Policies and Procedures”, and “WECC Policies and Procedures for Regional Planning Project Review, Project Rating Review, and Progress Reports”. To assess the impacts on affected systems(s), studies performed by the Interconnection Customer and PSE to achieve the required system performance may include, but are not limited to, power flow, transient stability, short circuit, and harmonics.

NERC Standard FAC-001-3 requirement 3.2 requires “Procedures for notifying those responsible for the reliability of affected system(s) of new or materially modified existing interconnections”. To comply with this requirement, plans for new or materially modified facilities will be provided to PSE’s Interconnection Customer as governed by PSE’s tariff. Additionally, plans for new or modified facilities will be provided to WECC and posted on OASIS when they can be made publicly available. Documents governing the notification of plans, and providing models of new or materially modified facilities include “WECC Progress Report Policies and Procedures”, “WECC Project Coordination, and Path Rating and Progress Report Processes”, “WECC Data Preparation Manual”, “WECC Dynamic Modeling Procedure”, and “WECC Approved Dynamic Model Library”.

NERC Standard FAC-001-3 requirement 3.3 requires “Procedures for confirming with those responsible for the reliability of affected systems of new or materially modified transmission Facilities are within a Balancing Authority Area’s metered boundaries”. To comply with this requirement, PSE will draft a metering diagram during the interconnection study process identifying Balancing Authority interchange meter(s) to the extent necessary. The metering diagram will identify in which Balancing Authority Area the Interconnection Customer’s facilities shall reside. PSE will identify any interchange metering required and coordinate the metering design with those neighboring Balancing Authority Area’s to ensure all metered boundaries are correct, and that the Interconnection Customer’s facilities reside in the appropriate Balancing Authority Area.

Under NERC Standard MOD-032-1 Data for Power System Modeling and Analysis, requirement R1, this document contains the data requirements for steady-state, dynamics, and short circuit modeling that has been jointly developed between the Planning
Coordinator and its Transmission Planners. It includes the data listed in MOD-032-1 Attachment 1 (requirement R1.1). This document contains specifications consistent with procedures for building WECC interconnection-wide case(s). The data formats are specified with units and as WECC approved models, and to specific extent so that complete models can be assembled, see Appendix A (requirement R1.2.1, 1.2.2). The data is required to be provided at least once every 13 calendar months (requirement R1.2.4 and R2).

1.3 SUBMISSION OF DATA AND FREQUENCY

The following data in Table 1.3 is required to be provided at least once every 13 calendar months. For data that has not changed since the last submission, a written confirmation that the data has not changed is sufficient.
Table 1.3 Submission of Data and Frequency

<table>
<thead>
<tr>
<th>steady-state</th>
<th>dynamics</th>
<th>short circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Items marked with an asterisk indicate data that vary with system</td>
<td></td>
<td>1. Provide for all applicable</td>
</tr>
<tr>
<td>operating state or conditions. Those items may have different data</td>
<td></td>
<td>elements in column “steady-</td>
</tr>
<tr>
<td>provided for different modeling scenarios)</td>
<td></td>
<td>state” [GO, RP, TO]</td>
</tr>
<tr>
<td>1. Each bus [TO]</td>
<td></td>
<td>a. Positive Sequence Data</td>
</tr>
<tr>
<td>a. nominal voltage</td>
<td></td>
<td>b. Negative Sequence Data</td>
</tr>
<tr>
<td>b. area, zone and owner</td>
<td></td>
<td>c. Zero Sequence Data</td>
</tr>
<tr>
<td>2. Aggregate Demand [LSE]</td>
<td></td>
<td>2. Mutual Line Impedance Data [TO]</td>
</tr>
<tr>
<td>a. real and reactive power*</td>
<td></td>
<td>3. Other information requested by</td>
</tr>
<tr>
<td>b. in-service status*</td>
<td></td>
<td>the Planning Coordinator or Transmission Planner necessary for</td>
</tr>
<tr>
<td>3. Generating Units [GO, RP (for future planned resources only)]</td>
<td></td>
<td>modeling purposes. [BA,</td>
</tr>
<tr>
<td>a. real power capabilities - gross maximum and minimum values</td>
<td></td>
<td>GO, LSE, TO, TSP]</td>
</tr>
<tr>
<td>b. reactive power capabilities - maximum and minimum values at real power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>capabilities in 3a above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. station service auxiliary load for normal plant configuration (provide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>data in the same manner as that required for aggregate Demand under item</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2, above)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. regulated bus* and voltage set point* (as typically provided by the TOP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. machine MVA base</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. generator step up transformer data (provide same as that required for</td>
<td></td>
<td></td>
</tr>
<tr>
<td>transformer under item 6, below)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. generator type (hydro, wind, fossil, solar, nuclear, etc)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h. in-service status*</td>
<td></td>
<td></td>
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<tr>
<td>4. AC Transmission Line or Circuit [TO]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. impedance parameters (positive sequence)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. susceptance (line charging)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. ratings (normal and emergency)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. in-service status*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. DC Transmission systems [TO]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Transformer (voltage and phase-shifting) [TO]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. nominal voltages of windings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. impedance(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. tap ratios (voltage or phase angle)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. minimum and maximum tap position limits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. number of tap positions (for both the ULTC and NLTC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. regulated bus (for voltage regulating transformers)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. ratings (normal and emergency)*</td>
<td></td>
<td></td>
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<tr>
<td>h. in-service status*</td>
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<tr>
<td><strong>PSE-ET-160.70</strong></td>
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<tr>
<td><strong>7. Reactive compensation (shunt capacitors and reactors) [TO]</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. admittances (MVars) of each capacitor and reactor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. regulated voltage band limits* (if mode of operation not fixed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. mode of operation (fixed, discrete, continuous, etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. regulated bus* (if mode of operation not fixed)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. in-service status*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>8. Static Var Systems [TO]</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. reactive limits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. voltage set point*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. fixed/switched shunt, if applicable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. in-service status*</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>9. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1.4 OPERATING AGREEMENTS

If the Interconnection Customer’s system has a transfer switch of the open transition type (break-before-make) at the Point of Interconnection, the switch must be approved in advance by PSE.

A closed transition switch designed to parallel less than 1 MVA of generation to the system for 100 ms or more requires a Letter of Agreement. All other designs using closed transition switches, or other systems designed to operate in parallel continuously require a Parallel Operation Agreement.

1.5 LIABILITY

This section sets forth the respective responsibilities and liabilities between PSE and the Interconnection Customer, subject to the provisions of any Parallel Operation Agreement or Letter of Agreement entered into between PSE and the Interconnection Customer.

The terms “approve,” “approved,” and “approval” used throughout this document means acceptance. Approval by PSE does not mean that PSE endorses or is to be responsible for the safety or reliability of the Interconnection Customer’s design or Generating Facility.

The Interconnection Customer shall submit in a timely manner sufficient design and specifications information relating to the facilities to be installed by the Interconnection Customer and PSE shall be entitled to review and approve or accept said facilities prior to their installation and energization. The Interconnection Customer agrees to incorporate any reasonable design changes requested by PSE prior to, during, or after installation of Customer’s facilities. PSE’s approval or acceptance of any design and specification information related to the facilities to be installed by the Interconnection Customer shall not be construed as an endorsement of such engineering plans, specifications or other information.

1.6 RELIABILITY CHARGES

From time to time new requirements for testing, equipment, and/or performance are established by WECC, NERC, or other electricity reliability authorities, for interconnected generation. To the extent the Interconnection Customer fails to meet future demonstration, testing, equipment and/or performance requirements, as they may apply, the Interconnection Customer shall be obligated to pay any charges incurred by PSE resulting from the Interconnection Customer’s noncompliance.
2. **PSE SYSTEM INFORMATION**

2.1 **VOLTAGE**

PSE’s most common primary local distribution voltage is 12.47 kV. Other local distribution voltages are sometimes used in specific areas (example 4.16 kV or 34.5 kV). The majority of the distribution circuits are “effectively grounded” (see Section 2.3) and are used for four-wire distribution (phase to neutral) connected loads. Other voltages of PSE’s electrical system are 57.5 kV, 115 kV and 230 kV. 115 kV and 230 kV are the most typical transmission facility voltages. The Interconnection Feasibility Study will determine the voltage at the Point of Interconnection.

2.2 **FREQUENCY**

The frequency for connection to the PSE’s system must be 60 Hz sinusoidal alternating current at a standard voltage (see Section 2.1) and phase rotation.

2.3 **PSE EFFECTIVE GROUNDING**

PSE maintains effective grounding on its distribution and transmission systems as defined by IEEE Std. 142.
3. SYSTEM INTEGRITY

3.1 GENERAL

The interconnection of the Interconnection Customer’s generating equipment with the PSE system must not cause any reduction in the quality of service being provided to PSE’s other customers. No abnormal voltages, frequencies, or interruptions will be permitted. If high or low voltage complaints, transient voltage complaints, and/or harmonic (voltage distortion) complaints result from operation of the Interconnection Customer’s generation, such generating equipment shall be disconnected from PSE’s system until the problem is resolved by the Interconnection Customer. The Interconnection Customer is responsible for the expense of keeping the generator(s) in good working order so that the voltage, total harmonic distortion, flicker, power factor, and VAR requirements are always met.

3.2 HARMONICS

The Total Harmonic Distortion (THD) from the Generating Facility will be measured at the Generating Facility’s metering point or Point of Interconnection. Harmonics on the power system from all sources must be kept to a minimum. Under no circumstances will the harmonic current and voltage flicker be greater than the values listed in Tables 1, 2, 3 and 4 reprinted from the most current version of IEEE Std. 519.

*Note:* Any interference with customers or communications caused by the Interconnection Customer’s harmonics in excess of federal, state, or local codes will be resolved at the Interconnection Customer’s expense.

<table>
<thead>
<tr>
<th>Bus voltage V at PCC</th>
<th>Individual harmonic (%)</th>
<th>Total harmonic distortion THD (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>V ≤ 1.0 kV</td>
<td>5.0</td>
<td>8.0</td>
</tr>
<tr>
<td>1 kV &lt; V ≤ 69 kV</td>
<td>3.0</td>
<td>5.0</td>
</tr>
<tr>
<td>69 kV &lt; V ≤ 161 kV</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>161 kV &lt; V</td>
<td>1.0</td>
<td>1.5*</td>
</tr>
</tbody>
</table>

*High-voltage systems can have up to 2.0% THD where the cause is an HVDC terminal whose effects will have attenuated at points in the network where future users may be connected.*
Table 2—Current distortion limits for systems rated 120 V through 69 kV

<table>
<thead>
<tr>
<th>Maximum harmonic current distortion in percent of $I_L$</th>
<th>Individual harmonic order (odd harmonics)$^a,^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{sc}/I_L$</td>
<td>$3 \leq h &lt; 11$</td>
</tr>
<tr>
<td>$&lt; 20^c$</td>
<td>4.0</td>
</tr>
<tr>
<td>20 &lt; 50</td>
<td>7.0</td>
</tr>
<tr>
<td>50 &lt; 100</td>
<td>10.0</td>
</tr>
<tr>
<td>100 &lt; 1000</td>
<td>12.0</td>
</tr>
<tr>
<td>&gt; 1000</td>
<td>15.0</td>
</tr>
</tbody>
</table>

Common footnotes for Tables 2, 3, and 4:

$^a$ Even harmonics are limited to 25% of the odd harmonic limits above.

$^b$ Current distortions that result in a dc offset, e.g., half-wave converters, are not allowed.

$^c$ All power generation equipment is limited to these values of current distortion, regardless of actual $I_{sc}/I_L$ where

$I_{sc} =$ maximum short-circuit current at PCC

$I_L =$ maximum demand load current (fundamental frequency component) at the PCC under normal load operating conditions

Table 3—Current distortion limits for systems rated above 69 kV through 161 kV

<table>
<thead>
<tr>
<th>Maximum harmonic current distortion in percent of $I_L$</th>
<th>Individual harmonic order (odd harmonics)$^a,^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{sc}/I_L$</td>
<td>$3 \leq h &lt; 11$</td>
</tr>
<tr>
<td>$&lt; 20^c$</td>
<td>2.0</td>
</tr>
<tr>
<td>20 &lt; 50</td>
<td>3.5</td>
</tr>
<tr>
<td>50 &lt; 100</td>
<td>5.0</td>
</tr>
<tr>
<td>100 &lt; 1000</td>
<td>6.0</td>
</tr>
<tr>
<td>&gt; 1000</td>
<td>7.5</td>
</tr>
</tbody>
</table>

Table 4—Current distortion limits for systems rated > 161 kV

<table>
<thead>
<tr>
<th>Maximum harmonic current distortion in percent of $I_L$</th>
<th>Individual harmonic order (odd harmonics)$^a,^b$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{sc}/I_L$</td>
<td>$3 \leq h &lt; 11$</td>
</tr>
<tr>
<td>$&lt; 25^c$</td>
<td>1.0</td>
</tr>
<tr>
<td>25 &lt; 50</td>
<td>2.0</td>
</tr>
<tr>
<td>$\geq 50$</td>
<td>3.0</td>
</tr>
</tbody>
</table>
3.3 VOLTAGE - DISTRIBUTION LEVEL

The Interconnection Customer shall ensure that operation of its generator(s) does not adversely affect the voltage stability of PSE’s system. Adequate voltage control shall be provided by all Interconnection Customers to minimize voltage deviations on the PSE system caused by changing generator loading conditions.

➢ **Synchronous Generator(s) Reactive Power Capability:** For synchronous generators, sufficient generator reactive power capability shall be provided to withstand normal voltage changes on the PSE system. The generator voltage-VAR schedule, voltage regulator, and transformer ratings (including taps if applicable) will be jointly determined by PSE and the Interconnection Customer to ensure proper coordination of voltages and regulator action.

➢ **Interconnection Customer’s Generator Ride-Through Capability:** The Interconnection Customer’s generator(s) shall be capable at all times of continuous operation at 0.95 to 1.05 per unit voltage, as measured at the Point of Interconnection. The Interconnection Customer’s generator(s) shall not cause the voltage as measured at the Point of Interconnection to be less than 0.95 or to exceed 1.05 per unit voltage. The Interconnection Customer’s generator(s) shall comply with IEEE 1547 voltage ride through requirements as applicable and be capable during electric system disturbances of short term operation at voltages (as measured at the Point of Interconnection), and for durations as provided in the most current version of the NERC and WECC voltage ride-through standards for high and low voltage. The generator(s) shall restore active power output rapidly following a disturbance, ceasing ramp-rate limiter settings programmed at the individual generator or plant-level controller as applicable, unless otherwise requested by PSE operators. In general, a generator must be designed to remain connected to the PSE system and generating under the following voltage conditions:

- **Normal Conditions.** Under normal conditions, the voltages at all Bulk-Electric System buses shall range between 95% and 105%.
- **Voltage Disturbance.** For a fault on the interconnection transmission bus or a fault on the transmission system that are cleared with normal clearing times. Momentary cessation of current is not acceptable ride-through performance within the no-trip range specified in Section 8.2.3, unless an equipment limitation prevents such performance per NERC standard PRC-024-2 requirement R3. The outside of the specified “No Trip Zone” in PRC-024-2 should not be interpreted as a “Must Trip Zone,” but rather, it should be considered a “May Trip Zone.” The generator(s) shall restore active power output rapidly following a disturbance, ceasing ramp-rate limiter settings programmed at the individual generator or plant-level controller as applicable, unless otherwise requested by PSE operators. Following fault clearing, transient and post-transient voltages shall remain within the following ranges, per WECC Criterion TPL-001-WECC-CRT-3.2:

1.1. Steady-state voltages at all applicable Bulk-Electric System (BES) buses shall stay within each of the following limits:
1.1.2. 90 percent to 110 percent of nominal for P1-P7\(^1\) events (post-contingency event powerflow).

1.2. Post-Contingency steady-state voltage deviation at each applicable BES bus serving load shall not exceed 8 percent for P1 events.

1.3. Following fault clearing, the voltage shall recover to 80 percent of the pre-contingency voltage within 20 seconds of the initiating event for all P1 through P7 events, for each applicable BES bus serving load.

1.4. Following fault clearing and voltage recovery above 80 percent, voltage at each applicable BES bus serving load shall neither dip below 70 percent of pre-contingency voltage for more than 30 cycles nor remain below 80 percent of pre-contingency voltage for more than two seconds, for all P1 through P7 events.

1.5. For Contingencies without a fault (P2.1 category event), voltage dips at each applicable BES bus serving load shall neither dip below 70 percent of pre-contingency voltage for more than 30 cycles nor remain below 80 percent of pre-contingency voltage for more than two seconds.

➢ **Synchronous Generator(s) Power Factor Requirement at POI:** Automatic power factor or VAR controllers must be provided for installations utilizing synchronous generators. Synchronous generator installations over 5 kW must maintain power factor as directed by PSE between 0.95 bucking or leading (VARS into the generator) and 0.95 boosting or lagging (VARS out of the generator), inclusive, over an operating range of 25% to 100% of maximum rated power during all hours of operation. These power factor requirements are to be met at the Point of Interconnection, during all hours of operation and overall operating conditions.

Note that the Point of Interconnection is often not the same as the generator terminals, and typically the generator must have capability to operate at a power factor that is lower than 0.95 boosting. For example, if the Point of Interconnection is the high side of the generator step-up transformer the generator must provide the sum of transformer VARS plus 0.95 boosting at the Point of Interconnection.

The above power factor requirement shall not apply to wind generators, solar power, battery storage and other non-Synchronous generation. Wind generator power factor requirement is described in Section 3.7 and solar power and battery energy storage power factor requirement is described in Section 3.8.

➢ **Voltage Flicker:** The magnitude and frequency of the voltage flicker (i.e., sudden momentary voltage change) caused by the Interconnection Customer shall not exceed the values given in the most current version of PSE’s Standard Practice 0650.4100, “Voltage Flicker” (see Figure 3.3). Voltage flicker percentage shall be referenced to generator pre-synchronize or motor pre-start conditions. Some PSE customers have voltage sensitive loads and, if PSE receives complaints from customers affected by

\(^1\) P1 through P7 refers to the categories of contingencies identified in Table 1 of NERC Standard TPL-001-4, Transmission System Planning Performance Requirements
The Interconnection Customer, the Interconnection Customer will be responsible for reducing voltage variations even if they are within the parameters stated in the voltage flicker chart in the above referenced PSE Voltage Flicker standard.

Voltage flicker will normally be measured at the Point of Interconnection between the Interconnection Customer and PSE. However, at PSE’s discretion, if voltage flicker problems are found, the measurement may be taken at the nearest possible present or future PSE customer.

The voltage flicker chart does not address the time duration of the voltage drop. For the purposes of this section, a drop of any duration shall be considered as a single occurrence. Such a voltage drop may be acceptable after consultation with PSE, but the Interconnection Customer is responsible for any associated damage caused to the equipment or lost productivity of other PSE customers. It is advised that Interconnection Customers review the most current version of IEEE Standard 141 (Red Book) for typical sensitivity to very short voltage disturbances.

Figure 3.3 Range of observable and objectionable voltage flicker versus time, from PSE Standard 0650.4100

3.4 FREQUENCY – DISTRIBUTION LEVEL

The Interconnection Customer shall ensure that operation of the generator(s) does not adversely affect the frequency stability of PSE’s system. Adequate frequency response shall be provided by all Interconnection Customers to minimize frequency deviations on the PSE system caused by generation and load mismatch and system disturbances. Any tripping on calculated frequency should be based on an accurately calculated and filtered
frequency measurement over a time window (e.g., around six cycles) and should not use an instantaneously calculated value.

➢ **Interconnection Customer’s Generator Ride-Through Capability:** The Interconnection Customer’s generator(s) shall comply with IEEE 1547 frequency ride through requirements as applicable. The generator(s) shall restore active power output rapidly following a disturbance, ceasing ramp-rate limiter settings programmed at the individual generator or plant-level controller as applicable, unless otherwise requested by PSE operators.

### 3.5 VOLTAGE - TRANSMISSION LEVEL

The Interconnection Customer shall ensure that operation of the generator(s) does not adversely affect the voltage stability of PSE’s system. Adequate voltage control shall be provided by all Interconnection Customers to minimize voltage deviations on the PSE system caused by changing generator loading conditions.

➢ **Synchronous Generators Reactive Power Capability:** For synchronous generators, sufficient generator reactive power capability shall be provided to withstand normal voltage changes on the PSE system. The generator voltage-VAR schedule, voltage regulator, and transformer ratings (including taps if applicable) will be jointly determined by PSE and the Interconnection Customer to ensure proper coordination of voltages and regulator action.

➢ **Interconnection Customer’s Generator Ride-Through Capability:** During electric system disturbances the Interconnection Customer’s generator(s) shall be capable of short term operation at voltages (as measured at the Generator Step Up transformer or collector transformer), and for durations as provided in the most current version of NERC and WECC voltage ride-through standards for high and low voltage. The Interconnection Customer’s generators shall operate to fulfill this requirement by selecting the appropriate generator main power transformer tap setting. In some cases, such as facilities with a high impedance generator step-up transformer, voltage regulators (or tap changing under load) will be needed and shall be installed at the Interconnection Customer’s expense. In general, a generator must be designed to remain connected to the PSE system and generating under the following voltage conditions:

- **Normal Conditions.** Under normal conditions, the voltage at all Bulk-Electric System buses shall range between 95% and 105%.

- **Voltage Disturbance.** For a fault on the interconnection transmission bus or a fault on the transmission system that are cleared with normal clearing times. Momentary cessation of current is not acceptable ride-through performance within the no-trip range specified in Section 8.2.3, unless an equipment limitation prevents such performance per NERC standard PRC-024-2 requirement R3. The outside of the specified “No Trip Zone” in PRC-024-2 should not be interpreted as a “Must Trip Zone,” but rather, it should be considered a “May Trip Zone.” The generator(s) shall restore active power output rapidly following a disturbance, ceasing ramp-rate limiter settings programmed at the individual generator or...
plant-level controller as applicable, unless otherwise requested by PSE operators. Following fault clearing, transient and post-transient voltages shall remain within the following ranges, per WECC Criterion TPL-001-WECC-CRT-3.2:

1.1. Steady-state voltages at all applicable Bulk-Electric System (BES) buses shall stay within each of the following limits:

1.1.2. 90 percent to 110 percent of nominal for P1-P72 events (post-contingency event powerflow).

1.2. Post-Contingency steady-state voltage deviation at each applicable BES bus serving load shall not exceed 8 percent for P1 events.

1.3. Following fault clearing, the voltage shall recover to 80 percent of the pre-contingency voltage within 20 seconds of the initiating event for all P1 through P7 events, for each applicable BES bus serving load.

1.4. Following fault clearing and voltage recovery above 80 percent, voltage at each applicable BES bus serving load shall neither dip below 70 percent of pre-contingency voltage for more than 30 cycles nor remain below 80 percent of pre-contingency voltage for more than two seconds, for all P1 through P7 events.

1.5. For Contingencies without a fault (P2.1 category event), voltage dips at each applicable BES bus serving load shall neither dip below 70 percent of pre-contingency voltage for more than 30 cycles nor remain below 80 percent of pre-contingency voltage for more than two seconds.

3.5.1 Voltage Control versus Power Factor Control at POI

➢ Synchronous Generator(s) The NetBoosting or Lagging Power Factor Requirement at POI: The Interconnection Customer’s synchronous generator(s) shall be designed to be able to operate in such a manner as to provide and deliver, at the Point of Interconnection, for voltage or power factor requested by PSE operators, enough VAR output to obtain a net 0.95 power factor boosting or lagging (VARS are supplied to PSE’s system by the Generating Facility) minimum at the maximum rated (MW) generator capacity. This power factor requirement of this section shall not apply to wind generators, solar power, battery storage and other non-Synchronous generation. Wind generator power factor requirement is shown in Section 3.7, solar power and battery energy storage power factor requirement is shown in Section 3.8.

➢ Synchronous Generator(s) The NetBucking or Leading Power Factor Requirement at POI: Additionally, the Interconnection Customer’s synchronous generator(s) shall be designed to be able to operate in such a manner as to provide and deliver, at the Point of Interconnection, for voltages or power factor requested by PSE operators, enough VAR absorption to obtain a net 0.95 power factor bucking or leading (VARS are absorbed

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2 P1 through P7 refers to the categories of contingencies identified in Table 1 of NERC Standard TPL-001-4, Transmission System Planning Performance Requirements
from PSE’s system by the Generating Facility) minimum at the maximum rated (MW) generator capacity.

**Notes:** the Point of Interconnection is often not the same as the generator terminals, and typically the generator must have capability to operate at a power factor that is lower than 0.95 boosting. For example, if the Point of Interconnection is the high side of the generator step-up transformer the generator must provide the sum of transformer VARS plus 0.95 boosting at the Point of Interconnection.

An example to further explain the power factor requirement at POI is included in Appendix C. This example shows the minimum reactive power required from generator to maintain lagging and leading 0.95 power requirement at POI when generator plans to produce the maximum rated real power.

### 3.6 FREQUENCY – TRANSMISSION LEVEL

The Interconnection Customer shall ensure that operation of the generator(s) does not adversely affect the frequency stability of PSE’s system. Adequate frequency response shall be provided by all Interconnection Customers to minimize frequency deviations on the PSE system caused by generation and load mismatch and system disturbances. Any tripping on calculated frequency should be based on an accurately calculated and filtered frequency measurement over a time window (e.g., around six cycles) and should not use an instantaneously calculated value.

- **Interconnection Customer’s Generator Ride-Through Capability:** During electric system disturbances, the Interconnection Customer’s generator(s) shall be capable of short term operation at frequencies for durations as provided in Section 8.2.1. The outside of the specified “No Trip Zone” should not be interpreted as a “Must Trip Zone,” but rather, it should be considered a “May Trip Zone.” The generator(s) shall restore active power output rapidly following a disturbance, ceasing ramp-rate limiter settings programmed at the individual generator or plant-level controller as applicable, unless otherwise requested by PSE operators. Primary frequency response shall follow the requirements described in Section 4.9.

### 3.7 WIND POWER INDUCTION GENERATING FACILITY

Under certain conditions, a self-excited induction generator can produce abnormally high voltages that can cause damage to the equipment of other Interconnection Customers and other customers. Overvoltage relays can limit the duration of such overvoltages but cannot control their magnitude. Because of these problems, the reactive power supply for large induction generators must be studied on an individual basis. In general, self-excitation problems are most likely in rural areas where the PSE system capacity and load density are low. Where self-excitation problems appear likely, special service arrangements will be required.

PSE requires the following power factors for a wind power Generating Facility:

1. For Non-Synchronous Generation, The Interconnection Customer shall design its Small Generating Facility to maintain a composite power delivery at continuous rated
power output at the high-side of the generator substation at a power factor within the range of 0.95 leading to 0.95 lagging, unless the Transmission Provider has established a different power factor range that applies to all similarly situated non-synchronous generators in the control area on a comparable basis. This power factor range standard shall be dynamic and can be met using, for example, power electronics designed to supply this level of reactive capability (taking into account any limitations due to voltage level, real power output, etc.) or fixed and switched capacitors, or a combination of the two.

The switching and control of the reactive power shall be done in small enough increments to limit the change in reactive power production or absorption in steady state to steps of no more than 10% of the generated power.

2. The following capacitor banks will be required to compensate the large reactive loads created by wind induction generators:
   - Several steps of capacitor banks for each generator at generator voltage, and
   - Capacitor banks at the collector feeder voltage and located at the substation to compensate the reactive losses in the substation transformers connected at the Point of Interconnection to the PSE system, and for transmission voltage regulation

3. The Planning and Operation experience shows capacitor banks at the collector feeder voltage and located at the substation should be worked as a dynamic reactive power resource, and being sized to provide reactive power of around +/- 30% of plant maximum active power capability (Pmax) is common. The wind power Generating Facility developer will be required to work with PSE to determine the appropriate size of capacitor banks.

4. To ensure adherence to the power factor correction criteria, the wind power Generating Facility developer will be required to perform VAR accounting for all generator loading levels to determine size of each individual capacitor bank at the collector feeder voltage at the substation connected to the PSE System in order to ensure that the wind power Generating Facility meets the power factor criteria defined above.

5. For induction generators, where starting will have an adverse impact on PSE system voltage, step-switched capacitors or other techniques may be required to limit the voltage changes and bring the unit to synchronous speed before connection to PSE.

6. The “WECC Lesson Learned” from utility operation practice shows: for some cases, it is possible that both voltage control and the power factor requirement at the POI are needed since only power factor requirement at the POI might not effectively control fast voltage excursions. To mitigate dynamic voltage issues such as voltage flicker due to fast wind power ramping up or down, fast switching dynamic reactive devices such as Statcom, D-Var or SVC may be needed to provide dynamic voltage control. The wind power generating facility developer is encouraged to work with PSE to determine if dynamic voltage issues exist and appropriate solutions. Time series power flow and transient stability studies shall be done to identify and verify if the
dynamic reactive power control devices are effective enough to eliminate fast voltage excursions. The simulation time shall be long enough to verify the effectiveness of static reactive power control devices as well.

3.8 SOLAR POWER, BATTERY STORAGE AND OTHER NON-SYNCHROUS GENERATING FACILITY

For solar power, battery storage and other non-synchronous generating facilities, the Interconnection Customer shall design the Large Generating Facility to maintain a composite power delivery at continuous rated power output at the high-side of the generator substation at a power factor within the range of 0.95 leading to 0.95 lagging, unless the Transmission Provider has established a different power factor range that applies to all non-synchronous generators in the Control Area on a comparable basis. This power factor range standard shall be dynamic and can be met using, for example, power electronics designed to supply this level of reactive capability (taking into account any limitations due to voltage level, real power output, etc.) or fixed and switched capacitors, or a combination of the two.

Similar to wind power, the switching and control of the reactive power shall be done in small enough increments to limit the change in reactive power in steady state to steps of no more than 10% of the generated power.
4. GENERAL DESIGN REQUIREMENTS

4.1 CODES, WECC AND NERC

The Interconnection Customer’s installation must be in compliance with all applicable laws, regulations, and codes. The Interconnection Customer must also meet all applicable interconnection requirements of WECC and NERC.

4.2 DISCONNECTING DEVICES

For all generation interties greater than 5 kVA, a disconnecting device (normally a disconnect switch) is required at the Point of Interconnection that separates the Interconnection Customer’s Generating Facility from PSE’s system. The switch must be operable by PSE, must be accessible to PSE at all times, and must be lockable in the open position with PSE’s standard padlock. For three-phase installations, gang-operated three pole switches must be installed. Each switch or other disconnecting device shall comply with the most current versions of PSE Standard Specifications 1300.2100 and 1300.2300. If the switch is located on the PSE side of the Point of Interconnection, it shall be installed by PSE at the Interconnection Customer’s expense. If the switch is located on the Interconnection Customer’s side, it shall be installed by the Interconnection Customer. Any interconnection breaker shall comply with the most current version of PSE Standard Specification 1300.4000.

4.3 INTERRUPTING DEVICES

Any interrupting device installed by the Interconnection Customer must be adequately rated for the available short circuit current. PSE will provide short-circuit data to the customer for use in calculating the required interrupting rating as part of the System Impact Study.

4.4 STEP AND TOUCH POTENTIAL

It is the Interconnection Customer’s responsibility to ensure that the step and touch potentials meet the most current version of IEEE Std. 80 and that construction complies with National Electrical Safety Code (NESC).

4.5 INSULATION COORDINATION

In general, stations with equipment operated at 15 kV and above, as well as all transformers and reactors, shall be protected against lightning and switching surges. Typically this includes station shielding against direct lightning strokes, surge arresters on all transformers, reactors, and surge protection with rod gaps (or arresters) on the incoming lines.

4.6 CONTROL REQUIREMENTS

Outputs or interposing relays controlled by programmable logic controls shall not be in series with the interconnection tripping relays and breaker trip coils. All interconnection protection relays shall be capable of tripping the breakers.
All interconnection protection shall be powered by station battery DC voltage and must include a DC undervoltage detection device and alarm. The station battery design shall be in compliance with the most current version of IEEE Std. 485.

4.7 EFFECTIVE GROUNDING

It is the Interconnection Customer’s responsibility to ensure that its system is effectively grounded at the Point of Interconnection. As defined by IEEE Std. 142, an effectively grounded system requires that $X_0/X_1 < 3$ and $R_0/X_1 < 1$. In general, PSE does not allow grounding banks (wye grounded – delta transformer connections) on distribution systems.

4.8 EXCITATION EQUIPMENT, INCLUDING POWER SYSTEM STABILIZERS - TRANSMISSION CONNECTED GENERATING FACILITY

Excitation equipment includes the exciter, automatic voltage regulator, power system stabilizer, and over-excitation limiter. The general requirement for these devices is as follows:

➢ The Exciter and Automatic Voltage Regulator:

The following NERC Standard VAR-002-4.1 requirements should be observed:

R1 The Generator Operator shall operate each generator connected to the interconnected transmission system in the automatic voltage control mode (with its automatic voltage regulator (AVR) in service and controlling voltage) or in a different control mode as instructed by the Transmission Operator unless: 1) the generator is exempted by the Transmission Operator, or 2) the Generator Operator has notified the Transmission Operator of one of the following: [Violation Risk Factor: Medium] [Time Horizon: Real-time Operations]

- That the generator is being operated in start-up, shutdown, or testing mode pursuant to a Real-time communication or a procedure that was previously provided to the Transmission Operator; or

- That the generator is not being operated in automatic voltage control mode or in the control mode that was instructed by the Transmission Operator for a reason other than start-up, shutdown, or testing.

R3 Each Generator Operator shall notify its associated Transmission Operator of a status change on the AVR, power system stabilizer, or alternative voltage controlling device within 30 minutes of the change. If the status has been restored within 30 minutes of such change, then the Generator Operator is not required to notify the Transmission Operator of the status change. [Violation Risk Factor: Medium] [Time Horizon: Real-time Operations]

➢ Power System Stabilizer:

New generators that are connected by a generator step-up transformer to the PSE system at a voltage of 60 kV or higher shall have power system stabilizers, and shall tune and
operate them according to the requirements of “WECC Policy Statement on Power System Stabilizers.” The Policy defines exceptions and suitability requirements. Generating Facilities that are less than or equal to 30 MVA are exempt from such requirements, unless they are part of a complex with an aggregate capacity larger than 75 MVA.

Power System Stabilizers shall be selected and designed according to the requirements of the “WECC Policy Statement on Power System Stabilizers”, and the “WECC Power System Stabilizer Design and Performance Criteria”.

Every power system stabilizer shall operate in-service at all times the Interconnection Customer’s Generating Facility is connected to the PSE system, except for reasons given in “WECC Standard VAR-501-WECC-3.1 — Power System Stabilizer”, and the “WECC Policy Statement on Power System Stabilizers.”

➢ The Overexcitation Limiter:

The voltage regulator shall include an overexcitation limiter. The overexcitation limiter shall be of the inverse-time type adjusted to coordinate with the generator field circuit time-overcurrent capability. Operation of the limiter shall cause a reduction of field current to the allowable level. Full automatic voltage regulation shall automatically be restored when system conditions allow field current within the continuous rating.

4.9 GOVERNOR REQUIREMENTS - TRANSMISSION CONNECTED GENERATING FACILITY

Governors shall be operated in automatic with droop set to greater than or equal to 3 percent but less than or equal to 5 percent as stated in the WECC Governor Droop Setting Criterion PRC-001-WECC-CRT-2 (or as otherwise provided in its most current criterion).

Governor dead bands should, as a minimum, be fully responsive to frequency deviations exceeding +/- 0.036 Hz ( +/-36mHz) or to a larger frequency deviation if approved by PSE transmission operators. Frequency should be calculated over a period of time (e.g., around six cycles), and filtered to take control action on the fundamental frequency component of the calculated signal. Calculated frequency should not be susceptible to spikes caused by phase jumps on the PSE system.

All “newly interconnecting” large and small generating facilities, both synchronous and non-synchronous, shall install, maintain, and operate equipment capable of providing primary frequency response as a condition of interconnection. Generating facilities that execute or request an unexecuted filing of an LGIA or SGIA (which include existing generating facilities that take any action that requires the submission of a new interconnection request resulting in execution of or the unexecuted filing of an LGIA or SGIA) on or after May 15, 2018 are subject to these requirements.
4.10 INDUCTION GENERATORS

Installations over 5 kVA capacity may require capacitors to be installed to maintain a power factor of at least 0.95 over a range of 25% to 100% of output rating (see Section 3.7) at the high-side of the generator substation. Such capacitor installation will be at the expense of the Interconnection Customer.

Under certain conditions, a self-excited induction generator can produce abnormally high voltages that can cause damage to the equipment of other Interconnection Customers and other customers. Overvoltage relays can limit the duration of such overvoltages but cannot control their magnitude. Because of these problems, the reactive power supply for large induction generators must be studied on an individual basis. In general, self-excitation problems are most likely in rural areas where the PSE system capacity and load density are low.

It is particularly important for the Interconnection Customer to contact PSE to determine if an induction generator can be connected to an existing distribution line. Where self-excitation problems appear likely, special service arrangements will be required.

4.11 INVERTER SYSTEMS

Since inverters can be a harmonic source, the Interconnection Customer shall strictly comply with Section 3.2.

4.12 GENERATORS CONNECTED THROUGH A CLOSED-TRANSITION TRANSFER SWITCH

Certain installations, such as demand reducing units (sometimes referred to as “peak shaving” units, where the local demand is reduced), or emergency backup generation, may operate in parallel with PSE’s system for some period of time. Although no power is intentionally shipped to PSE, and no power is purchased by PSE, faults that occur on PSE’s system while the generation is operating in parallel will be subject to fault contributions from the generator.

A Parallel Operation Agreement is not required for the following:

- For installations with an aggregate capacity of 25 kVA or less. The installation must comply with the requirements of PSE’s Schedule 150.
- For installations with an aggregate capacity of 26 to 999 kVA of generation, paralleled to PSE’s system through an automatic transfer switch that is designed to have the systems in parallel for less than 100 milliseconds.
- For installations with an aggregate capacity of 1000 kVA to 20 MVA of generation, paralleled to PSE’s system through an automatic transfer switch that is designed to have the systems in parallel for less than 500 milliseconds.

However, for aggregate capacity greater than 25 kVA, written approval outlining the Interconnection Customer’s liability is required per Schedule 80.
A Parallel Operation Agreement is required for either of the following instances:

- Installations with an aggregate capacity of 1000 kVA or more of generation, regardless of the intended duration of the parallel, or;
- Installations with an aggregate capacity of 26 to 999 kVA of generation that is designed to operate in parallel with PSE’s system for 100 milliseconds or longer.

Note: When a Parallel Operation Agreement is required, the interconnection requirements in this document will apply. If the Interconnection Customer’s system has a transfer switch of the open transition type (break-before-make) at the Point of Interconnection, the switch must be approved in advance by PSE.

4.13 WIND POWER, SOLAR POWER AND BATTERY ENERGY STORAGE GENERATING FACILITIES

All developers must provide detailed technical data for their wind turbine, solar panel/inverter or battery cell/inverter for each wind turbine type, solar panel type or battery cell type to be installed at the Generating Facility. If PSE or the developer do not have an approved Power Technologies, Inc. PSS/E software model(s) for each of the proposed wind turbines, the developer shall be responsible for funding the development of a new wind turbine model(s). See also “WECC Dynamic Modeling Procedure”, and “WECC Approved Dynamic Model Library”.

4.13.1 Production Control of Wind Power, Solar Power and Battery Energy Storage

The Interconnection Customer’s Generating Facility plant must be capable to, and must control production when requested under the direction of PSE operators to comply with the following conditions:

(a) The production ramp-up limit, determined as a one-minute average value, or specified in terms of MWs per minute, must not at any time exceed five percent (5%) per minute of the maximum power of the Interconnection Customer’s Generating Facility;

(b) The production ramp-up and ramp-down under "spill wind" (i.e., turbines generating below wind speed capability) or solar curtailment conditions must be able to be controlled by a single central signal, and control algorithms must be capable of being changed from time to time;

(c) Production control must be capable of reducing output by at least fifty percent (50%) of then-current power production in less than two (2) minutes;

(d) For wind generation, a single central signal shall not be used to shut down multiple turbines simultaneously due to high wind speed, instead individual turbine sensors will be used to ramp down individual turbines.
5. MINIMUM INTERCONNECTION PROTECTION REQUIREMENTS

To ensure that all proposed interconnections are handled uniformly, this section outlines the minimum protection requirements for the interconnection to protect PSE’s system.

Note: PSE reserves the right to require additional protection necessary to preserve the integrity of the PSE System. Each request will be studied individually to identify protection requirements specific to the project, as well as required network upgrades resulting from the project.

5.1 TYPICAL INTERCONNECTION REQUIREMENTS

See Table 5.1 for a listing of Attachments for one-line diagrams of typical interconnection requirements, located in the back of this document.

- Project design shall include redundancy and backup protection, in accordance with Good Utility Practice.
- For all Generating Facilities ≥ 25 kVA, connection to the PSE system must be through a service transformer that is not used to serve other customers.
- For all non-inverter technology > 25 kVA, the interconnection protection shall be utility grade, and shall conform to the most current version of ANSI Standard C37.90. Frequency relays must be solid-state or microprocessor technology.
- All Generating Facilities > 50 kVA require three-phase connections.
- If generation ≤ 300 kVA connects to PSE’s system through an inverter or static power converter which complies with UL1741 for non-islanding operation, then no further interconnection protection is required.
- The design of the interconnection protection shall be based upon a single failure philosophy. Discrete relays may act as a back-up to one another. For multifunction microprocessor based relays, two separate redundant relays are required. For installations ≤ 300 kVA, a single microprocessor-based relay is permissible if its alarm will automatically isolate the generation from the PSE system. The microprocessor-based alarm must be of the normally held-open type that closes upon alarm or loss of power.
- Microprocessor relays provide event recording. Event recording is recommended for all Generating Facilities > 300 kVA and may later be required if needed for unresolved operational or fault events.
- PSE will specify interconnection transformer connections for projects greater than 500 kVA.
- Overcurrent protection and breaker failure detection and tripping are required on all generation > 300 kVA. Failure of the interconnection breaker must initiate secondary action to isolate the generation from PSE’s system.
- If adequate sensitivity of interconnection relays is not achievable with aggregated generation, individual relaying will be required on each generator.
Any protective relay not equipped with an internal isolation device must be connected through an external test device, such as the ABB FT-1 switch or equivalent.

If lightning arresters are installed, they must be properly rated for the system. Protection of the Generating Facility is the responsibility of the Interconnection Customer.

Because of feeder relay desensitization, potential islanding and fault duty, connection to the distribution substation by a dedicated feeder is required under the following conditions: from 12 kV to 34.5 kV, projects > 5 MVA and ≤ 10 MVA require a dedicated feeder.

Generation over 10 MVA must be connected to facilities that operate at a voltage greater than 35 kV. Generation over 10 MVA must not be connected to facilities that are used to serve non-generator loads.

### Table 5.1 List of One-Line Diagrams

<table>
<thead>
<tr>
<th>Generation Capability:</th>
<th>See Attachment:</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ 25 kVA</td>
<td>• Schedule 150</td>
</tr>
<tr>
<td>&gt; 25 kVA to ≤ 300 kVA</td>
<td>• Attachment 1</td>
</tr>
<tr>
<td>&gt; 300 kVA to ≤ 5 MVA</td>
<td>• Attachment 2</td>
</tr>
<tr>
<td>&gt; 5 to ≤ 10 MVA</td>
<td>• Attachment 3</td>
</tr>
<tr>
<td>&gt; 10 MVA</td>
<td>• Attachment 4</td>
</tr>
</tbody>
</table>

### 5.2 MINIMUM SYSTEM REQUIREMENTS

In all cases, the interconnection equipment must isolate the Generating Facility from the PSE system when power is disconnected from its PSE source, including, but not limited to, before any reclosing (automatic or manual) takes place. The Interconnection Customer shall prevent its generation equipment from automatically re-energizing the PSE system.

For all generation added to the PSE distribution system, the total symmetrical three-phase fault current shall not exceed 10,000 amps rms and the total symmetrical single-phase-to-ground fault current shall not exceed 7,100 amps rms. This total includes the proposed generation and the existing system, which includes all aggregate generation as calculated by PSE.

### 5.3 PROTECTION SYSTEM MODIFICATIONS

The following PSE protection system modifications may be required at the Interconnection Customer’s expense:

#### 5.3.1 Modifications for Distribution Interconnections

- For a Generating Facility whose total capacity is ≥ 50% of the Interconnection feeder minimum load, system modifications to PSE’s system may be required to detect and clear certain faults.
- Certain conditions may dictate use of direct transfer trip from PSE’s substation to the Generation Facility. These conditions include unacceptably
slow clearing for PSE end-of-line faults, the Generation Facility being capable of carrying the minimum feeder load with the PSE source disconnected, or other undesirable operations (such as extended overvoltages or ferro-resonance) that cannot be resolved by local protection measures. The communication medium for direct transfer trip is typically dedicated optical fiber.

- Depending upon the location of the Generating Facility along the distribution circuit, smaller generation may require further protection than previously described and system changes to the PSE distribution system when its capacity is a high percentage of the PSE’s system load.

- For a Generating Facility greater than 1 MVA connected to a 12.5 kV distribution line (size of facility is proportional for other voltages), all existing single-phase fault interrupting devices between the generator and PSE’s substation shall be replaced with three-phase interrupting devices. This will help prevent possible single-phase islanding of other PSE customers.

- When special system modifications are required on the normal feed to a Generating Facility, the generator will not be allowed to operate when fed from an alternate source, unless the alternate source has been similarly modified.

- The interconnection equipment is to be located as close as possible to the Point of Interconnection between the Interconnection Customer’s Generating Facility and PSE’s system. Typical distances are within one span of overhead line or 200 feet of unspliced cable. PSE will use prudent engineering judgment to determine when additional protective devices are required at the Point of Interconnection to limit exposure to the PSE system.

### 5.3.2 Modifications for Substation Interconnections

- When the generation capacity is 50% or more of the minimum load of the substation feeding the Generating Facility, and if the substation transformer feeding the Generating Facility is protected by fuses on the primary, then the fuses must be replaced with a three-phase interrupting device and necessary protection that will also trip the interconnection breaker when opened.

### 5.3.3 Modifications for Transmission Interconnections

- When the generation is \(\geq 50\%\) of the minimum load of the transmission line feeding the substation, the generation must be disconnected for transmission system faults, in order to prevent islanding. Additional protection devices may be required.

- Any generation connected to the transmission system will require overlapping zones of protection.

- Certain conditions may dictate use of direct transfer trip between PSE’s transmission stations or to the Generation Facility. These conditions may include RAS schemes, issues with clearing times, stability issues or undesired operations.
6. METERING: PSE REVENUE, OPERATIONS AND SCHEDULING REQUIREMENTS

6.1 GENERAL

Metering may be required for revenue purposes, System Operations purposes, or both, depending on the specifics of the project.

Revenue metering is required for the measurement of any function that will be billed under a PSE Scheduled Tariff. The Washington Administrative Code (WAC) requires that revenue metering be owned and operated by PSE, and that it meets stringent accuracy requirements. Even if revenue metering is not required on a project initially, it is often advisable, during the planning and construction of interconnection facilities, to include all the provisions for the possibility of future installation of PSE-owned revenue metering as retrofit installation at a later date can be extremely costly and complicated compared to the incremental cost of including those provisions during the initial construction.

Systems Operation metering is used for dispatching, reserves, accounting, and control of the PSE Transmission and Distribution systems. Whether or not System Operations metering is required is the sole discretion of PSE. Often, the revenue metering can also be used to provide meter data for system operations, which is the most cost effective solution when both metering systems are necessary. If System Operations metering is required but revenue metering is not required, it may be possible for the System Operation metering to be customer-owned as Systems Operation metering does not fall under the WAC. Systems Operation metering that is customer-owned must be reviewed in advance by the PSE Electric Meter Engineering Department for function and accuracy. Accuracy must be within +/- 1.0%.

6.2 REVENUE METERING

In general, Revenue Metering installation requirements for the different categories of the Interconnection Customer-owned parallel generators are the same as those outlined in PSE’s Electric Service Handbook for Commercial/Industrial/Multifamily & Manufactured Housing Developments (PSE Standards 6325.3000-3370). In addition to the PSE Handbook, metering installations shall comply with the requirements of the Electric Utility Service Entrance Requirement Committee (EUSERC), Section 300 or 400, as appropriate. PSE will provide a current one page EUSERC acceptability summary.

Preferably, the metering will be located on PSE’s side of ownership of the electric facilities and the metering voltage shall normally be the same voltage as the Point of Interconnection for the Generating Facility output. Primary Metering Cabinet per PSE standards shall be required for most primary metered interconnections sized for 15 kV-600 amp main feeder or smaller. If the voltage at the Point of Interconnection exceeds 15 kV, metering may be installed at the low side of the step-up transformer. In this case, loss compensation shall be applied at the meter to adjust for transformer and line losses between the meter point and the Point of Interconnection. In this case, the
Interconnection Customer shall provide PSE with a standard ANSI Power Transformer Test report to be used for transformer loss compensation calculations.

For qualifying facility Interconnection Customers who have contracted to sell the total output of the Generating Facility to PSE, two metering schemes are available.

1. **Metering Scheme Option "A"** shall be used when the Interconnection Customer's load requirements are served directly by the Interconnection Customer's generator. Bi-directional metering shall be utilized for this option, with the delivered energy registers measuring power entering the facility when load exceeds generation, and the received energy registers measuring the power leaving the facility when generation exceeds load. Metering Scheme Option “A” is illustrated in Attachment 5. This option is available where the station service loads fall within the range of accuracy for the bi-directional revenue accuracy class metering equipment.

2. **Metering Scheme Option "B"** shall be used when the Interconnection Customer has contracted to provide all generator output and PSE or another utility serves the Interconnection Customer's entire load requirements from a separate source. Two revenue meters will be used for this option. At the first metering point, the generator meter, the received energy registers of a bi-directional meter will measure the net output of the generator, that is to say the gross output of the generator minus the metered power consumed by the power production process. The delivered energy registers on the same bi-directional meter will measure the power consumed by the power production support equipment when the generator is off-line, and that is not metered separately. The second metering point, the station service meter, will measure all other loads. The Interconnection Customer is responsible for all metering costs for the generation metering. Metering Scheme Option “B” is illustrated in Attachment 6.

PSE shall provide, at the Interconnection Customer’s expense, revenue accuracy class current and potential transformers, concrete vaults, conduits, conductions, terminations, pad mounted primary metering cabinets, test switches, and the meter(s) for pad mounted primary metering cabinets or overhead mounted primary metering installations where applicable. In cases where customer switchgear primary metering per EUSERC 400 is suitable, revenue accuracy class instrument transformers shall be installed by the Interconnection Customer. The Interconnection Customer is responsible for furnishing, installing, and maintaining the meter sockets, switches, enclosures, conduit, protection equipment, and all necessary wiring and connections (except CT and VT secondary wiring) where applicable.

The Interconnection Customer is required to provide a phone line to the site for remote interrogation of the meter. If several meters are required, the Interconnection Customer shall provide a 1-1/2-inch conduit between meter cabinets for communication and control cables between the meters.
The Interconnection Customer will provide an auxiliary single-phase 120-Volt source to all meter points. This will provide auxiliary power to the meter in the event the interconnection metering point is de-energized.

All revenue and system operation metering installations must be reviewed and approved by the PSE Electric Meter Engineering Department.

6.3 **SCADA RTU (REMOTE TERMINAL UNIT) METERING**

Balancing Authorities, such as the one operated by PSE, are required to meet NERC, WECC and NWPP operating policies and to conform to Good Utility Practices. One such requirement is to have generating reserves per the WECC Minimum Operating Reliability Criteria and the NWPP Reserve Sharing Procedure. These reserves include regulating, contingency spinning, and contingency non-spinning. For System Operations generation SCADA RTU metering is needed to manage reserves and to account for contingency load obligations. This section deals with those requirements.

6.3.1 **Generator Sites with a Combined Output Less Than 2 MW**

Real time monitoring is not required for generator sites having a combined output of less than 2 MW. Also, real time monitoring is not required for generators that do not operate in parallel with PSE’s system. For the purpose of this Standard, this includes standby generation intended for emergency use only, and generators connected to the system momentarily via closed transition switching (100 ms or less).

6.3.2 **Generator Sites with a Combined Output of 2 MW or Greater**

Real-time monitoring data is required for generation sources with a combined output of 2 MW or greater. This data is sent from the generator site to PSE’s Operating Center using SCADA RTU equipment. A dedicated communication circuit (e.g., leased line) is required to transmit such data. Generation values are transmitted continuously from the source to the Operating Center and hourly accumulations are calculated at the end of each hour for Balancing Authority accounting purposes.

These generation values are used for Automatic Generation Control (AGC), reserves calculations, forecasting, and for Balancing Authority energy accounting. If applicable, PSE may require indication of the spinning reserve available and for reserves under control.

The following includes specific requirements:

- Meter values sent via the SCADA RTU include bus voltage, real power (MW), energy (MWh) and reactive power (MVAR).
- Totalizing metering quantities from multiple generators at one site is desirable in most cases.
• PSE will determine SCADA RTU requirements for temporary generators (12 months or less) on a case-by-case basis. Energy Pre-Scheduling may be used as an alternative to a SCADA RTU for temporary sites.

• The SCADA RTU requires dedicated communication circuits between the project and the PSE operating center.

• Reasonable access must be provided by the Interconnection Customer to PSE for installation, testing, and repair of the SCADA RTU equipment and circuits.

• The design, purchase, installation, testing, maintenance, and replacement of the remote generation SCADA RTU equipment will be the responsibility of PSE.

6.4 GENERATION COORDINATION AND REQUIREMENTS

Interconnected generation that is either temporary or permanent and equal to or greater than 2 MW shall be pre-scheduled for each scheduling period using PSE’s normal scheduling procedures and consistent with NERC Reliability Standards and NAESB Business Practice Standards and PSE’s Open Access Transmission Tariff and applicable business practices. The pre-schedule shows hourly generation plans on a 7-day (168-hour) advance time period, and is updated weekly or as conditions change. If prescheduled generation is taken off line for any reason, the Interconnection Customer shall ensure it will be consistent with the applicable generator interconnection agreement, PSE’s tariff, and applicable business practices.

Temporary generation (less than 12 months) that is greater than or equal to 2 MW, but less than or equal to 10 MW, does not require a SCADA RTU but does require prescheduling as described above.

Generators 5 MW or greater will be subject to PSE’s Energy Imbalance Market Business Practice and the applicable requirements under PSE’s Open Access Transmission Tariff.

Specifically resources 5 MW or greater whether participating resources or non-participating resources must be accurately modeled in both PSE’s and the market operator’s network models eight months prior to energization. Additional information in regards to PSE’s Open Access Transmission Tariff, Energy Imbalance Market Business Practice, templates, forms and training can be found at: http://www.oatioasis.com/PSEI.

Generation forecast data for participating and non-participating resources 5 MW or greater will also be required to submit their generation forecast data consistent with PSE’s Open Access Transmission Tariff and Energy Imbalance Market Business Practice.

Participating and non-participating resources 5 MW or greater that are variable energy resources to generating facilities will also be required to additional generation forecast data consistent with PSE’s Open Access Transmission Tariff and Energy Imbalance Market Business Practice.
6.5 SCADA RTU REQUIREMENTS

The general SCADA RTU requirements from the Interconnection Customer to PSE are provided for each generating unit greater than or equal to 2 MW in Table 6.5.1, and for the Point of Interconnection the requirements are provided in Table 6.5.2.

SCADA for breaker status is required for the Point of Interconnection between PSE and the Customer generator when generators are connected to the transmission system.

PSE’s 24-Hour Operating Center must have the ability to disconnect the Generating Facility from PSE’s system via SCADA for sites that are 10 MW or greater. Switching procedures for disconnecting the Generating Facility will vary depending upon the interconnection facility configuration.

Each wind power Generating Facility shall provide a signal to PSE indicating why the Generating Facility’s power production has stopped, including lack of wind high speed wind cutout, forced outage, or by external control. Using signals from the PSE system operator and from local measurements (i.e., voltage, frequency, wind speed, etc.), the Interconnection Customer will provide a control system managing the operation of the wind turbines.

Each solar power Generation Facility shall provide a signal to PSE indicating why the Generation Facility’s power production has stopped, including cloud cover, forced outage, or by external control. Using signals from the PSE system operator and from local measurements (i.e., voltage, frequency, solar index, etc.) the Interconnection Customer will provide a control system managing the operation of the solar panels.
Table 6.5.1 SCADA RTU Points on Generating Units ≥ 2 MW

| Generator - Non PSE Control | • MW showing direction of flow (+ / -)  
|                           | • MWh delivered by PSE per hour  
|                           | • MWh received by PSE per hour  
|                           | • MVAR showing direction of flow (+ / -)  
|                           | • Bus Voltage  
|                           | • Interconnecting Breaker - Control  
|                           | • Alarms  

| Generator - Operated by PSE | • MW for each unit  
|                            | • MW Total Output showing direction of flow (+ / -)  
|                            | • MVAR Total showing direction of flow (+ / -)  
|                            | • MWh delivered by PSE per hour  
|                            | • MWh received by PSE per hour  
|                            | • Bus Voltage  
|                            | • Station Service voltage  
|                            | • Generator breaker status  
|                            | • Local/Remote Status  
|                            | • Interconnecting Breaker - Control  
|                            | • Start/Stop  
|                            | • Raise/Lower MW  
|                            | • Raise/Lower MVAR  
|                            | • Ramp Rate  
|                            | • Run Mode Select (peak/base)  
|                            | • Load Limit Select  
|                            | • Fuel Select (if applicable)  
|                            | • Alarms  

Table 6.5.2 At Point of Interconnection

| Point of Interconnection - (For All Generators) | 55 kV – 230 kV | • Requires SCADA Control and Indication.  
|                                                 |               | • MW and MVAR Metering  
| 4 kV – 34.5 kV                                 |               | • Requires SCADA Control and indication for generators 10 MWs and greater.  
|                                                 |               | • System Planning shall determine needs based circuit configuration |
7. DESIGN REVIEW AND DOCUMENTATION

Generating Facilities that are \( \leq 25 \text{ kVA} \) are to follow the review process prescribed by PSE’s Schedule 150.

For all Generating Facilities over 25 kVA, the following review process must take place.

7.1 DESIGN REVIEW PROCESS

**Step 1: Interconnection Customer Submits an Interconnection Request**

The Interconnection Customer initially submits a preliminary design package to PSE for review and approval. This package shall include:

- A proposed electrical one-line diagram that identifies basic service voltages, manufacturer’s name, and equipment rating.
- Major facility equipment and ratings, such as generators (gross and net), Generating Facility address, transformers, breakers, or approximate load/station service requirements.
- Metering and Point of Interconnection (voltage and physical location).
- Any pertinent information on normal operating modes, proposed in-service dates (both initial energization and commercial operation).
- Appropriate Paperwork:
  - \textit{Generating Facility Connected to the Distribution System} - The Interconnection Customer completes the generator and transformer data as shown in Appendix A.
  - \textit{Generating Facility Connected to the Transmission System} - The Interconnection Customer completes the generator and transformer data as shown on Appendix B.

\textit{Note:} In order to avoid any unnecessary costs associated with changes to the preliminary design plans, this preliminary design package should be submitted prior to the Interconnection Customer ordering any equipment, or beginning any major detailed engineering consultant work.

**Step 2: PSE Performs Interconnection Feasibility Study**

After a Feasibility Study is completed by the PSE Planning department, the PSE Protection and Control groups will then review the general requirements and work with the Interconnection Customer during the preliminary evaluation of the Generating Facility.

**Step 3: PSE’s Design Review**

The Interconnection Customer is required to submit various design documentation to PSE for review, and undergo specified PSE-witnessed start-up testing procedures (see Sections 9 and 10) prior to interconnecting with the PSE system. The specific design
documents and test procedures will vary depending on each Generating Facility; however, the general requirements for the design review process are outlined below. The PSE representative is to be contacted for the actual procedures to be followed on a specific project.

7.2 PSE PERFORMS REVIEW OF INTERCONNECTION CUSTOMER'S PROTECTION DESIGN

The PSE Protection department will have primary responsibility for reviewing and commenting on all required protection design and associated settings. This data shall be provided after the Interconnection Customer works with PSE on the appropriate system requirements.

The Interconnection Customer shall provide the following information:

**Detailed one-line diagram of entire Generating Facility system:**
This drawing shows the functional arrangement of all interconnection and generation equipment using single line and standard symbol notations per ANSI 432.2 and 41.1. It must include a table that lists the equipment ratings.

**An AC current and potential control schematic of the Generating Facility:**
The AC schematic is a primary three line drawing showing the phasing and interconnection of the CTs and VTs with the interconnection protection. The drawings shall show all grounding of cables, CTs, etc., as well as indicating polarity.

**A control schematic of the Generating Facility:**
The schematic shall be functionally complete showing all DC potential circuits with all relays and control connections to the tripping and closing coils of the interconnection breaker. All relay output contacts and switches require a development table. The schematic must show the terminal designation of all devices.

**A three-line diagram of the Generating Facility:**
This drawing must include all the equipment shown on the one line diagram. Phasing and bushing designations for all primary equipment shall be shown.

**All protective equipment ratings:**
Provide ratings for all protective equipment.

**Generator data:**
Provide the generator data.

**Ground Mat design and test data:**
Provide the ground mat design and test data.

**Equipment specifications and details:**
This should include the specifications and details for transformers, circuit breakers, current transformers, voltage transformers, and any other major equipment or special items. Transformer information is to include configuration, ratings, nameplate diagram,
and % positive and zero sequence impedance based upon the transformer’s self-cooled rating.

Specific setting information on all of the interconnection and generation relays:
Information is to include the manufacturer, model, style number, and setting range information for each relay.

7.3 PSE’S REVIEW TIMELINE

PSE will review the preliminary design documentation and provide comments in a timely manner. This may include cost estimates, as appropriate, for any modifications to the PSE system required to accommodate the interconnection. PSE will also provide maximum PSE system short circuit data as requested by the Interconnection Customer.

PSE will review the final design documentation and provide comments in a timely manner. If any changes are made, the Interconnection Customer shall provide to PSE a set of revised one-lines, schematics, and construction drawings. The Interconnection Customer may elect to also supply at this time the proposed test procedure as required for PSE witnessing of tests (see Sections 9 and 11). This should be done in advance (at least 30 days) of the actual testing. In addition, the Interconnection Customer shall provide a copy of the electrical permit issued by the local jurisdiction prior to scheduling witness tests. Usually a coordination meeting is held with PSE and the Interconnection Customer to clarify any questions that may exist before testing begins.

7.4 AS-BUILT DOCUMENTATION DEADLINE

The final “As-Built” documentation, including all drawings and final “As-Left” relay settings, must be provided by the Interconnection Customer to PSE not later than 90 days after the date of commercial operation. If the Generating Facility is 1 MVA or greater, the final As-Built drawings shall be stamped by a Professional Electrical Engineer, registered in the State of Washington.
8. PROTECTION SETTINGS

The Interconnection Customer, in accordance with the following guidelines, shall specify all relay settings of the interconnection protection. PSE shall review and approve the settings to verify coordination with the PSE system.

8.1 INTERCONNECTION PROTECTION

The following lists the general settings and guidelines:

Undervoltage (27) with Time Delay
Detected abnormal voltage conditions caused by islanded operation scenarios and adheres to NWPP requirements. Relay to be set at approximately 80% of nominal voltage with a 3.5 second delay.

Overvoltage (59) with Time Delay
Detected abnormal voltage conditions caused by islanded operation scenarios. Relay to be set at approximately 120% of nominal voltage.

Overfrequency (81O)
The frequency relays must be solid state or microprocessor technology. Detected abnormal frequency conditions caused by islanded operation scenarios. Relay to be set at 61.7 Hz with a 0.2 second delay.

Underfrequency (81U) with Time Delay
The frequency relays must be solid state or microprocessor technology. Detected abnormal frequency conditions caused by islanded operation scenarios. Relay to be set at 56.4 Hz with a 0.2 second delay.

PSE Transmission Over and Under voltage with Time Delay (27/59 & 59N)
Set by PSE to coordinate with PSE system.

Voltage restrained time overcurrent relays (51V)
Set by the Interconnection Customer to coordinate with downstream devices. Setting checked by PSE to ensure coordination with upstream PSE system and PSE line end clearing sensitivity.

Phase and Ground Overcurrent Relaying (51, 51N)
Set by PSE to protect feeder to Generating Facility. 51N at Point of Interconnection set by the Interconnection Customer and checked by PSE to ensure coordination with distribution system and PSE line end clearing sensitivity.

Distance Relaying (21)
May be required to detect phase faults on the tapped transmission line and remove generator contribution. Set by PSE.

Negative Sequence Overcurrent (46)
May be required for further fault sensitivity or detection of upstream fuse operation. Set by the Interconnection Customer and checked by PSE to ensure coordination with PSE’s system.

**Negative Sequence Overvoltage (47)**
May be required for further fault sensitivity or detection of upstream fuse operation. Set by the Interconnection Customer and checked by PSE to ensure coordination with PSE’s system. Relay to be set at approximately 10% nominal voltage with a 3.5 second delay.

**Synchronism Check (25)**
Required on all breakers that may be used to synchronize the synchronous generator to the system. The parameters must be a voltage differential of 5% or less, a frequency differential of 0.2 Hz or less, and a phase window of 10 degrees maximum difference.

### GENERATION PROTECTION

All generation protection settings are to be specified by the Interconnection Customer. PSE will review the underfrequency and overfrequency settings. The underfrequency and overfrequency settings must comply with NWPP and WECC requirements. A copy of all other generator settings shall be sent to PSE for general information only.

#### 8.2.1 Overfrequency / Underfrequency (81 O/U)

The frequency relays must be solid state or microprocessor technology. Frequency relays on transmission level facilities, and all distribution level facilities that are above 5 MW are required to have multiple setpoints.

The relay settings listed below are current WECC requirements for coordinating overfrequency and underfrequency generator tripping. The Interconnection Customer shall meet WECC requirements as may be modified from time to time.

**Table 8.2.1 Relay Setting Requirements**

<table>
<thead>
<tr>
<th>Underfrequency Limit</th>
<th>Overfrequency Limit</th>
<th>WECC Minimum Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 59.4 Hz</td>
<td>60 Hz to &lt; 60.6 Hz</td>
<td>N/A (continuous operation)</td>
</tr>
<tr>
<td>≤ 59.4 Hz</td>
<td>≥ 60.6 Hz</td>
<td>3 minutes</td>
</tr>
<tr>
<td>≤ 58.4 Hz</td>
<td>≥ 61.6 Hz</td>
<td>30 seconds</td>
</tr>
<tr>
<td>≤ 57.8 Hz</td>
<td>–</td>
<td>7.5 seconds</td>
</tr>
<tr>
<td>≤ 57.3 Hz</td>
<td>–</td>
<td>45 cycles</td>
</tr>
<tr>
<td>≤ 57.0 Hz</td>
<td>&gt; 61.7 Hz</td>
<td>Instantaneous trip</td>
</tr>
</tbody>
</table>

The Interconnection Customer is responsible for protecting its Generating Facilities. The manufacturer’s recommendations for some units may be more restrictive than the values shown in the table above.

#### 8.2.2 Alternative to Meeting Underfrequency WECC Requirements

The Interconnection Customer is responsible for protecting its electrical generating units. The manufacturer’s recommendations for some units may be
more restrictive than the values shown in the Table 8.2.1 or then-current WECC requirements. Generating Facilities having generators that do not meet the above underfrequency requirements must automatically trip load or arrange with another system to automatically trip loads to match the anticipated generation loss at comparable frequency levels.

8.2.3 Overvoltage / Undervoltage (59/27)

The voltage relays must be solid state or microprocessor technology. Frequency relays must have multiple setpoints.

The relay settings listed below are current WECC requirements for coordinating over- and undervoltage generator tripping based on voltage measurements at the Point of Interconnection. The Interconnection Customer shall meet WECC requirements as may be modified from time to time.

<table>
<thead>
<tr>
<th>Voltage (pu)</th>
<th>Minimum Time (sec)</th>
<th>Voltage (pu)</th>
<th>Minimum Time (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;1.200</td>
<td>0.00</td>
<td>&lt;0.45</td>
<td>0.15</td>
</tr>
<tr>
<td>≥1.175</td>
<td>0.20</td>
<td>&lt;0.65</td>
<td>0.30</td>
</tr>
<tr>
<td>≥1.15</td>
<td>0.50</td>
<td>&lt;0.75</td>
<td>2.00</td>
</tr>
<tr>
<td>≥1.10</td>
<td>1.00</td>
<td>&lt;0.90</td>
<td>3.00</td>
</tr>
</tbody>
</table>

The Interconnection Customer is responsible for protecting its Generating Facilities. The manufacturer’s recommendations for some units may be more restrictive than the values shown in the table above, in which case equipment limitations that prevent such performance per NERC standard PRC-024-2 requirement R3 are allowed.
9. DEMONSTRATION OF INTERCONNECTION CUSTOMER’S PROTECTIVE DEVICES

9.1 GENERAL
The Interconnection Customer shall send PSE a copy of the proposed test plans at least 30 days before planned testing in order for PSE to review and approve the plans. The Interconnection Customer shall demonstrate to PSE’s representative the correct operation of the interconnection protective devices, as described below. PSE shall not be responsible for performing such demonstration. The Interconnection Customer must provide qualified electricians, technicians, and operators to perform the demonstration(s). The Interconnection Customer must supply all personal protective equipment and designate any procedures necessary to ensure that safety precautions are taken while working near energized equipment. The scheduling of this demonstration shall be coordinated with PSE, with a minimum of 72 hours advance notice.

The protective device demonstration shall be divided into two parts,

1. **Calibration** - The Calibration demonstration is to ensure that the agreed-upon settings are used on each of the relays required by PSE. This demonstration is also to ensure that the relays are functional and calibrated to manufacturers’ tolerances.

2. **Trip and Circuit Checks** - The Trip and Circuit Check demonstration is to ensure that each of the required relays is properly connected to the instrument transformers and operate the proper interrupting device. All of the initial tests must be successfully completed and certified test reports of relay and instrument transformers provided to PSE prior to interconnection with PSE’s system.

The following Calibration and Trip and Circuit Check sections are intended to serve as general requirements. The actual demonstration will depend upon the final approved AC/DC schematics, relay settings, etc. It is the Interconnection Customer’s responsibility to demonstrate operation of all protective devices in a safe manner that does not adversely affect any equipment on the line.

9.2 CALIBRATION

9.2.1 Current Transformer (CT)
Visually check polarity mark orientation on all CTs with respect to the AC schematics in the design drawings. Perform polarity checks of the CTs per the most current version of ANSI Standard C57.

The following calibration tests shall also be performed:
- Verify the CT polarity.
- Verify that all grounding, shorting connections, and test blocks provided make good contact.
• CT single point grounding shall be confirmed for each CT circuit as shown on the drawings, with the preferred grounding location at or near the relay panel.
• Ratio CTs at specified tap ratio.
• Perform Megger® tests on all CTs to ground.
• Perform demagnetization and excitation tests on CTs as the final tests on CTs.
• Check excitation test data against CT excitation curves.

9.2.2 Voltage Transformer (VT), Potential Device (PD), Capacitor Voltage Transformer (CVT), and Coupling-Capacitor Voltage Transformer (CCVT)

Visually check polarity mark orientation on all VTs, PDs, CVTs, and CCVTs with respect to the three-line diagrams in the design drawings and the manufacturer’s drawings. Test all polarities per the most current version of ANSI Standard C57.13.

• Verify polarity electrically relative to polarity marks.
• Verify ratio at specified tap.
• Verify VT, PD, CVT, and CCVT circuit single point grounding as shown on the drawings.
• Doble® power factor test all VTs, CVTs, and CCVTs.
• Adjust the PDs for the voltage and the burden of the secondary circuits to that they are being connected.

9.2.3 Relays

Test relays with actual setting values to verify calibration, input mapping, and output mapping.

9.2.4 Testing and Calibration

All testing and calibration of CTs, VTs, PDs, CVTs, CCVTs, and relays will be performed using test equipment of current calibration. “Current calibration” means:

• According to manufacturer’s calibration specifications and intervals.
• Within a one-year interval of the last equipment calibration.
• Proof of test equipment calibration must be provided to PSE prior to relay calibration.

9.3 TRIP AND CIRCUIT CHECKS

All required relays shall be functionally operated to demonstrate proper interrupting device operation. Tests may be performed off-line, if possible. Tests that cannot be performed off-line must be demonstrated to operate on-line. Trip outputs from the relay
may be arrived at either by manually operating all appropriate contacts, or by injecting an electrical signal to cause a trip output.

Check continuity of the CT circuit to each relay by primary injection. Following energization, verify correct voltage polarity at relays (where applicable).

Demonstrate that the interlocks between the generator and the interconnection breaker(s) operate properly (e.g., Interconnection Customers cannot energize a dead line and can only tie to a hot line via a synchronizing device).
10. DEMONSTRATION OF GENERATING SYSTEM FUNCTIONALITY

Interconnection Customers shall demonstrate to PSE the generator voltage controls and required reactive capabilities, the dispatch controls and monitoring equipment, the power system stabilizers, and the dynamic system response. PSE shall not be responsible for performing such demonstration(s). Interconnection Customers shall provide qualified personnel to perform the demonstrations. The Interconnection Customer must supply all personal protective equipment and designate any procedures necessary to ensure that safety precautions are taken while working near energized equipment. It is the responsibility of the Interconnection Customer to supply to PSE the actual written test procedures that incorporate the following types of tests, for PSE’s review prior to actual On-Line Start-Up Testing. The scheduling of this demonstration shall be coordinated with PSE, with a minimum of 7 days advance notice. The test procedures shall clearly show how generating system controls and parameters will be demonstrated, and they shall be provided to PSE for review and approval a minimum of 14 days before the demonstration.

These requirements are intended to be non-destructive; PSE shall not be liable for any loss, damage or injury to equipment or persons (including death) resulting from the implementation of these requirements by the Interconnection Customer. It is the Interconnection Customer’s responsibility to test and demonstrate generating system in a safe manner that does not adversely affect the generator or other interconnected equipment.

10.1 ON-LINE START-UP TESTING

The On-Line Start-Up Testing demonstration is to verify expected operation of synch check and interlocks specific to PSE/Interconnection Customer. The testing shall verify phase and rotation and the proper operation of the synchronizing relay. Voltage and current harmonics from the generator shall also be measured and must fall within the requirements of Section 3.2.

For generation systems greater than 1 MVA, a power quality analyzer (provided by the Interconnection Customer) shall be used to monitor all three-phase currents, three-bus voltages, neutral current or generator neutral current, and an auxiliary contact from the Interconnection Customer’s generator breaker and also PSE’s line breaker(s). The analyzer will have a minimum sample rate of 167 microseconds (128 points per cycle). PSE requires that the analyzer monitor the pre-breaker close conditions, the breaker closing, and the post close conditions of the system. Smaller generation sites may require this type of monitoring if the paralleling of the two systems produces a noticeable voltage dip or surge.

10.1.1 Synchronous Generators

Phase-out and check the rotation of the primary potential on both the incoming and running sides of the generator breaker with the generator running unloaded (such as between the generator and the PSE system). The primary phase-out voltage measurements are typically performed using two sets of hot sticks.
(supplied by the Interconnection Customer’s testing group) to verify zero voltage across the generator poles on two phases simultaneously.

While performing the phase-out and rotation check, test phasing and rotation across the open generator breaker using a syncroscope and voltmeter for VT secondary verification. Verify the proper operation of the synchronizing relay.

10.1.2 **Induction Generators**

Allow the prime mover to rotate the generator with generator breaker open. Then, with the prime mover removed and stopped, use a suitable voltage to bump the machine to verify electrical rotation. Expected result is the same direction of rotation.

1. Shut off the generator, open the line breaker and rack in the open generator breaker.
2. Close the line breaker, start up the generator and synchronize the generator to the PSE-energized system.
3. Verify that acceptable minimal flicker occurs at the close of the generator breaker and that the generator runs in a stable unloaded condition in parallel with PSE’s system. Synchronizing should normally take place while the syncroscope is moving in the “fast” direction (generator faster than system), but this is not required.

A power quality analyzer or BMI (supplied by the Interconnection Customer) will be used to verify proper breaker pole alignment and voltage flicker (see Section 3.7). Voltage and current harmonics from the generator will also be measured and must be in accordance with the requirements of Section 3.2.

10.1.3 **Solar Generation and Battery Energy Storage Devices**

1. The On-Line Testing is needed to verify expected operation of synch check and interlocks. The testing shall verify phase and the proper operation of the synchronizing relay.

2. The test of voltage and current harmonics at POI should be conducted and the presence of harmonics must fall within the requirements of Section 3.2.

10.2 **POWER FACTOR (PF) CONTROLLER TEST**

This test is intended to demonstrate that the Generating Facility (less than 10 MVA) added to the PSE distribution system will automatically disconnect when PF goes outside the limits established in Section 3.3. This test is to be done with plant load that can be interrupted during test procedures.

Many PF controllers (e.g., Basler) typically have a bias limit adjustment that may need to be adjusted to assure the voltage regulator operates in the proper voltage control range. The bias limit must be set to greater than 30%.
1. With the generator off-line, measure the power factor (PF) of the full house power kVA load. The measured value will usually be lagging, not unity.

2. Set the generator PF controller to a more leading PF (usually unity). This creates a VAR mismatch between the load and generator. Also, temporarily block the 81 O/U relay.

3. Bring the generator on-line. The station service load should be served by the generator.

4. Match the generator kVA to the house power load.

5. Trip the line breaker.

6. The generator should trip on low voltage due to PF mismatch by means of the undervoltage relay.

**Note:** A demonstration of compliance with contracted PF will be performed for induction generators and inverters.

### 10.3 VAR CAPACITY TESTS

The Interconnection Customer is advised that for transmission or distribution-connected generators there may be significant VAR losses absorbed into the generator’s step-up transformer. These losses will impact the Generating Facility’s net VAR capability (and PF) when the metered Point of Interconnection is on the HV side of the transformer.

#### 10.3.1 Distribution Connected Generators

Synchronous generator installations 5 kVA and higher must maintain a power factor between 0.95 bucking or leading and 0.95 boosting or lagging, inclusive, over an operating range of 25% (if possible), 50%, 75%, and 100% of rated generator MW or real power load at the Point of Interconnection.

Synchronous generators below 5 kVA must maintain 0.95 bucking or leading power factor at 100% rated generator MW or real power load at the Point of Interconnection. The capacity tests into the lead may be limited because of operational limitations due to manufacturer’s design criteria or stator end iron heating concerns. See Section 3.3 for power factor requirements.

#### 10.3.2 Transmission Connected Generators

For synchronous generators a demonstration of the Generating Facility’s lag and lead capability is required. Unless otherwise specified in the Parallel Operation Agreement between PSE and the Producer, each generator must supply VARs as measured at the Point of Interconnection, in a range of operation between 0.95 bucking or leading to 0.95 boosting or lagging power factor. These tests must be conducted at 25% (if possible), 50%, 75%, and 100% of rated generator MW or real power load. The capacity tests into the lead may be limited because of operational limitations due to manufacturer’s design criteria or stator end iron heating concerns.
10.3.3 Transmission Connected Wind Power Generating Facility

Wind power Generating Facilities shall demonstrate the facility’s reactive power compensation scheme. Tests must be conducted beginning at 25% (if possible), 50%, 75%, and 100% of rated generator MW or real power load, that demonstrate that the switching and control of the reactive power can be done in small enough increments to limit the change in reactive power production or absorption in steady state of no more than 10% of the generated power. The wind power Generating Facility must regulate reactive power in a range of operation between a net 0.95 power factor bucking or leading and a net 0.95 power factor boosting or lagging at maximum generation output, at the high-side of the generator substation.

10.3.4 Transmission Connected Solar Generation and Battery Energy Storage Devices

Solar Generation and Battery Energy Storage Facilities shall test the facility’s reactive power compensation scheme. Solar Generation and Battery Energy Storage must supply VAR's as measured at the high-side of the generator substation, in a range of operation between 95% bucking or leading to 95% boosting or lagging power factor. These tests must be conducted at 25%, 50%, 75%, and 100% of the rated battery storage MW or real power load.

10.4 AUTOMATIC GENERATION CONTROL DISPATCHABILITY TESTING

When the MW output of the Interconnection Customer’s Generating Facility is required by PSE to be controlled with automatic generation control (AGC), the appropriate control and monitoring SCADA RTU equipment must be installed and tested prior to commercial operation. These tests verify that the Generating Facility is able to continuously respond to PSE’s commands (pulses) at the required ramp rates (typically two percent of seasonal test capacity per minute), over the required regulating range of the Generating Facility (typically forty percent of seasonal test capacity).

The SCADA RTU meter indication (MW) is typically compared and verified with the revenue metering and local plant metering indications at this time. Often, the Generating Facility’s VAR capacity testing is performed at or about the same time as the AGC testing. The periodic testing (see Section 10.6) is normally performed later, after completion of all other On-Line Start-Up Testing, as the last test prior to commercial operation. For dispatchable generation, the Interconnection Customer may be required to demonstrate dispatch performance periodically.

10.5 POWER SYSTEM STABILIZER TESTS AND TUNING

Power system stabilizers will be tested and tuned by a person that is qualified and trained in the operation of power system stabilizers. Power system stabilizers equipment shall be periodically tested and tuned in accordance with the WECC Standards. This document is available on the WECC Web site at www.wecc.org under Generator Testing.
10.6 THE REQUIRED INITIAL AND PERIODIC TESTING

All Interconnection Customers are required to perform testing on initial start-up of the Generating Facility and to perform periodic testing consistent with the requirements of related NERC standards. The tests should be performed consistent with the WECC Generating Facility Data, Testing and Model Validation Requirements, and the WECC Synchronous Machine Reactive Limits Verification (or successor requirements). NERC Standards are available on the NERC website at www.nerc.com under Standards. WECC documents are available on the WECC Web site at www.wecc.org under Generator Testing.

These tests include:

- Model verification which must be consistent with the requirements of NERC Standards MOD-025, MOD-026, and MOD-027.
- Verification of real and reactive power limits.
- Proper performance of the dynamic control systems.
- Computer simulation modeling data used for transient stability analysis, including excitation systems, voltage regulators, var controls, turbine-governor systems and its control system, power system stabilizers, and other associated generation equipment.

10.7 BATTERY ENERGY STORAGE DEVICE INITIAL AND PERIODIC TESTING

So far when this tech specs is posted, NERC, WECC and IEEE don’t have standard or guideline for battery energy storage test, so PSE proposes similar tests as synchronous generator, but it could change once the standard is published by NERC, WECC and IEEE.

- Capacity Initial Test: Verification of real and reactive power limits.
- Performance Initial Test: Verification of the dynamic control systems.
- Computer Simulation Modeling Initial Test: to verify the models used for transient stability analysis, including all related control models.
11. GENERAL MAINTENANCE REQUIREMENTS

11.1 INSPECTION

PSE may inspect Interconnection Customer’s facilities whenever it appears that the Interconnection Customer is operating in a manner hazardous to PSE’s system integrity and/or customer safety. Interconnection Customer shall perform functional testing of all breakers, relays, and instrument transformers on a yearly basis, at the Interconnection Customer’s expense.

11.2 ANNUAL DEMONSTRATION

All interconnection trip schemes and interlocks will be tested by the Interconnection Customer annually for proper operation. Refer to Table 11.2 for the demonstration process.

<table>
<thead>
<tr>
<th>Action</th>
<th>Compliance Time Limit</th>
<th>Failure to Comply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Demonstration Test</td>
<td>Must be performed within forty-five (45) days after the Interconnection Customer’s anniversary of the Installation date.</td>
<td>PSE may physically interrupt the flow of energy from the Generating Facility until the test has been completed.</td>
</tr>
<tr>
<td>Interconnection Customer shall notify PSE of their selection of Protection and Control Contractor and coordinate the test date with PSE.</td>
<td>No fewer than thirty (30) calendar days prior to the scheduled test date.</td>
<td>PSE may require Interconnection Customer to reschedule the demonstration test if Interconnection Customer fails to timely notify PSE of the scheduled test date.</td>
</tr>
<tr>
<td>Interconnection Customer’s protection and control contractor shall document the demonstration test in a certified report.</td>
<td>A copy of the test report shall be provided to PSE within fifteen (15) business days after testing has been completed.</td>
<td>PSE may require Interconnection Customer to schedule another demonstration test if the demonstration of the initial test or its reported test results do not conform or adhere to the requirements set forth in this document (as modified from time to time).</td>
</tr>
</tbody>
</table>

*Note:* PSE, at its sole discretion, may be present to witness testing of equipment. Any and all costs incurred by PSE for such witnessing shall be the responsibility of the Interconnection Customer.

Synchronizing will be demonstrated by the Interconnection Customer in automatic and manual mode (if applicable).
11.3 CALIBRATION DEMONSTRATION (EVERY 3 YEARS)

In addition to all annual checks, the Interconnection Customer shall be required to demonstrate that the relays and meters are functional and calibrated to manufacturer’s tolerances and set to approved settings. Refer to manufacturer’s pamphlet for test procedures. Refer to Table 11.3 for the calibration demonstration process.

**Table 11.3 Calibration Demonstration Process**

<table>
<thead>
<tr>
<th>Action</th>
<th>Compliance Time Limit</th>
<th>Failure to Comply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration Demonstration Every 3 Years</td>
<td>Must be performed within forty-five (45) days after the Interconnection Customer’s anniversary of the Installation date.</td>
<td>PSE may physically interrupt the flow of energy from the Generating Facility until the test has been completed.</td>
</tr>
<tr>
<td>Interconnection Customer shall notify PSE of their selection of Protection and Control Contractor and coordinate the test date with PSE.</td>
<td>No fewer than thirty (30) calendar days prior to the scheduled test date.</td>
<td>PSE may require Interconnection Customer to reschedule the demonstration test if Interconnection Customer fails to timely notify PSE of the scheduled test date.</td>
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<tr>
<td>Interconnection Customer’s protection and control contractor shall document the demonstration test in a certified report.</td>
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<td>PSE may require Interconnection Customer to schedule another demonstration test if the demonstration of the initial test or its reported test results do not conform or adhere to the requirements set forth in this document (as modified from time to time).</td>
</tr>
</tbody>
</table>

**Note:** PSE, at its sole discretion, may be present to witness testing of equipment. Any and all costs incurred by PSE to witness such testing shall be the responsibility of the Interconnection Customer.

Some distribution-connected facilities (usually larger than 1 MW, but at PSE’s option) will need to successfully perform VAR capacity tests for this demonstration. Operation at 0.95 bucking or leading and boosting or lagging power factor must be performed. Tests need to be conducted at 25%, 50%, 75%, and 100% of rated generator MW or real power output. The capacity tests into the lead can be limited or waived by PSE because of operational limitations due to manufacturer’s design criteria or stator end iron heating concerns.

For all transmission-connected Generating Facilities, VAR capacity tests and generating unit model validation will need to be performed and demonstrated in accordance with WECC and NERC requirements.
11.4 DESIGN CHANGES AFTER COMMERCIAL OPERATION

Any modifications to the Generating Facility after the Commercial Operation Date must be submitted to PSE for review. Demonstration of Relay Calibration, Trip and Circuit Tests and On-Line Start-Up Testing may be required depending on the extent of the modification. Setting changes of any interconnection protection or synchronizing device must be approved by PSE with a hard copy of the changes forwarded to the designated PSE representative.

Any “Field Modification” or “As-Built” AC/DC protection and synchronizing schematics associated with any interconnection device must be forwarded to the designated PSE representative. If the Generating Facility is 1 MVA or greater, the final As-Built drawings shall be stamped by a Professional Engineer, registered in the State of Washington.

PSE system changes may necessitate additional interconnection protection being required, which shall be paid for by the Interconnection Customer. For example, line reconfigurations may result in the Interconnection Customer’s generation being greater than 50% of the high line minimum load. Therefore, high side VTs, under/over voltage relaying, and direct transfer trip to the Generating Facility may be required to avoid the parallel generator islanding the PSE system for a high side single-phase to ground fault.
12. OPERATING REQUIREMENTS

12.1 SWITCHING AND TAGGING RULES

PSE will provide the Interconnection Customer with a copy of PSE’s Standard Practice 0201.1011, Switching & Clearances Handbook, and the Interconnection Customer shall comply with applicable switching and tagging rules in obtaining or in providing clearances for work or for switching operations on equipment.

12.2 DE-ENERGIZED CIRCUITS

A generation source shall not energize a de-energized PSE circuit under any circumstances unless under the direct orders of PSE’s Power Dispatcher/System Operator. Failure to observe this requirement will be cause for immediate (and possibly permanent) disconnection of the Generating Facility. In addition, the generator source shall be responsible for all damages and injuries resulting from such actions.

12.3 OPERATING LOG

The Interconnection Customer shall maintain an operating log at each Generating Facility 300 kVA and over that parallels with the PSE system. The log shall indicate changes in operating status, trip operations, and other unusual conditions. The operating log shall be open to review by PSE in order to help resolve interconnected operating issues.

The Generating Facility Operator will cooperate with PSE in the analysis of disturbances to the Facility’s generator or PSE’s electric system by gathering and providing access to information relating to any disturbance, including information from oscillography, protective relay targets, breaker operations, and sequence of events records.

12.4 COMMUNICATIONS - FACILITIES 2 MW AND GREATER

Generation sites of 2 MW and larger must provide the following:

- Voice communication to the Generating Facility via normal telephone lines or mutually agreed upon circuits.
- A 24-hour phone or pager number for the Generating Facility operator. The Generating Facility operator shall also have information for contacting PSE’s 24-hour Operations Center dispatchers.
- Demonstrated familiarity by the plant operating personnel with PSE line clearance/operating procedures (PSE Standard Practice 0201.1011 – Switching and Clearances Handbook) and applicable standard practices.
- Notification to PSE’s Dispatch Center prior to bringing any generating unit on-line in parallel with PSE’s system and the time of interconnection.
- Generator sites that are dispatchable, 10 MW or greater, or are connected to the transmission system are required to notify PSE’s Dispatch Center concerning plans to switch on or off-line.
- Immediate notification to PSE’s Dispatch Center of unplanned trip operations.
12.5 DISCONTINUANCE OF OPERATIONS

Interconnection Customers shall discontinue parallel operation when requested by PSE, as follows:

- To facilitate maintenance, test, or repair of PSE facilities.
- To accommodate line clearances or non-recloses on associated circuit. PSE will notify the generator operator in advance of planned clearances or non-recloses. During emergencies, PSE may not be able to give advance warning of being disconnected from the system.
- When the Interconnection Customer’s generating equipment is interfering with customers on the system due to degradation of power quality or service.
- When an inspection of the Interconnection Customer’s generating equipment reveals a condition hazardous to the PSE system or a lack of scheduled maintenance or maintenance records for equipment necessary to protect the PSE system.
- When Good Utility Practices warrant discontinued operation.

12.6 STATION SERVICE, STARTUP POWER AND BACKFEED POWER

Power provided for local use at a generating facility or substation to operate lighting, heat auxiliary equipment is defined as station service. In addition, power generated by a generator and then consumed by equipment that contributes to the generation process is considered as station service. Alternate station service is a backup source of power, only used in emergency situations or during maintenance when primary station service is not available.

Station service is the responsibility of the Interconnection Customer. The station service requirements, including voltage and reactive power requirements, shall not impose operating restrictions on the PSE transmission system beyond those specified in the NERC, WECC and NWPP reliability criteria.

Appropriate providers of station service and alternate station service are determined during the project planning process and the Interconnection Customer is required to provide metering for station service and alternate station service. Arrangement for station service, startup power and backfeed power is required prior to energization, testing and commissioning.

PSE requires generation projects to self-supply parasitic loads when generating. When not generating, the generation plant station service load may be served by backfeed over the transmission line that interconnects PSE and the generation plant. Generation plant station service and start-up loads must be properly and accurately metered. At a minimum, bi-directional revenue metering and extended range current transformers are required.
12.7 BEHIND THE METER GENERATION

Any generation connected behind the delivery point meter of a customer’s delivery point must follow industry recognized interconnection standards to maintain reliability, safety, and power quality at the delivery points as required by and in compliance with any applicable NERC or NAESB Standards and/or Business Practices as well as any applicable provision of the Network Operating Agreement. The total amount of generation produced in any hour by a behind the meter generating facility should not exceed the delivery point load such that energy would flow from the customer’s delivery point to PSE’s transmission system.

Where the behind the meter generating capacity is greater than the delivery point load, a transmission interconnection agreement may be required with PSE’s and transmission service arrangements for delivery of the behind the meter generation may be required. Further, sites with 10 MW or more must abide by PSE metering requirements as well as market, operational and settlement requirements.

PSE requires generation projects to self-supply parasitic loads when generating. When not generating, the generation plant station service load may be served by backfeed over the transmission line that interconnects PSE and the generation plant. Generation plant station service and start-up loads must be properly and accurately metered. At a minimum, bi-directional revenue metering and extended range current transformers are required.
ATTACHMENTS 1 through 6

INTERCONNECTION PROTECTION AND METERING DIAGRAMS
DISTRIBUTION SECONDARY CONNECTIONS > 25 KW TO ≤ 300 KVA

NOTES:
1. FOR SYNCHRONOUS GENERATORS ONLY
2. ALL GENERATORS >50kVA REQUIRE THREE-PHASE CONNECTIONS
3. UL 1741 COMPLIANT INVERTER-BASED SINGLE PHASE GENERATORS MAY RELY ON INTERNAL PROTECTIVE FUNCTIONS INSTEAD OF DEVICES SHOWN
4. OVERCURRENT AND GROUND PROTECTION MAY BE REQUIRED

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>SYNCHRONIZING</td>
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<tr>
<td>27</td>
<td>UNDERVOLTAGE</td>
</tr>
<tr>
<td>52</td>
<td>AC CIRCUIT BREAKER</td>
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<tr>
<td>59</td>
<td>OVERVOLTAGE</td>
</tr>
<tr>
<td>81 O/U</td>
<td>OVER/UNDERFREQUENCY</td>
</tr>
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</table>

INTERCONNECTION REQUIREMENTS
DISTRIBUTION SECONDARY CONNECTIONS
>25kVA TO ≤300kVA

SYSTEM PROTECTION
ATTACHMENT 1 1 3
DISTRIBUTION SECONDARY CONNECTIONS > 300 KVA TO ≤ 5 MVA

NOTES:
1-DIRECT TRANSFER TRIP (DTT) MAY BE REQUIRED
2-FOR SYNCHRONOUS GENERATORS ONLY
3-PSE TO SPECIFY TRANSFORMER CONNECTIONS FOR PROJECTS OVER 1 MVA
4-BREAKER FAILURE MUST INITIATE SECONDARY ACTION TO ISOLATE THE GENERATOR FROM PSE'S SYSTEM

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>BF</td>
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<td>OverVoltage</td>
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<td>81</td>
<td>Over/UnderFrequency</td>
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</table>

INTERCONNECTION REQUIREMENTS
DISTRIBUTION SYSTEM CONNECTIONS >300KVA TO ≤5MVA
DISTRIBUTION SECONDARY CONNECTIONS > 5 MVA TO ≤ 10 MVA
TRANSMISSION CONNECTIONS

NOTES:
1-PILOT PROTECTION MAY BE REQUIRED ON TRANSMISSION LINES
2-VARIOUS BUS CONFIGURATIONS AND TRANSFORMER CONNECTIONS MAY BE USED

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>BF</td>
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<td>25</td>
<td>SYNCHRONIZING</td>
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INTERCONNECTION REQUIREMENTS
TRANSMISSION CONNECTIONS

ATTACHMENT 4
METERING – OPTION “A”

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
<td>AC CIRCUIT BREAKER</td>
</tr>
</tbody>
</table>

INTERCONNECTION REQUIREMENTS
METERING – OPTION A

SYSTEM PROTECTION

ATTACHMENT 5 1 0
METERING – OPTION “B”

DEVICE | FUNCTION
--- | ---
52 | AC CIRCUIT BREAKER
APPENDIX A

INTERCONNECTION REQUEST FOR GENERATING FACILITY CONNECTED TO DISTRIBUTION SYSTEM

1. The undersigned Interconnection Customer submits this request to interconnect its Distribution Generating Facility with the Transmission Provider’s Distribution System.

2. This Interconnection Request is for (check one):
   _____ A proposed new Generating Facility.
   _____ An increase in the generating capacity or a Material Modification of an existing Generating Facility.

4. The Interconnection Customer provides the following information:
   a. Address or location or the proposed new Generating Facility site (to the extent known) or, in the case of an existing Generating Facility, the name and specific location of the existing Generating Facility;
   b. Maximum summer at ____ degrees C and winter at _____ degrees C kilowatt electrical output of the proposed new Generating Facility or the amount of megawatt increase in the generating capacity of an existing Generating Facility;
   c. General description of the equipment configuration;
   d. Commercial Operation Date by day, month, and year;
   e. Name, address, telephone number, and e-mail address of the Interconnection Customer’s contact person;
   f. Approximate location of the proposed Point of Interconnection (optional); and
   g. Interconnection Customer Data (set forth in Appendix A)

5. Applicable deposit amount.

6. Evidence of Site Control (check one)
   _____ Is attached to this Interconnection Request
   _____ Will be provided at a later date

7. This Interconnection Request shall be submitted to the representative indicated below:
   [To be completed by Transmission Provider]
8. Representative of the Interconnection Customer to contact:

[To be completed by Interconnection Customer]

9. This Interconnection Request is submitted by:

Name of Interconnection Customer:

________________________________________

By (signature):

________________________________________

Name (type or print):

________________________________________

Title:

________________________________________

Date:

________________________________________
1. SYNCHRONOUS GENERATORS

1.1 GENERATOR UNIT RATINGS

Note: If requested information is not applicable, indicate by marking “N/A.”

Capacity Rating: \( = \quad \text{KVA@} \quad \text{°F} \)
Voltage Rating: \( = \quad \text{kV} \)
Power Factor Rating: \( = \quad \)
Speed Rating: \( = \quad \text{RPM} \)
Connection (e.g. Wye or Delta): \( = \quad \)
Short Circuit Ratio: \( = \quad \)
Frequency Rating: \( = \quad \text{Hz} \)
Stator Amperes at Rated kVA: \( = \quad \text{AMPS} \)
Exciter Field Voltage: \( = \quad \text{Volts} \)
Max Turbine: \( = \quad \text{kW@} \quad \text{°F} \)
Turbine / Generator Pmax: \( = \quad \text{kW} \)

1.2 COMBINED TURBINE-GENERATOR-EXCITER INERTIA DATA

Inertia Constant, H: \( = \quad \text{W*sec/kVA} \)
Moment-of-Inertia, WR2: \( = \quad \text{lb. ft.}^2 \)

1.3 REACTANCE DATA (Per Unit Rated kVA)

\( X_{\text{di}}, \text{Synchronous d-axis Unsaturated Reactance:} \quad = \quad \text{pu} \)
\( X_{\text{qi}}, \text{Synchronous q-axis Unsaturated Reactance:} \quad = \quad \text{pu} \)
\( X_{\text{dv}}, \text{Synchronous d-axis Saturated Reactance:} \quad = \quad \text{pu} \)
\( X_{\text{qv}}, \text{Synchronous q-axis Saturated Reactance:} \quad = \quad \text{pu} \)
\( X'_{\text{di}}, \text{d-axis Unsaturated Transient Reactance:} \quad = \quad \text{pu} \)
\( X'_{\text{qi}}, \text{q-axis Unsaturated Transient Reactance:} \quad = \quad \text{pu} \)
\( X'_{\text{dv}}, \text{d-axis Saturated Transient Reactance:} \quad = \quad \text{pu} \)
\( X'_{\text{qv}}, \text{q-axis Saturated Transient Reactance:} \quad = \quad \text{pu} \)
\( X''_{\text{di}}, \text{d-axis Unsaturated Subtransient Reactance:} \quad = \quad \text{pu} \)
X''_qi, q-axis Unsaturated Subtransient Reactance: = ________________pu
X''_dv, d-axis Saturated Subtransient Reactance: = ________________pu
X''_qv, q-axis Saturated Subtransient Reactance: = ________________pu
X2i, Negative Sequence Unsaturated Reactance: = ________________pu
X2v, Negative Sequence Saturated Reactance: = ________________pu
X0i, Zero Sequence Unsaturated Reactance: = ________________pu
X0v, Zero Sequence Saturated Reactance: = ________________pu
Xlm, Stator Leakage Reactance: = ________________pu

1.4 FIELD TIME CONSTANT DATA (Seconds)

T''_do, d-axis Open Circuit Transient Time Constant: = ________________s
T''_qo, q-axis Open Circuit Transient Time Constant: = ________________s
T''_d3, d-axis 3-Phase Short Circuit Transient Time Constant: = ________________s
T''_q3, q-axis 3-Phase Short Circuit Transient Time Constant: = ________________s
T''_d2, d-axis Line to Line Short Circuit Transient Time Constant: = ________________s
T''_d1, d-axis Line to Neutral Short Circuit Transient Time Constant: = ________________s
T''_do, d-axis Open Circuit Subtransient Time Constant: = ________________s
T''_qo, q-axis Open Circuit Subtransient Time Constant: = ________________s
T''_d, d-axis Short Circuit Subtransient Time Constant: = ________________s
T''_q, q-axis Short Circuit Subtransient Time Constant: = ________________s

1.5 ARMATURE TIME CONSTANT DATA (Seconds)

T_{a3}, 3-Phase Short Circuit Time Constant: = ________________s
T_{a2}, Line to Line Short Circuit Time Constant: = ________________s
T_{a1}, Line to Neutral Short Circuit Time Constant: = ________________s

1.6 EXCITATION SATURATION

S(1.0), Saturation Factor at 1.0 pu Terminal Voltage = ________________
S(1.2), Saturation Factor at 1.2 pu Terminal Voltage = ________________

1.7 ARMATURE WINDING RESISTANCE DATA (Per Unit Rated kVA)

R1, Positive Sequence Resistance: = ________________pu
R_2, Negative Sequence Resistance: = __________________pu
R_0, Zero Sequence Resistance: = __________________pu
I_2t Rotor Short Time Thermal Capacity: = ____________________
Field Current at Rated kVA, Voltage and PF: = _____________AMPS
Field Current at Rated kVA, Voltage and 0 PF: = _____________AMPS
Three Phase Armature Winding Capacitance: = _______________uF
Field Winding Resistance: = _____ Ohms at_____ °C
Armature Winding Resistance (Per Phase): = _____ Ohms at_____ °C

1.8 CURVES

Provide the following generator’s curves and designate normal and emergency Hydrogen Pressure operating range for multiple curves.

Saturation Curve is Attached: = ___________ (Yes/No)
Vee Curve is Attached: = ___________ (Yes/No)
Reactive Capability is Attached: = ___________ (Yes/No)
Capacity Temperature Correction curve is Attached: = ___________ (Yes/No)

1.9 COMPUTER MODELS

In order to represent the Interconnection Customer’s generator(s) in power system stability simulations for system impact study, the completed model type and block diagrams along with the corresponding model constants must be supplied with the Interconnection Request. The Interconnection Customer shall follow the “WECC Dynamic Modeling Procedure”. The WECC procedure specifies that models shall be those in the “WECC Approved Dynamic Model Library”, or it gives direction if a non-WECC approved model(s) is required. If the Interconnection Customer seeks to use a non-WECC approved model(s) the Interconnection Customer shall also follow the “WECC Criteria for Acceptance of New Dynamic Models”. These documents are available on the WECC web site under: www.wecc.org > Program Areas > Reliability Planning & Performance Analysis > System Stability Planning > Modeling > Generators.

Generator Model:

Generator Model name: =______________
Is Generator Model the WECC-Approved One? =__________ (Yes/No)
Are Generator Model’s Parameters Attached? =__________ (Yes/No)

Excitation System Model:
Excitation System Model name: =__________
Is Excitation Model the WECC-Approved One? =________ (Yes/No)
Are Excitation Model’s Parameters Attached? =________ (Yes/No)

**Power System Stabilizer (PSS) Model:**
Please Note: If PSS isn’t applicable to your case, just mark the first question as “No” and then skip other questions.

Is PSS applicable to your project? =________ (Yes/No)
PSS Model name: =________
Is PSS Model the WECC-Approved One? =________ (Yes/No)
Are PSS Model’s Parameters Attached? =________ (Yes/No)

**Governor System Model:**

Governor System Model name: =__________
Is Governor Model the WECC-Approved One? =________ (Yes/No)
Are Governor Model’s Parameters Attached? =________ (Yes/No)

**Over and Under Excitation Limiter (O/UEL) Model:**

Please Note: If O/UEL isn’t applicable to your case, just mark the first question as “No” and then skip other questions.

O/UEL Model name: =__________
Is O/UEL Model the WECC-Approved One? =________ (Yes/No)
Are O/UEL Model’s Parameters Attached? =________ (Yes/No)

**1.10 Synchronous Generator’s Step-Up Transformer Data**
The following is the generator step-transformer data interconnection customer needs to provide.

Transformer Capacity: =__________
Self-Cooled Type: =__________
Maximum Nameplate: =__________ kVA
Voltage Rating at Generator Side: =__________ kV
Voltage Rating at System Side: =__________ kV
Voltage Rating at Tertiary Side: \( = \) \( \text{__________ kV} \)

Winding Connection at Low Voltage Side: \( = \text{______________} \)

Winding Connection at High Voltage Side: \( = \text{______________} \)

Winding Connection at Tertiary Voltage Side: \( = \text{______________} \)

Available Total H.V Taps: \( = \text{______________} \)

*The Percentage of Each Available H.V Tap \( = \text{__________}\% \)

Available Total L.V Taps: \( = \text{______________} \)

*The Percentage of Each Available L.V Tap \( = \text{__________}\% \)

The Present Tap Setting at H.V: \( = \text{__________}_\text{kV} \)

The Present Tap Setting at L.V: \( = \text{__________}_\text{kV} \)

Positive \( Z_1 \) on Self-Cooled kVA Rating: \( = \text{__________}\% \)

X/R Ratio of Positive \( Z_1 \): \( = \text{______________} \)

Zero \( Z_0 \) on Self-Cooled kVA Rating: \( = \text{__________}\% \)

X/R Ratio of Zero \( Z_0 \): \( = \text{______________} \)

**Notes:**

*: The Percentage of Each Available H.V Tap and L.V Tap are the percent of high and low side nominal voltages, respectively.
2 WIND POWER GENERATORS

For transmission connected wind power generators, the following machine, reactive, and control data shall also be provided for each generator:

2.1 General Data:

Type of Induction Generating Unit =
Type of Wind Turbine =
Number of Generators Pursuant to This Interconnection Request =
Single Phase? = (Yes/No)
Three Phase? = (Yes/No)
Generator Rated kVA = kVA
Generator Maximum Gross Output kW = kW
Generator Manufacturer =
Inverter Manufacturer =
Model Name =
Model Number =
Model version =

2.2 INDUCTION GENERATORS DATA:

Please Note: Please consult Transmission Provider prior to submitting the Interconnection Request to determine if the following information is required.

Field Volts = volts
Field Amperes = amps
Motoring Power = kW
Neutral Grounding Resistor(If Applicable) = ohms
I2t or K (Heating Time Constant) =
Rotor Resistance = ohms
Stator Resistance = ohms
Stator Reactance = ohms
Rotor Reactance = ohms
Magnetizing Reactance = ohms
Short Circuit Reactance = ohms
Exciting Current: \[= \text{ohms}\]

Temperature Rise: \[= \text{°C}\]

Frame Size: \[= \text{_______}\]

Design Letter: \[= \text{_______}\]

Reactive Power Required (No Load): \[= \text{VARs}\]

Reactive Power Required (Full Load): \[= \text{VARs}\]

Total Rotating Inertia, H on kVA Base \[= \text{pu}\]

Is the Table of Turbine/Generator Under-Frequency Versus Time Operating Limits Attached: \[= \text{(Yes/No)}\]

Is the Table of Turbine/Generator Over-Frequency Versus Time Operating Limits Attached: \[= \text{(Yes/No)}\]

Customer Site Load Data:
Station Service Load for the Facility in kW: \[= \text{kW}\]
Station Service Load for the Facility in kVAR: \[= \text{kVAR}\]
Percent of the Types of Load: \[= \text{%}\]
Source for Station Service Load: \[= \text{_______}\]

Note: Please consult Transmission Provider prior to submitting the Interconnection Request to determine if the information designated by (*) is required.

2.3 Power factor (PF) control:

Is Uncompensated Table or Curve (load % v.s PF) Attached: \[= \text{(Yes/No)}\]

Is Compensated Table or Curve (load % v.s PF) Attached: \[= \text{(Yes/No)}\]

Number of PF Improvement Capacitors at Each Generator: \[= \text{_______}\]

Rated Voltage of PF Improvement Capacitors at Each Generator: \[= \text{V}\]

Rated Size of PF Improvement Capacitors at Each Generator: \[= \text{_______}\]

The Capacitor Sizes: \[= \text{_______}\]

What is Control for Switching On and Off? \[= \text{_______}\]

Any Time Delays at Each Generator: \[= \text{_______}\]

Number of PF Correction Capacitors at the Switchyard: \[= \text{_______}\]

Rated Voltage of PF Correction Capacitors at the Switchyard: \[= \text{V}\]

Rated Size of PF Correction Capacitors at the Switchyard: \[= \text{_______}\]
The Controls Selected for Switchyard Capacitor Banks Steps:
Voltage Control: =_________ (Yes/No)
kVAr Control: =_________ (Yes/No)
kW Control: =_________ (Yes/No)
Or Other (Please Specify):

*For the above Selected Controls Provide (See the note):
Settings: =________________
Time Delay: =________________
Provide the Curve or Table Showing Starting Scenario of Each Wind Generator: kW, kVAr load, operation of Capacitor Banks and Steps. Is the Curve or Table Attached? =_________ (Yes/No)
Provide Starting Sequence of Generators in the Wind Power. Indicate the Maximum Number of Generator Units that Could Be Started Simultaneously. Interconnection Customer Can Write Here or Attach the info: =________________

Each Generator’s
Voltage Trip Setting: =________________
Pick up Time: =_____________ s
Reconnection Time:

Notes: *: The time delays are generally not permitted unless it is demonstrated that the delays do not have adverse effects on the operation of the PSE system

2.4 Voltage control
Nominal Voltage: =_____________kV
Acceptable Voltage Range (Volts +/- %): =________________

Maximum Voltage Deviation Due to Switching of PF Correction Capacitors on L.V. Side of Transmission Step-up Transformer: =_____________%

Estimated Load Factor: =_____________
Estimated Number of Hours/Year of Operation: =_____________
Estimated MWh/Year: =_____________
The Moment of Inertia Blade/Gearbox/Turbine/Generator: =_________kW-sec
Slip or Speed at Full Load : =_____________
Locked Rotor Current at 100% Voltage: =___________A
Locked Rotor Power Factor: =___________
Provide Electrical Torque Versus Speed Curve (from 0% to 100% speed). Is It Attached? =_______(Yes/No)

Provide The Current Versus Speed Curve (from 0% to 100% speed). Is It Attached? =_______(Yes/No)
Is the Equivalent Circuit of Generator Attached: =_______(Yes/No)
Is Pad-mounted Transformer Data Attached: =_______(Yes/No)
Is Transmission Step-up Transformer Attached: =_______(Yes/No)

2.5 COMPUTER MODELS
To represent the Interconnection Customer’s generator(s) in power system stability simulations for the study, the completed model type and block diagrams along with the corresponding model constants must be supplied with the Interconnection Request. The Interconnection Customer shall follow the “WECC Dynamic Modeling Procedure”. The WECC procedure specifies that models shall be those in the “WECC Approved Dynamic Model Library”, or it gives direction if a non-WECC approved model(s) is required. If the Interconnection Customer seeks to use a non-WECC approved model(s) the Interconnection Customer shall also follow the “WECC Criteria for Acceptance of New Dynamic Models”. These documents are available on the WECC web site under: www.wecc.org > Program Areas > Reliability Planning & Performance Analysis > System Stability Planning > Modeling > Generators.

Wind Generator Model:

Generator Model name: =_______________
Is Generator Model the WECC-Approved One? =_______ (Yes/No)
Are Generator Model’s Parameters Attached? =_______ (Yes/No)

Pseudo Excitation System Model:

Excitation System Model name: =_______________
Is Excitation Model the WECC-Approved One? =_______ (Yes/No)
Are Excitation Model’s Parameters Attached? =_______ (Yes/No)

Wind Turbine System Model:

Wind Turbine System Model name: =_______________
Is the Model WECC-Approved? =_______ (Yes/No)
Are The Model’s Parameters Attached? =_______ (Yes/No)
Patch Control Model:

Patch Control Model name: = __________________
Is the Model WECC-Approved? = _______ (Yes/No)
Are The Model’s Parameters Attached? = _______ (Yes/No)

Aerodynamic Control Model:

Aerodynamic Control Model name: = __________________
Is the Model WECC-Approved? = _______ (Yes/No)
Are The Model’s Parameters Attached? = _______ (Yes/No)

Other Control Model:

The Control Model name: = __________________
Is the Model WECC-Approved? = _______ (Yes/No)
Are The Model’s Parameters Attached? = _______ (Yes/No)

2.6 Customer-Owned Generator Step-Up Transformer Data

The following is the wind generator step-up transformer data interconnection customer needs to provide. The transformer test report can be submitted in lieu of the above data if it contains all of the required data.

<table>
<thead>
<tr>
<th></th>
<th>Primary Winding</th>
<th>Secondary Winding</th>
<th>Tertiary Winding</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Rated Voltage:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>_______________ kV</td>
<td>_______________ kV</td>
<td>_______________ kV</td>
</tr>
<tr>
<td>Rating Self-Cooled:</td>
<td>__________ MVA</td>
<td>__________ MVA</td>
<td>__________ MVA</td>
</tr>
<tr>
<td>Rating Maximum</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forced Cooled:</td>
<td>__________ MVA</td>
<td>__________ MVA</td>
<td>__________ MVA</td>
</tr>
<tr>
<td>Winding Connections</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Wye, Delta or Grounded Wye...):</td>
<td>__________</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>If Grounded WYE, Neutral</td>
<td>__________ Ohms</td>
<td>__________ Ohms</td>
<td>__________ Ohms</td>
</tr>
</tbody>
</table>
### Table II

<table>
<thead>
<tr>
<th></th>
<th>Primary To Secondary Winding</th>
<th>Primary To Tertiary Winding</th>
<th>Primary To Secondary Winding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If Grounded WYE, Neutral</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactance:</td>
<td>______ Ohms</td>
<td>______ Ohms</td>
<td>______ Ohms</td>
</tr>
<tr>
<td>Capacity Base Between Two</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Windings:</td>
<td>______ MVA</td>
<td>______ MVA</td>
<td>______ MVA</td>
</tr>
<tr>
<td>Load Loss @ 75C:</td>
<td>______ Watts</td>
<td>______ Watts</td>
<td>______ Watts</td>
</tr>
<tr>
<td>Positive Sequence Impedance:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>_____ %</td>
<td>_____ %</td>
<td>_____ %</td>
</tr>
<tr>
<td>Zero Sequence Impedance:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>_____ %</td>
<td>_____ %</td>
<td>_____ %</td>
</tr>
<tr>
<td>Fixed Taps Available:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planned Tap Setting:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A-13
3 SOLAR POWER AND BATTERY ENERGY STORAGE DEVICE

For transmission connected battery energy storage device, the following data, controls and models shall be provided:

3.1 GENERAL BATTERY ENERGY STORAGE DEVICE DATA:

Total Nominal Discharge/Charge Power: = _________________ MW
Total Storage Energy at rated temperature: = ______ MWH @ ______ °C
Nominal Output AC Voltage: = _________________ Volts
Permissible AC Voltage Range: = From ______ To ______ Volts
Nominal Output AC Frequency: = _________________ Hz
Permissible AC Frequency Range: = From ______ To ______ Hz
External Output Wiring (Phase/Wire Numbers): = ______ Phases ______ Wires
The Upper Limit of State of Charge (SOC): = _________________ %
The Lower Limit of State of Charge (SOC): = _________________ %
The Limit of Depth of Discharge (DOD): = _________________ %
Maximum Charging Duration: = _________________ Hours
Maximum Discharging Duration: = _________________ Hours
The responding time of switching between charge and discharge: = _________________ Seconds
Maximum Current THD Rate: = _________________
Maximum Voltage THD Rate: = _________________
Power Factor Range: = From ______ To ______
Operation Ambient Temperature: = _________________ °C
Permissible Ambient Humidity Range: = From ______ To ______
Noise Level: = _________________ dB
Cell Standard Cycle Life: = _________________ Cycles
Assuming 1 Cycle Each Day, What’s Cell Life Time in Years: = _________________ Years
Provide Voltage Abnormality Tolerance Table (Voltage% Vs. Seconds): = _________________ (Yes/No)
Provide Frequency Abnormality Tolerance Table (Voltage% Vs. Seconds): = _________________ (Yes/No)
Provide Low Voltage Ride Through Curve: = _________________ (Yes/No)
Is Following PCS Protection Provided?
Short circuit protection: = _________________ (Yes/No)
Overload protection: = _________________ (Yes/No)
AC over/under-voltage protection: = _________________ (Yes/No)
AC over/under-frequency protection: __________________________ (Yes/No)
Over-temperature protection: __________________________ (Yes/No)
Anti-islanding Protection: __________________________ (Yes/No)
Please List Other Protection If Any: __________________________ (Yes/No)
The Size of Plant Load Served by Battery Storage: __________________________ MVA

The Type of Plant Load Served by Battery Storage: __________________________

The Power Factor of Plant Load Served by Battery Storage: __________________________

Is the Battery Storage Manufacturer’s Technical Document attached? __________________________

3.2 SOLAR GENERATION OR BATTERY STORAGE POWER FACTOR CONTROL:
In order to meet 0.95 lagging and leading power factor requirement at the high-side of the generator substation, the appropriate control should be implemented. The following data is required:

Provide the Curve or Table Showing load% V.S Power Factor: __________________________ (Yes/No)

What is the Power Factor Control used? __________________________

Provide the Control Block Diagram of the Power Factor Control: __________________________ (Yes/No)
Provide Parameter Table for the Control Block Diagram of the Power Factor Control: __________________________ (Yes/No)
Is There Capacitor Installed to Compensate and Achieve PF Requirement at POI? __________________________ (Yes/No)
If Yes to Above Question, The Data, Step and Control of Capacitor Must Be Provided. __________________________ (Yes/No or N/A)

3.3 VOLTAGE CONTROL:
If interconnection customer has voltage control function, the data should be provided:

Is Voltage Control Implemented? __________________________ (Yes/No)
If Yes, Please Fill in the Following Questions. If No, Skip.
Which Bus Is Regulated By Voltage Control Scheme? (BES Terminal Bus or Transformer Bus?) __________________________
The Target Voltage Range (Volts +/- %): __________________________
Provide Control Block Diagram: __________________________ (Yes/No)
Provide Parameter Table of Control Block Diagram: __________________________ (Yes/No)

3.4 COMPUTER MODELS.
WECC Renewable Energy Modeling Task Force (REMTF) worked with a group of utilities to develop generic computer model for wind, solar generation and battery energy storage systems
(BESS). The models called REEC_A (preferred), REEC_B (not preferred) for wind and solar and REEC_C for BESS was approved and implemented in GE PSLF, PTI/PSSE and PowerWorld.

The model REEC_C connects with REGC_A to control active power and reactive power. The REEC_C model is essential based on the REEC_A model with some changes and the following block addition:

This model is recommended by PSE so far since it has BESS characteristics such as initial State of Charge (SOC₀) and SOC upper, lower limits and etc. In order to use this model, regc_a model should be ahead of this model in dynamic models table.

Certainly, if interconnection customer would like to choose other WECC-approved models, they should consult with PSE engineers.

The parameters required for BESS Model REEC_C in either PowerWorld aux file, PTI/PSSE dyr file or PSLF dyd file is acceptable for PSE

### 3.5 CUSTOMER-OWNED GENERATOR STEP-UP TRANSFORMER DATA

The following is the battery energy storage’s step-up transformer data interconnection customer needs to provide. The transformer test report can be submitted in lieu of the above data if it contains all of the required data.

| Table I |
|---|---|---|
| **The Rated Voltage:** | Primary Winding | Secondary Winding | Tertiary Winding |
| | ______________ kV | ______________ kV | ______________ kV |
| **Rating Self-Cooled:** | __________ MVA | __________ MVA | __________ MVA |
| **Rating Maximum Forced Cooled:** | __________ MVA | __________ MVA | __________ MVA |
| Winding Connections (such as Wye, Delta or Grounded Wye...): |   |   |   |
| If Grounded WYE, Neutral Resistance: | Ohms | Ohms | Ohms |
| If Grounded WYE, Neutral Reactance: | Ohms | Ohms | Ohms |

### Table II

<table>
<thead>
<tr>
<th></th>
<th>Primary To Secondary Winding</th>
<th>Primary To Tertiary Winding</th>
<th>Primary To Secondary Winding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity Base Between Two Windings:</td>
<td>__________ MVA</td>
<td>__________ MVA</td>
<td>__________ MVA</td>
</tr>
<tr>
<td>Load Loss @ 75C</td>
<td>__________ Watts</td>
<td>__________ Watts</td>
<td>__________ Watts</td>
</tr>
<tr>
<td>Positive Sequence Impedance</td>
<td>__________ %</td>
<td>__________ %</td>
<td>__________ %</td>
</tr>
<tr>
<td>Zero Sequence Impedance</td>
<td>__________ %</td>
<td>__________ %</td>
<td>__________ %</td>
</tr>
</tbody>
</table>

| Fixed Taps Available: |   |
| Planned Tap Setting:  |   |
APPENDIX B

INTERCONNECTION REQUEST FOR GENERATING FACILITY CONNECTED TO TRANSMISSION SYSTEM

1. The undersigned Interconnection Customer submits this request to interconnect its Transmission Generating Facility with the Transmission Provider’s Transmission System.

2. This Interconnection Request is for (check one):
   _____ A proposed new Generating Facility.
   _____ An increase in the generating capacity or a Material Modification of an existing Generating Facility.

4. The Interconnection Customer provides the following information:
   a. Address or location or the proposed new Generating Facility site (to the extent known) or, in the case of an existing Generating Facility, the name and specific location of the existing Generating Facility;
   b. Maximum summer at ____ degrees C and winter at _____ degrees C kilowatt electrical output of the proposed new Generating Facility or the amount of megawatt increase in the generating capacity of an existing Generating Facility;
   c. General description of the equipment configuration;
   d. Commercial Operation Date by day, month, and year;
   e. Name, address, telephone number, and e-mail address of the Interconnection Customer’s contact person;
   f. Approximate location of the proposed Point of Interconnection (optional); and
   g. Interconnection Customer Data (set forth in Appendix B)

5. Applicable deposit amount.

6. Evidence of Site Control (check one)
   _____ Is attached to this Interconnection Request
   _____ Will be provided at a later date

7. This Interconnection Request shall be submitted to the representative indicated below:
   [To be completed by Transmission Provider]
8. Representative of the Interconnection Customer to contact:

[To be completed by Interconnection Customer]

9. This Interconnection Request is submitted by:

Name of Interconnection Customer:

________________________________________

By (signature): ____________________________

Name (type or print): _______________________

Title: ________________________________

Date: ________________________________
GENERATING FACILITY DATA
CONNECTED TO TRANSMISSION SYSTEM

1. SYNCHRONOUS GENERATORS

1.1 GENERATOR UNIT RATINGS

*Note:* If requested information is not applicable, indicate by marking “N/A.”

| Capacity Rating: | = _______ KVA@____ °F |
| Voltage Rating: | =_______________ kV |
| Power Factor Rating: | =_______________ |
| Speed Rating: | =___________ RPM |
| Connection (e.g. Wye or Delta): | =_______________ |
| Short Circuit Ratio: | =_______________ |
| Frequency Rating: | =_______________ Hz |
| Stator Amperes at Rated kVA: | =_______________ AMPS |
| Exciter Field Voltage: | =_______________ Volts |
| Max Turbine: | =_______ kW@____ °F |
| Turbine / Generator Pmax: | =_______________ kW |

1.2 COMBINED TURBINE-GENERATOR-EXCITER INERTIA DATA

| Inertia Constant, H: | =_______________ W*sec/kVA |
| Moment-of-Inertia, WR2: | =_______________ lb. ft.² |

1.3 REACTANCE DATA (Per Unit Rated kVA)

\[ X_{di}, \text{ Synchronous d-axis Unsaturated Reactance:} = \text{_______________ pu} \]
\[ X_{qi}, \text{ Synchronous q-axis Unsaturated Reactance:} = \text{_______________ pu} \]
\[ X_{dv}, \text{ Synchronous d-axis Saturated Reactance:} = \text{_______________ pu} \]
\[ X_{qv}, \text{ Synchronous q-axis Saturated Reactance:} = \text{_______________ pu} \]
\[ X'_{di}, \text{ d-axis Unsaturated Transient Reactance:} = \text{_______________ pu} \]
\[ X'_{qi}, \text{ q-axis Unsaturated Transient Reactance:} = \text{_______________ pu} \]
\[ X'_{dv}, \text{ d-axis Saturated Transient Reactance:} = \text{_______________ pu} \]
\[ X'_{qv}, \text{ q-axis Saturated Transient Reactance:} = \text{_______________ pu} \]
\[ X''_{di}, \text{ d-axis Unsaturated Subtransient Reactance:} = \text{_______________ pu} \]
\[ X''_{qi}, \text{ q-axis Unsaturated Subtransient Reactance:} = \text{_______________ pu} \]
X''_d, d-axis Saturated Subtransient Reactance: = _______________pu
X''_q, q-axis Saturated Subtransient Reactance: = _______________pu
X_{2i}, Negative Sequence Unsaturated Reactance: = _______________pu
X_{2v}, Negative Sequence Saturated Reactance: = _______________pu
X_{0i}, Zero Sequence Unsaturated Reactance: = _______________pu
X_{0v}, Zero Sequence Saturated Reactance: = _______________pu
X_{lm}, Stator Leakage Reactance: = _______________pu

1.4 FIELD TIME CONSTANT DATA (Seconds)

T'_{do}, d-axis Open Circuit Transient Time Constant: = _______________s
T'_{qo}, q-axis Open Circuit Transient Time Constant: = _______________s
T'_{d3}, d-axis 3-Phase Short Circuit Transient Time Constant: = _______________s
T'_{q3}, q-axis 3-Phase Short Circuit Transient Time Constant: = _______________s
T'_{d2}, d-axis Line to Line Short Circuit Transient Time Constant: = _______________s
T'_{d1}, d-axis Line to Neutral Short Circuit Transient Time Constant: = _______________s
T''_{do}, d-axis Open Circuit Subtransient Time Constant: = _______________s
T''_{qo}, q-axis Open Circuit Subtransient Time Constant: = _______________s
T''_{d}, d-axis Short Circuit Subtransient Time Constant: = _______________s
T''_{q}, q-axis Short Circuit Subtransient Time Constant: = _______________s

1.5 ARMATURE TIME CONSTANT DATA (Seconds)

T_{a3}, 3-Phase Short Circuit Time Constant: = _______________s
T_{a2}, Line to Line Short Circuit Time Constant: = _______________s
T_{a1}, Line to Neutral Short Circuit Time Constant: = _______________s

1.6 EXCITATION SATURATION

S(1.0), Saturation Factor at 1.0 pu Terminal Voltage = ________________
S(1.2), Saturation Factor at 1.2 pu Terminal Voltage = ________________

1.7 ARMATURE WINDING RESISTANCE DATA (Per Unit Rated kVA)

R_{1}, Positive Sequence Resistance: = ________________pu
R_{2}, Negative Sequence Resistance: = ________________pu
**1.8 CURVES**

Provide the following generator’s curves and designate normal and emergency Hydrogen Pressure operating range for multiple curves.

Saturation Curve is Attached: = (Yes/No)
Vee Curve is Attached: = (Yes/No)
Reactive Capability is Attached: = (Yes/No)
Capacity Temperature Correction curve is Attached: = (Yes/No)

**1.9 COMPUTER MODELS**

In order to represent the Interconnection Customer’s generator(s) in power system stability simulations for system impact study, the completed model type and block diagrams along with the corresponding model constants must be supplied with the Interconnection Request. The Interconnection Customer shall follow the “WECC Dynamic Modeling Procedure”. The WECC procedure specifies that models shall be those in the “WECC Approved Dynamic Model Library”, or it gives direction if a non-WECC approved model(s) is required. If the Interconnection Customer seeks to use a non-WECC approved model(s) the Interconnection Customer shall also follow the “WECC Criteria for Acceptance of New Dynamic Models”. These documents are available on the WECC web site under: www.wecc.org > Program Areas > Reliability Planning & Performance Analysis > System Stability Planning > Modeling > Generators.

**Generator Model:**

Generator Model name: = 
Is Generator Model the WECC-Approved One? = (Yes/No)
Are Generator Model’s Parameters Attached? = (Yes/No)

**Excitation System Model:**
Excitation System Model name: =___________________
Is Excitation Model the WECC-Approved One? =_______ (Yes/No)
Are Excitation Model’s Parameters Attached? =_______ (Yes/No)

**Power System Stabilizer (PSS) Model:**
Please Note: If PSS isn’t applicable to your case, just mark the first question as “No” and then skip other questions.

Is PSS applicable to your project? =_________ (Yes/No)
PSS Model name: =___________________
Is PSS Model the WECC-Approved One? =_________ (Yes/No)
Are PSS Model’s Parameters Attached? =_________ (Yes/No)

**Governor System Model:**

Governor System Model name: =___________________
Is Governor Model the WECC-Approved One? =_________ (Yes/No)
Are Governor Model’s Parameters Attached? =_________ (Yes/No)

**Over and Under Excitation Limiter (O/UEL) Model:**
Please Note: If O/UEL isn’t applicable to your case, just mark the first question as “No” and then skip other questions.

O/UEL Model name: =___________________
Is O/UEL Model the WECC-Approved One? =_________ (Yes/No)
Are O/UEL Model’s Parameters Attached? =_________ (Yes/No)

1.10 Synchronous Generator’s Step-Up Transformer Data
The following is the generator step-transformer data interconnection customer needs to provide.

Transformer Capacity: =___________________
Self-Cooled Type: =___________________
Maximum Nameplate: =___________ kVA
Voltage Rating at Generator Side: =___________ kV
Voltage Rating at System Side: =___________ kV
Voltage Rating at Tertiary Side: =___________ kV
Winding Connection at Low Voltage Side: =___________________
Winding Connection at High Voltage Side: =___________________
Winding Connection at Tertiary Voltage Side: =___________________
Available Total H.V Taps: =___________________
*The Percentage of Each Available H.V Tap = _________________%  
Available Total L.V Taps: =___________________
*The Percentage of Each Available L.V Tap = _________________%  
The Present Tap Setting at H.V: =_______________kV  
The Present Tap Setting at L.V: =_______________kV  
Positive Z₁ on Self-Cooled kVA Rating: =_______________%  
X/R Ratio of Positive Z₁: =___________________  
Zero Z₀ on Self-Cooled kVA Rating: =_______________%  
X/R Ratio of Zero Z₀: =___________________

Notes:
*: The Percentage of Each Available H.V Tap and L.V Tap are the percent of high and low side nominal voltages, respectively.
2 WIND POWER GENERATORS

For transmission connected wind power generators, the following machine, reactive, and control data shall also be provided for each generator:

2.1 General Data:

Type of Induction Generating Unit = ________________
Type of Wind Turbine: = ________________
Number of Generators Pursuant to This Interconnection Request: = ________________
Single Phase? = __________ (Yes/No)
Three Phase? = __________ (Yes/No)
Generator Rated kVA: = ________________ kVA
Generator Maximum Gross Output kW: = ________________ kW
Generator Manufacturer: = ________________
Inverter Manufacturer: = ________________
Model Name: = ________________
Model Number: = ________________
Model version: = ________________

2.2 INDUCTION GENERATORS DATA:

Please Note: Please consult Transmission Provider prior to submitting the Interconnection Request to determine if the following information is required.

Field Volts: = ________________ volts
Field Amperes: = ________________ amps
Motoring Power: = ________________ kW
Neutral Grounding Resistor (If Applicable): = ________________ ohms
Iₚ²t or K (Heating Time Constant): = ________________
Rotor Resistance: = ________________ ohms
Stator Resistance: = ________________ ohms
Stator Reactance: = ________________ ohms
Rotor Reactance: = ________________ ohms
Magnetizing Reactance: = ________________ ohms
Short Circuit Reactance: = ________________ ohms
Exciting Current: =__________ ohms
Temperature Rise: =__________ °C
Frame Size: =_____________
Design Letter: =_____________
Reactive Power Required (No Load): =__________ VARs
Reactive Power Required (Full Load) =__________ VARs
Total Rotating Inertia, H on kVA Base =_____________ pu

Is the Table of Turbine/Generator Under-Frequency Versus Time Operating Limits Attached: =__________(Yes/No)
Is the Table of Turbine/Generator Over-Frequency Versus Time Operating Limits Attached: =__________(Yes/No)

Customer Site Load Data:
Station Service Load for the Facility in kW: =__________kW
Station Service Load for the Facility in kVAR: =__________kVAR
Percent of the Types of Load: =__________%
Source for Station Service Load: =________________

Note: Please consult Transmission Provider prior to submitting the Interconnection Request to determine if the information designated by (*) is required.

2.3 Power factor (PF) control:

Is Uncompensated Table or Curve (load % v.s PF) Attached: =_________(Yes/No)
Is Compensated Table or Curve (load % v.s PF) Attached: =_________(Yes/No)
Number of PF Improvement Capacitors at Each Generator: =_____________
Rated Voltage of PF Improvement Capacitors at Each Generator: =__________V
Rated Size of PF Improvement Capacitors at Each Generator: =_____________
The Capacitor Sizes: =_____________
What is Control for Switching On and Off? =_____________
Any Time Delays at Each Generator: =_____________
Number of PF Correction Capacitors at the Switchyard: =_____________
Rated Voltage of PF Correction Capacitors at the Switchyard: =__________V
Rated Size of PF Correction Capacitors at the Switchyard: =_____________
The Controls Selected for Switchyard Capacitor Banks Steps:
Voltage Control: ______ (Yes/No)
kVAr Control: ______ (Yes/No)
kW Control: ______ (Yes/No)
Or Other (Please Specify): ______________

*For the above Selected Controls Provide (See the note):
Settings: ____________________________
Time Delay: __________________________

Provide the Curve or Table Showing Starting Scenario of Each Wind Generator: kW, kVAr load, operation of Capacitor Banks and Steps. Is the Curve or Table Attached? ______ (Yes/No)

Provide Starting Sequence of Generators in the Wind Power. Indicate the Maximum Number of Generator Units that Could Be Started Simultaneously. Interconnection Customer Can Write Here or Attach the info: ______________

Each Generator’s
Voltage Trip Setting: ________________________
Pick up Time: _______ s
Reconnection Time: _______ s

Notes: *: The time delays are generally not permitted unless it is demonstrated that the delays do not have adverse effects on the operation of the PSE system

2.4 Voltage control

Nominal Voltage: _______________kV
Acceptable Voltage Range (Volts +/- %): ______________________

Maximum Voltage Deviation Due to Switching of PF Correction Capacitors on L.V Side of Transmission Step-up Transformer: ________________%

Estimated Load Factor: ______________________
Estimated Number of Hours/Year of Operation: ______________________
Estimated MWh/Year: ______________________
The Moment of Inertia Blade/Gearbox/Turbine/Generator: kW-sec ______________
Slip or Speed at Full Load: ______________________
Locked Rotor Current at 100% Voltage: =___________A
Locked Rotor Power Factor: =___________
Provide Electrical Torque Versus Speed Curve (from 0% to 100% speed). Is It Attached? =_______(Yes/No)
Provide The Current Versus Speed Curve (from 0% to 100% speed). Is It Attached? =_______(Yes/No)
Is the Equivalent Circuit of Generator Attached: =_______(Yes/No)
Is Pad-mounted Transformer Data Attached: =_______(Yes/No)
Is Transmission Step-up Transformer Attached: =_______(Yes/No)

2.5 COMPUTER MODELS
To represent the Interconnection Customer’s generator(s) in power system stability simulations for the study, the completed model type and block diagrams along with the corresponding model constants must be supplied with the Interconnection Request. The Interconnection Customer shall follow the “WECC Dynamic Modeling Procedure”. The WECC procedure specifies that models shall be those in the “WECC Approved Dynamic Model Library”, or it gives direction if a non-WECC approved model(s) is required. If the Interconnection Customer seeks to use a non-WECC approved model(s) the Interconnection Customer shall also follow the “WECC Criteria for Acceptance of New Dynamic Models”. These documents are available on the WECC website under: www.wecc.org > Program Areas > Reliability Planning & Performance Analysis > System Stability Planning > Modeling > Generators.

Wind Generator Model:
Generator Model name: =______________
Is Generator Model the WECC-Approved One? =_______ (Yes/No)
Are Generator Model’s Parameters Attached? =_______ (Yes/No)

Pseudo Excitation System Model:
Excitation System Model name: =______________
Is Excitation Model the WECC-Approved One? =_______ (Yes/No)
Are Excitation Model’s Parameters Attached? =_______ (Yes/No)

Wind Turbine System Model:
Wind Turbine System Model name: =______________
Is the Model WECC-Approved? =_______ (Yes/No)
Are The Model’s Parameters Attached? =_______ (Yes/No)
Patch Control Model:

Patch Control Model name: ______________________
Is the Model WECC-Approved? = (Yes/No)
Are The Model’s Parameters Attached? = (Yes/No)

Aerodynamic Control Model:

Aerodynamic Control Model name: ______________________
Is the Model WECC-Approved? = (Yes/No)
Are The Model’s Parameters Attached? = (Yes/No)

Other Control Model:

The Control Model name: ______________________
Is the Model WECC-Approved? = (Yes/No)
Are The Model’s Parameters Attached? = (Yes/No)

2.6 Customer-Owned Generator Step-Up Transformer Data
The following is the wind generator step-up transformer data interconnection customer needs to provide. The transformer test report can be submitted in lieu of the above data if it contains all of the required data.

Table I

<table>
<thead>
<tr>
<th></th>
<th>Primary Winding</th>
<th>Secondary Winding</th>
<th>Tertiary Winding</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Rated Voltage:</td>
<td>________________ kV</td>
<td>________________ kV</td>
<td>________________ kV</td>
</tr>
<tr>
<td>Rating Self-Cooled:</td>
<td>________________ MVA</td>
<td>________________ MVA</td>
<td>________________ MVA</td>
</tr>
<tr>
<td>Rating Maximum Forced Cooled:</td>
<td>________________ MVA</td>
<td>________________ MVA</td>
<td>________________ MVA</td>
</tr>
<tr>
<td>Winding Connections (Wye, Delta or Grounded Wye...):</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>If Grounded WYE, Neutral</td>
<td>________________ Ohms</td>
<td>________________ Ohms</td>
<td>________________ Ohms</td>
</tr>
<tr>
<td>Resistance:</td>
<td>If Grounded WYE, Neutral Reactance:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ohms</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table II**

<table>
<thead>
<tr>
<th></th>
<th>Primary To Secondary Winding</th>
<th>Primary To Tertiary Winding</th>
<th>Primary To Secondary Winding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity Base Between Two Windings:</td>
<td>MVA</td>
<td>MVA</td>
<td>MVA</td>
</tr>
<tr>
<td>Load Loss @ 75C</td>
<td>Watts</td>
<td>Watts</td>
<td>Watts</td>
</tr>
<tr>
<td>Positive Sequence Impedance</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Zero Sequence Impedance</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Fixed Taps Available:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planned Tap Setting:</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3 SOLAR POWER AND BATTERY ENERGY STORAGE DEVICE

For transmission connected battery energy storage device, the following data, controls and models shall be provided:

3.1 GENERAL BATTERY ENERGY STORAGE DEVICE DATA:

Total Nominal Discharge/Charge Power: =______________MW
Total Storage Energy at rated temperature: =_______MWH @_______°C
Nominal Output AC Voltage: =______________Volts
Permissible AC Voltage Range: = From____ To ____ Volts
Nominal Output AC Frequency: =______________Hz
Permissible AC Frequency Range: = From____ To ____ Hz
External Output Wiring (Phase/Wire Numbers): =_______Phases______Wires
The Upper Limit of State of Charge (SOC): =______________%
The Lower Limit of State of Charge (SOC): =______________%
The Limit of Depth of Discharge (DOD): =______________%
Maximum Charging Duration: =______________ Hours
Maximum Discharging Duration: =______________ Hours
The responding time of switching between charge and discharge: =______________Seconds
Maximum Current THD Rate: =______________
Maximum Voltage THD Rate: =______________
Power Factor Range: = From____ To______
Operation Ambient Temperature: =________________°C
Permissible Ambient Humidity Range: = From____ To______
Noise Level: =______________dB
Cell Standard Cycle Life: =______________Cycles
Assuming 1 Cycle Each Day, What’s Cell Life Time in Years: =______________Years
Provide Voltage Abnormality Tolerance Table (Voltage% Vs. Seconds): =______________ (Yes/No)
Provide Frequency Abnormality Tolerance Table (Voltage% Vs. Seconds): =______________ (Yes/No)
Provide Low Voltage Ride Through Curve: =______________ (Yes/No)
Is Following PCS Protection Provided?
Short circuit protection: =______________ (Yes/No)
Overload protection: =______________ (Yes/No)
AC over/under-voltage protection: =______________ (Yes/No)
AC over/under-frequency protection: =___________ (Yes/No)
Over-temperature protection: =___________ (Yes/No)
Anti-islanding Protection: =___________ (Yes/No)
Please List Other Protection If Any: =___________ (Yes/No)
The Size of Plant Load Served by Battery Storage: =______________ MVA

The Type of Plant Load Served by Battery Storage: =______________

The Power Factor of Plant Load Served by Battery Storage: =______________

Is the Battery Storage Manufacturer’s Technical Document attached? =______________ (Yes/No)

3.2 SOLAR GENERATION OR BATTERY STORAGE POWER FACTOR CONTROL:

In order to meet 0.95 lagging and leading power factor requirement at the high-side of the generator substation, the appropriate control should be implemented. The following data is required:

Provide the Curve or Table Showing load% V.S Power Factor: =___________ (Yes/No)
What is the Power Factor Control used? =______________
Provide the Control Block Diagram of the Power Factor Control: =___________ (Yes/No)
Provide Parameter Table for the Control Block Diagram of the Power Factor Control: =___________ (Yes/No)
Is There Capacitor Installed to Compensate and Achieve PF Requirement at POI? =______________ (Yes/No)
If Yes to Above Question, The Data, Step and Control of Capacitor Must Be Provided. =___________ (Yes/No or N/A)

3.3 VOLTAGE CONTROL:

If interconnection customer has voltage control function, the data should be provided:

Is Voltage Control Implemented? =________ (Yes/No)
If Yes, Please Fill in the Following Questions. If No, Skip.
Which Bus Is Regulated By Voltage Control Scheme? (BES Terminal Bus or Transformer Bus?) =______________
The Target Voltage Range (Volts +/- %): =______________
Provide Control Block Diagram: =________ (Yes/No)
Provide Parameter Table of Control Block Diagram: =________ (Yes/No)
3.4 COMPUTER MODELS.

WECC Renewable Energy Modeling Task Force (REMTF) worked with a group of utilities to develop generic computer model for wind, solar generation and battery energy storage systems (BESS). The models called REEC_A (preferred), REEC_B (not preferred) for wind and solar and REEC_C for BESS were approved and implemented in GE PSLF, PTI/PSSE and PowerWorld.

The model REEC_C connects with REGC_A to control active power and reactive power. The REEC_C model is essential based on the REEC_A model with some changes and the following block addition:

![Diagram of model REEC_C](image)

This model is recommended by PSE so far since it has BESS characteristics such as initial State of Charge (SOC₀) and SOC upper, lower limits and etc. In order to use this model, regc_a model should be ahead of this model in dynamic models table.

Certainly, if interconnection customer would like to choose other WECC-approved models, they should consult with PSE engineers.

The parameters required for BESS Model REEC_C in either PowerWorld aux file, PTI/PSSE dyr file or PSLF dyd file is acceptable for PSE.

3.5 CUSTOMER-OWNED GENERATOR STEP-UP TRANSFORMER DATA

The following is the battery energy storage’s step-up transformer data interconnection customer needs to provide. The transformer test report can be submitted in lieu of the above data if it contains all of the required data.

<p>| Table I |
|---------|---------|---------|---------|
|         | Primary Winding | Secondary Winding | Tertiary Winding |
| The Rated Voltage: | _______ kV | _______ kV | _______ kV |
| Rating Self-Cooled: | _______ MVA | _______ MVA | _______ MVA |</p>
<table>
<thead>
<tr>
<th>Rating Maximum Forced Cooled:</th>
<th>_________ MVA</th>
<th>_________ MVA</th>
<th>_________ MVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winding Connections (such as Wye, Delta or Grounded Wye...):</td>
<td>__________________</td>
<td>__________________</td>
<td>__________________</td>
</tr>
<tr>
<td>If Grounded WYE, Neutral Resistance:</td>
<td>_______ Ohms</td>
<td>_______ Ohms</td>
<td>_______ Ohms</td>
</tr>
<tr>
<td>If Grounded WYE, Neutral Reactance:</td>
<td>_______ Ohms</td>
<td>_______ Ohms</td>
<td>_______ Ohms</td>
</tr>
</tbody>
</table>

Table II

<table>
<thead>
<tr>
<th>Capacity Base Between Two Windings:</th>
<th>Primary To Secondary Winding</th>
<th>Primary To Tertiary Winding</th>
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</table>
APPENDIX C

THE EXAMPLE TO ILLUSTRATE POWER FACTOR REQUIREMENT AT POI

Here is an example to further explain power factor requirement at Point of Interconnection which is described in Section 3.5.1.

Let us assume an interconnection customer plans to connect a generator to power network as in Fig.1. The total impedance of GSU and Line is \( R + jX \) shown in Fig.2. \( P_g + jQ_g \) is the real power and reactive power that the generator plans to operate. When \( P_g + jQ_g \) flows though GSU and line, the real power and reactive power became \( P_s + jQ_s \) at POI. \( V_g \) is generator’s scheduled bus voltage.

When \( P_g + jQ_g \) flows though GSU and line the loss of the real power and reactive power among GSU and line is:

\[
\Delta P + j\Delta Q = \frac{P_g^2 + Q_g^2}{V_g^2} (R + jX)
\]

The relationship between \( P_g + jQ_g \) from generator and \( P_s + jQ_s \) flowing to POI is:

\[
P_s + jQ_s = P_g + jQ_g + \Delta P + j\Delta Q
\]
Please Note, if Qg flows out from generator as shown in Fig.1 and Fig.2, it is boosting (lagging); if Qg flows into generator, reverse direction of Fig.1 and Fig.2, it is bucking (Leading).

Let us further assume total impedance R + jX in Fig.2 is 0.01pu + j 0.05pu converted at 100 MVA base. And the generator plans to produce the maximum rated 100 MW real power operating in lagging mode or leading mode. Using above equations, the following results need to notice:

**In Lagging Mode:**

(1) The minimum reactive power that generator should produce is 38.22 MVAr to maintain 0.95 power factor at POI, which results in power factor 0.9341 at generator. It is less than 0.95 power factor of POI.

Therefore, in lagging mode, to maintain power factor 0.95 requirement at POI, the generator should be sized (designed) to produce at least 38.22 MVAr reactive power if generator plans to produce the maximum rated 100 MW real power in lagging mode.

**In Leading Mode:**

(1) The minimum reactive power that generator should absorb is 27.145 MVAr to maintain 0.95 power factor at POI, which results in power factor 0.965 at generator. It is higher than 0.95 power factor of POI.

Therefore, in leading mode, to maintain power factor 0.95 requirement at POI, the generator should be sized (designed) to absorb at least 27.145 MVAr if generator plans to produce the maximum rated 100 MW real power in leading mode.