TECHNICAL SPECIFICATIONS

AND

OPERATING PROTOCOLS AND PROCEDURES

FOR

INTERCONNECTION OF LARGE GENERATION FACILITIES

Document 9020

Puget Sound Energy, Inc.

PSE-TC-160.50

December 19, 2016

TABLE OF CONTENTS

1. INTRODUCTION

1.1 GENERAL POLICY

This document is issued in connection with the Federal Energy Regulatory Commission's (FERC) order, Standardization of Generator Interconnection Agreements and Procedures, Final Rule, Order No. 2003, 68 Fed. Reg. 49,846 (Aug. 19, 2003), 104 FERC ¶ 61,103 (issued July 24, 2003) (the "Order") and the Standard Large Generator Interconnection Agreement (LGIA) set forth in the Order. All capitalized terms used in this document are used with same meanings given to them in the Order and the LGIA.

The requirements stated in this document are intended to ensure, pursuant to Section 5.10.2 of the LGIA, that the Interconnection Customer's Interconnection Facilities (ICIF) are compatible with the SCADA RTU metering, communications and safety requirements of PSE. In addition, the requirements stated in this document are intended to provide, pursuant to Section 9.3 of the LGIA, operating instructions to the Interconnection Customer consistent with the LGIA and these operating protocols and procedures. To those ends, the requirements cover the necessary interconnection equipment (relays, breakers, etc.) to be installed, owned, and maintained by the Interconnection Customer and the ICIF needed to disconnect parallel generation from PSE's electric system whenever a fault or abnormality occurs. Any modifications to this document will be provided to applicable Interconnection Customers.

For purposes of this document and the LGIA, "Applicable Reliability Council" means the Western Electricity Coordinating Council (WECC).

Interconnection Customers and PSE personnel shall apply this document and the system reliability performance requirements of the North American Electric Reliability Corporation (NERC), 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 document provides PSE interconnection requirements for generation Facilities, addressing NERC Standard FAC-001-1 Facility Connection Requirements and FAC-001-2 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 OASIS (FAC-001-1, requirement R4).

NERC Standard FAC-001-1 and -2, requirement R3 states the Transmission Owner shall, "address the following items in its Facility interconnection requirements". Requirement R3.1.1 in FAC-001-1 and R3.1 in FAC-001-2, 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-001-1 requirement 3.1.2 and FAC-001-2 requirement 3.2 further 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".

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

steady-state *(Items marked with an asterisk indicate data that vary with system operating state or conditions. Those items may have different data provided for different modeling scenarios)*	**dynamics**	**short circuit**
1. Each bus [TO] a. nominal voltage b. area, zone and owner 2. Aggregate Demand [LSE] a. real and reactive power* b. in-service status* 3. Generating Units [GO, RP (for future planned resources only)] a. real power capabilities - gross maximum and minimum values b. reactive power capabilities - maximum and minimum values at real power capabilities in 3a above c. station service auxiliary load for normal plant configuration (provide data in the same manner as that required for aggregate Demand under item 2, above). d. regulated bus* and voltage set point* (as typically provided by the TOP) e. machine MVA base f. generator step up transformer data (provide same data as that required for transformer under item 6, below) g. generator type (hydro, wind, fossil, solar, nuclear, etc) h. in-service status* 4. AC Transmission Line or Circuit [TO] a. impedance parameters (positive sequence) b. susceptance (line charging) c. ratings (normal and emergency)* d. in-service status* 5. DC Transmission systems [TO] 6. Transformer (voltage and phase-shifting) [TO] a. nominal voltages of windings b. impedance(s) c. tap ratios (voltage or phase angle)* d. minimum and maximum tap position limits e. number of tap positions (for both the ULTC and NLTC) f. regulated bus (for voltage regulating transformers)* g. ratings (normal and emergency)* h. in-service status* 7. Reactive compensation (shunt capacitors and reactors) [TO] a. admittances (MVars) of each capacitor and reactor	1. Generator [GO, RP (for future planned resources only)] 2. Excitation System [GO, RP(for future planned resources only)] 3. Governor [GO, RP(for future planned resources only)] 4. Power System Stabilizer [GO, RP(for future planned resources only)] 5. Demand [LSE] 6. Wind Turbine Data [GO] 7. Photovoltaic systems [GO] 8. Static Var Systems and FACTS [GO, TO, LSE] 9. DC system models [TO] 10. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]	1. Provide for all applicable elements in column "steady-state" [GO, RP, TO] a. Positive Sequence Data b. Negative Sequence Data c. Zero Sequence Data 2. Mutual Line Impedance Data [TO] 3. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]

b. regulated voltage band limits* (if mode of operation not fixed) c. mode of operation (fixed, discrete, continuous, etc.) d. regulated bus* (if mode of operation not fixed) e. in-service status* 8. Static Var Systems [TO] a. reactive limits b. voltage set point* c. fixed/switched shunt, if applicable d. in-service status* 9. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]		

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.

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 HARMONICS

The Total Harmonic Distortion (THD) from the facility will be measured at the 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.

Table 1—Voltage distortion limits

Bus voltage V at PCC	Individual harmonic (%)	Total harmonic distortion THD (%)
$V \le 1.0$ kV	5.0	8.0
1 kV < $V \le$ 69 kV	3.0	5.0
69 kV < $V \le$ 161 kV	1.5	2.5
161 kV < V	1.0	1.5[a]

[a]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

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (odd harmonics)[a, b]						
I_{SC}/I_L	$3 \le h < 11$	$11 \le h < 17$	$17 \le h < 23$	$23 \le h < 35$	$35 \le h \le 50$	TDD
< 20[c]	4.0	2.0	1.5	0.6	0.3	5.0
20 < 50	7.0	3.5	2.5	1.0	0.5	8.0
50 < 100	10.0	4.5	4.0	1.5	0.7	12.0
100 < 1000	12.0	5.5	5.0	2.0	1.0	15.0
> 1000	15.0	7.0	6.0	2.5	1.4	20.0

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

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (odd harmonics) [a, b]						
I_{sc}/I_L	$3 \leq h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h \leq 50$	TDD
< 20[c]	2.0	1.0	0.75	0.3	0.15	2.5
20 < 50	3.5	1.75	1.25	0.5	0.25	4.0
50 < 100	5.0	2.25	2.0	0.75	0.35	6.0
100 < 1000	6.0	2.75	2.5	1.0	0.5	7.5
> 1000	7.5	3.5	3.0	1.25	0.7	10.0

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

Maximum harmonic current distortion in percent of I_L						
Individual harmonic order (odd harmonics) [a, b]						
I_{sc}/I_L	$3 \leq h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$35 \leq h \leq 50$	TDD
< 25[c]	1.0	0.5	0.38	0.15	0.1	1.5
25 < 50	2.0	1.0	0.75	0.3	0.15	2.5
≥ 50	3.0	1.5	1.15	0.45	0.22	3.75

3.2 VOLTAGE - TRANSMISSION LEVEL

The Interconnection Customer shall ensure that operation of the ICIF 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 Point of Interconnection), and for durations as provided in the most current version of NERC and WECC voltage ride-through standards for high and low voltage, and NERC/WECC Planning Standards Steady State and Dynamic Data Requirements MOD-(11 and 13)-WECC-CRT-1 WECC Regional Criterion. The Interconnection Customer's generators shall operate to fulfill this requirement by selecting the appropriate generator main power transformer tap setting. In general, a generator must be designed to remain connected to the PSE system under the following voltage conditions:

- Normal Conditions. Under normal conditions, the voltage at the Point of Interconnection may 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. And, following fault clearing, for transient and post-transient voltages remain within the following ranges:

Disturbance	Transient Voltage Dip Standard	Post Transient Voltage Deviation Standard
N-1 (Single Contingency)	Not to exceed 25% at load buses. Not to exceed 20% for more than 20 cycles at load buses.	Not to exceed 5% at any bus.
N-2 (Double Contingency)	Not to exceed 30% at any bus. Not to exceed 20% for more than 40 cycles at load buses.	Not to exceed 10% at any bus.

3.2.1 Voltage Control versus Power Factor Control at POI

- **The *Net* Boosting 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 continuous power output, 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 paragraph shall not apply to wind generators. Wind generator power factor requirement is shown in 3.2.2

- **The *Net* Bucking 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 continuous power output, 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 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. The further explanation and an example are provided.

An example to further explain the power factor requirement at POI is included in Appendix B. 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.

3.2.2 Wind Power Induction Generating Facilities

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 wind power Generating Facilities:

1 According to the newly approved FERC RM16-1/Order 827: for Non-Synchronous Generation, 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.

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 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 POI are likely needed since only power factor requirement at POI might not effectively control fast dynamic voltage. To combat potential severe dynamic voltage issues such as voltage flicker due to fast wind power ramping up or down, the fast switching dynamic reactive devices such as Statcom, D-Var or SVC is possibly needed to provide dynamic voltage control. The wind power generating facility developer is encouraged to work with PSE to determine if the dynamic voltage issue exists and solutions. The 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.

4. GENERAL DESIGN REQUIREMENTS

4.1 DISCONNECTING DEVICES

Any switch or other disconnecting device installed by the Interconnection Customer pursuant to Section 9.7.5 of the LGIA 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. Any interconnection breaker shall comply with the most current version of PSE Standard Specification 1300.4000.

4.2 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.

4.3 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).

4.4 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.

4.5 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.

4.6 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 X0/X1 <3 and R0/X1 < 1.

4.7 EXCITATION EQUIPMENT, INCLUDING POWER SYSTEM STABILIZERS - TRANSMISSION CONNECTED INTERCONNECTION CUSTOMERS

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/WECC VAR-002-4 and VAR-002-WECC-2 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]
>
> 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]

And VAR-002-WECC-2:

> R1 Generator Operators and Transmission Operators shall have AVR in service and in automatic voltage control mode 98% of all operating hours for synchronous generators or synchronous condensers. Generator Operators and Transmission Operators may exclude hours for R1.1 through R1.10 to achieve the 98% requirement. [Violation Risk Factor: Medium] [Time Horizon: Operations Assessment]

- **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 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-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.

4.8 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-1(or as otherwise provided in its most current standard).

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.

4.9 INVERTER SYSTEMS

Since inverters can be a harmonic source, the Interconnection Customer shall strictly comply with *Section 3.1*.

4.10 WIND POWER GENERATING FACILITIES

Developers must provide wind turbine detailed technical data for each wind turbine type to be installed at the wind power Generating Facility.

4.10.1 Production Control

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) 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) 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. This section does not address protection requirements for the Generating Facility.

5.1 TYPICAL INTERCONNECTION REQUIREMENTS

See Attachment 1 for a one-line diagram of typical interconnection requirements.

- Project design shall, in accordance with Good Utility Practice, include redundancy and backup protection.
- Connection to the PSE system through a dedicated service transformer is required.
- For all non-inverter technology, the interconnection protection shall conform to the most current version of ANSI Standard C37.90. Frequency relays must be solid-state or microprocessor technology.
- All Generating Facilities require three-phase connections.
- Overcurrent protection and breaker failure detection and tripping are 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.
- Microprocessor relays provide event recording. Event recording is recommended for all Generating Facilities and may later be required if needed for unresolved operational or fault events.
- PSE will specify transformer connections.
- If adequate sensitivity of interconnection relays is not achievable with aggregated generation, phase overcurrent 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, and must be within the protective zone of the interconnection relays.
- Generation over 10 MVA must not be connected to facilities that operate at a voltage of 35 kV or lower and that are used to serve non-generator distribution loads.

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.

5.3 PROTECTION SYSTEM MODIFICATIONS

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

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. 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 Interconnection Customers who have contracted to sell power 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 2.

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. Metering Scheme Option "B" is illustrated in Attachment 3.

PSE shall provide current and potential transformers, test switches, and the meter(s). 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).

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.

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 SCHEDULING

Interconnected generation that is either temporary or permanent shall be prescheduled for each scheduling period using PSE's normal scheduling procedures and consistent with NERC Reliability Standards, NAESB Business Practice Standards and PSE's Open Access Transmission Tariff and applicable business practices. The preschedule 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.

Interconnected generators will be subject to PSE's Energy Imbalance Market Business Practice and the applicable requirements under PSE's Open Access Transmission Tariff.

Interconnected generators must be accurately modeled in both PSE's and the market operators 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.

Interconnected generators will also be required to submit their generation forecast data consistent with PSE's Open Access Transmission Tariff, Energy Imbalance Market Business Practice.

Interconnected generators 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, Energy Imbalance Market Business Practice.

6.5 EXPORTING ENERGY

All transmission or distribution arrangements for must be completed prior to the exporting of energy off-site, either within, across, or out of the PSE Balancing Area., This includes requires prescheduling protocols, along with SCADA RTU metering equipment consistent with NERC Reliability Standards and NAESB Business Practice Standards. For applicable rules and procedures for arranging for the exporting of transporting energy from the PSE Balancing Area, see PSE's Open Access Transmission Tariff (OATT) and posted business practices at www.oatioasis.com/psei/.

6.6 SCADA RTU REQUIREMENTS

The general SCADA RTU requirements from the Interconnection Customer to PSE are provided for each generating unit in *Table 6.6.1*, and such requirements for the Point of Interconnection are provided in *Table 6.6.2*.

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

PSE's 24-Hour Operating Center must have the ability to disconnect the Generating Facility from PSE's system via SCADA. 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.

Table 6.6.1 SCADA RTU Points on Generating Units

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 6.6.2 At Point of Interconnection

Point of Interconnection - (For All Generators)	55 kV – 230 kV	• Requires SCADA Control and Indication • MW and MVAR Metering

7. DESIGN REVIEW AND DOCUMENTATION

For all Generating Facilities 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.)
- Anticipated 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:

  Generating Facility Connected to the Transmission System - The Interconnection Customer completes the generator and transformer data as shown on Appendix A.

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 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:

<u>Detailed one-line diagram of entire Generating Facility system:</u>
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.

<u>An AC current and potential control schematic of the Generating Facility:</u>
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.

<u>A control schematic of the Generating Facility:</u>
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.

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

<u>All protective equipment ratings:</u>
Provide ratings for all protective equipment.

<u>Generator data:</u>
Provide the generator data.

<u>Ground Mat design and test data:</u>
Provide the ground mat design and test data.

<u>Equipment specifications and details:</u>
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. The final As-Built drawings shall be stamped by a Professional 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
Detects 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
Detects 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. Detects 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. Detects 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.

8.2 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 Underfrequency / Overfrequency (81 O/U)

The frequency 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 underfrequency generator tripping. The Interconnection Customer shall meet WECC requirements as may be in effect from time to time.

Table 8.2.1 Relay Setting Guidelines

Underfrequency Limit	Overfrequency Limit	WECC Minimum Time
> 59.4 Hz	60 Hz to < 60.6 Hz	N/A (continuous operation)
≤ 59.4 Hz	≥60.6 Hz	3 minutes
≤ 58.4 Hz	≥61.6 Hz	30 seconds
≤ 57.8 Hz		7.5 seconds
≤ 57.3 Hz		45 cycles
≤ 57.0 Hz	> 61.7 Hz	Instantaneous trip

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.

9. DEMONSTRATION OF INTERCONNECTION CUSTOMER'S PROTECTIVE DEVICES

9.1 GENERAL

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 manufacturer's 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 and are subject to negotiation. 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 8.2.4 Testing and Calibration

All testing and calibration of CT, VT, PDs, CVTs, CCVTs, and relays will be performed with 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; and
- 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 PSE’s breakers 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 the actual written test procedures, that incorporate the following types of tests, to PSE for 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; however, 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 3.1*.

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.

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 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.

Voltage and current harmonics from the generator will also be measured and must be in accordance with the requirements of *Section 3.1*.

10.1.3 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 3.1*.

10.2 VAR CAPACITY TESTS

The Interconnection Customer is advised that 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.

10.2.1 Transmission Connected Generators

For synchronous generators, a demonstration of the Generating Facility's lag and lead capability is required. Unless otherwise specified in the LGIA between PSE and the Producer, each generator must supply VAR's as measured at the Point of Interconnection, in a range of operation between 95% bucking or leading to 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.

10.2.2 Transmission Connected Wind Power Generating Facilities

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 generator substation.

10.2.3 Transmission Connected Battery Energy Storage Devices:

Battery Energy Storage Facilities shall test the facility's reactive power compensation scheme as well. 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.

10.3 AUTOMATIC GENERATION CONTROL DISPATCHABILITYTESTING

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 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 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 9.5*) 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.

10.4 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 stabilizer equipment shall be periodically tested and tuned in accordance with the "WECC Power System Stabilizer Tuning Guidelines" (or its successor requirement). This document is available on the WECC Web site at www.wecc.biz under Generator Testing.

10.5 WECC-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 NERC, the WECC Generating Unit Model Validation Policy, the WECC Generating Facility Data, Testing and Model Validation Requirements, and the WECC Synchronous Machine Reactive Limits Verification (or successor requirements). These documents are available on the WECC Web site at www.wecc.biz under Generator Testing. These tests are for:

- 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, turbine-governor systems, power system stabilizers, and other associated generation equipment.

10.6 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.

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 11.2 Annual Demonstration Process

Action	Compliance Time Limit	Failure to Comply
Annual Demonstration Test	Must be performed within forty-five (45) days after the Interconnection Customer's anniversary of the Installation date.	PSE may physically interrupt the flow of energy from the Facility until the test has been completed.
Interconnection Customer shall notify PSE of their selection of Protection and Control Contractor and coordinate the test date with PSE.	No fewer than thirty (30) calendar days prior to the scheduled test date.	PSE may require Interconnection Customer to reschedule the demonstration test if Interconnection Customer fails to notify PSE of the scheduled test date.
Interconnection Customer's protection and control contractor shall document the demonstration test in a certified report.	A copy of the test report shall be provided to PSE within fifteen (15) business days after testing has been completed.	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).

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 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

Action	Compliance Time Limit	Failure to Comply
Calibration Demonstration Every 3 Years	Must be performed within forty-five (45) days after the Interconnection Customer's anniversary of the Installation date.	PSE may physically interrupt the flow of energy from the Facility until the test has been completed.
Interconnection Customer shall notify PSE of their selection of Protection and Control Contractor and coordinate the test date with PSE.	No fewer than thirty (30) calendar days prior to the scheduled test date.	PSE may require Interconnection Customer to reschedule the demonstration test if Interconnection Customer fails to notify PSE of the scheduled test date.
Interconnection Customer's protection and control contractor shall document the demonstration test in a certified report.	A copy of the test report shall be provided to PSE within fifteen (15) business days after testing has been completed.	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).

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.

12. OPERATING REQUIREMENTS

12.1 SWITCHING AND TAGGING RULES

As contemplated by Section 12.1 of the LGIA, 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 disconnection of the Generating Facility.

12.3 OPERATING LOG

The Interconnection Customer shall maintain an operating log at each Generating Facility 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 to 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

Interconnection Customers 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.
- Notification to PSE's Dispatch Center concerning plans to switch on or off-line.

- Immediately 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-relcoses. 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.

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

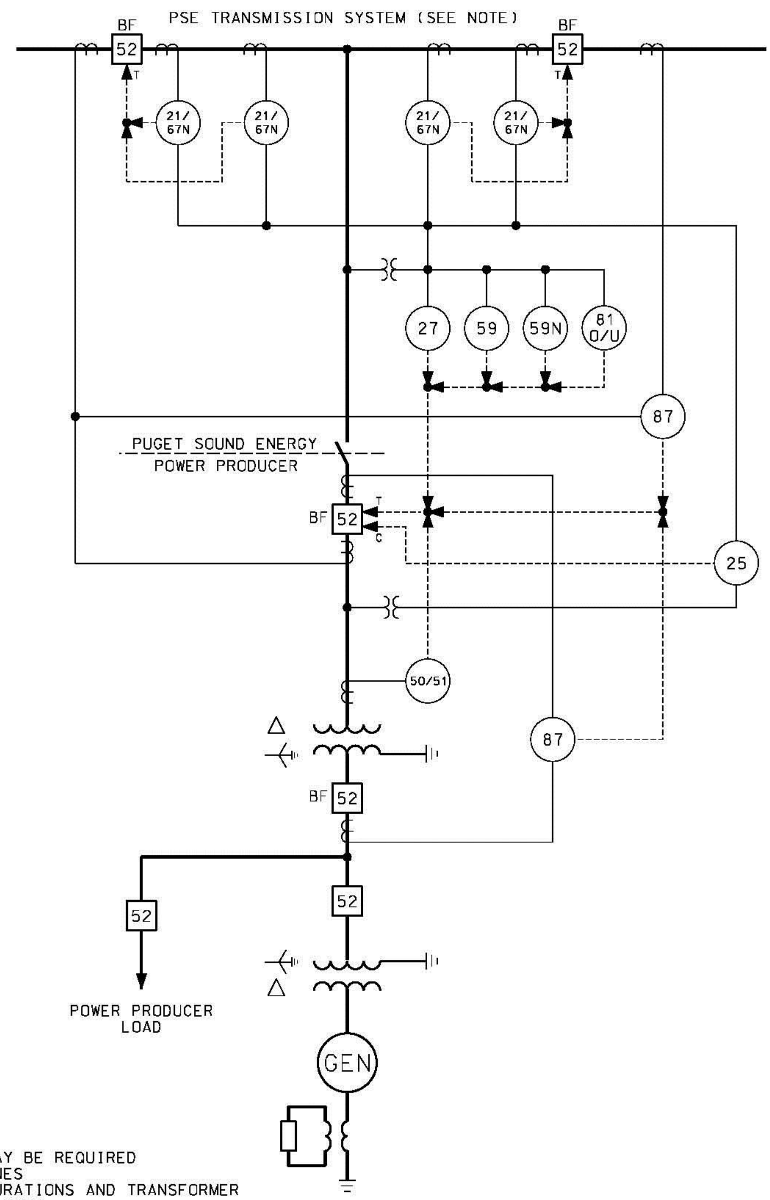
NERC or NAESB Standards and/or Business Practices as well as any applicable provision of the Network Operating Agreement. The total amount of generation produced in any hour by a behind the meter generating facility should not exceed the delivery point load such that energy would flow from the customer's 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 require

ATTACHMENTS 1 through 4

INTERCONNECTION PROTECTION AND METERING DIAGRAMS

TRANSMISSION CONNECTIONS



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

DEVICE	FUNCTION
BF	BREAKER FAILURE
21	DISTANCE
25	SYNCHRONIZING
27	UNDERVOLTAGE
51	PHASE TIME OVERCURRENT
50/51	PHASE TIME/INSTANTANEOUS OVERCURRENT
51G	GROUND TIME OVERCURRENT
51N	NEUTRAL TIME OVERCURRENT
52	AC CIRCUIT BREAKER
59	OVERVOLTAGE
59N	ZERO SEQUENCE OVERVOLTAGE
67N	DIRECTIONAL NEUTRAL OVERCURRENT
81	O/U OVER/UNDERFREQUENCY
87	DIFFERENTIAL

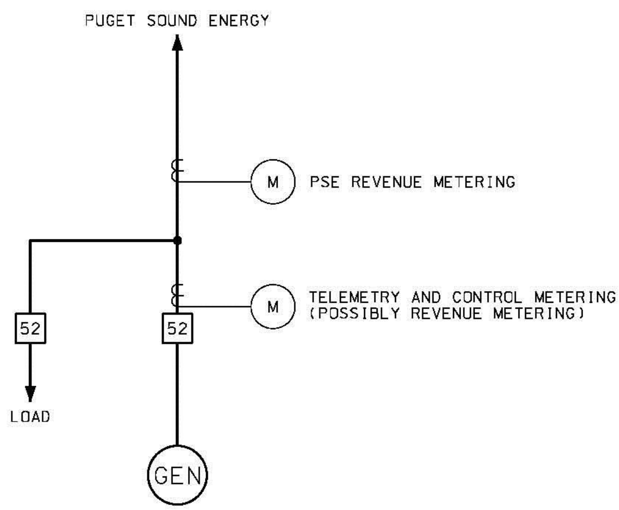
INTERCONNECTION REQUIREMENTS

TRANSMISSION CONNECTIONS

PUGET SOUND ENERGY — SYSTEM PROTECTION

DRAWING NO	SHEET NO	REV NO
ATTACHMENT 1	1	1

METERING – OPTION "A"



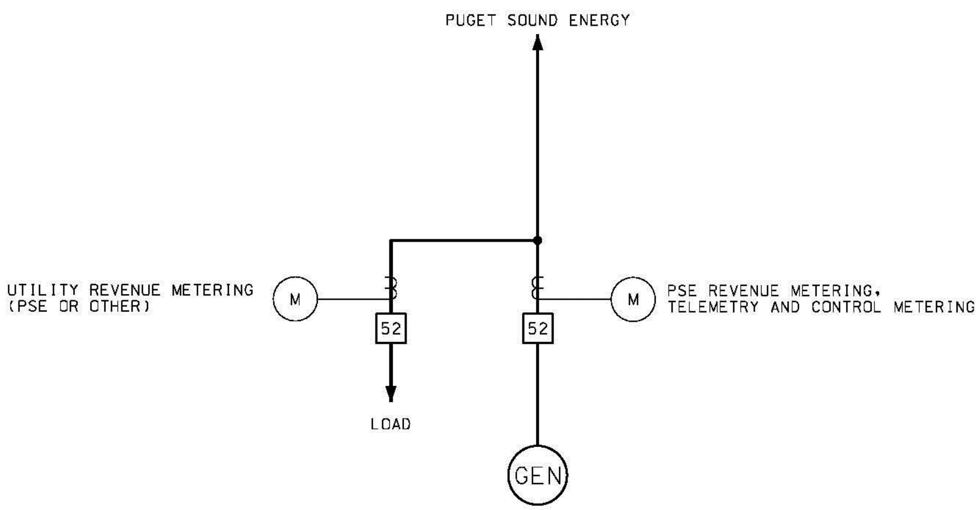
DEVICE	FUNCTION
52	AC CIRCUIT BREAKER

INTERCONNECTION REQUIREMENTS
METERING – OPTION A

PUGET SOUND ENERGY
SYSTEM PROTECTION

DRAWING NO	SHEET NO	REV NO
ATTACHMENT 2	1	0

METERING – OPTION “B”



DEVICE	FUNCTION
52	AC CIRCUIT BREAKER

INTERCONNECTION REQUIREMENTS

METERING - OPTION B

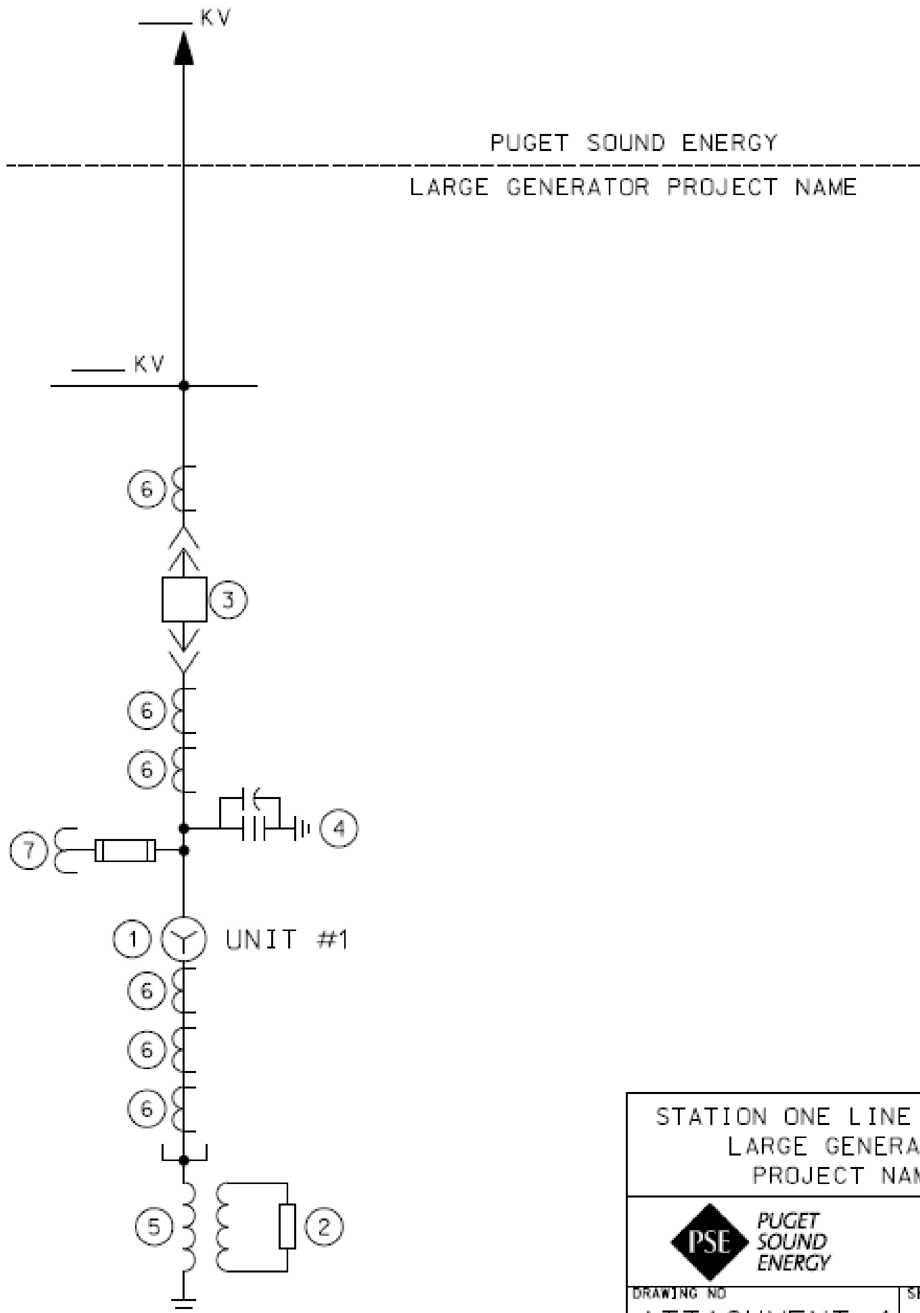
PUGET SOUND ENERGY

SYSTEM PROTECTION

DRAWING NO	SHEET NO	REV NO
ATTACHMENT 3	1	0

EQUIPMENT

ITEM	DESCRIPTION
1	GENERATOR #1,MFR,____KV,____ MVA,___PF,__HZ,3 PHASE
2	NEUTRAL RESISTOR,MFR,___KV,_____ OHMS,___
3	GENERATOR BREAKER,MFR,____KV,____A,_____ MVA
4	SURGE ARRESTER,__KV & ____ μ f CAPACITORS
5	GROUND TRANSFORMER,__KV- ___V
6	CURRENT TRANSFORMER,MFR,___KV,____ :5A,____TYPE
7	POTENTIAL TRANSFORMER,____KV-___V



STATION ONE LINE DIAGRAM
LARGE GENERATOR
PROJECT NAME

PSE PUGET SOUND ENERGY

DRAWING NO	SHEET NO	REV NO
ATTACHMENT 4	01	00

ATTACHMENT4.dgn 11/23/2015 1:35:44 PM

APPENDIX A

TECHNICAL SPECIFICATIONS AND OPERATING PROTOCOLS AND PROCEDURES

FOR LARGE GENERATION INTERCONNECTIONS – INTERCONNECTION REQUEST FOR GENERATING FACILITY

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}, Synchronous d-axis Unsaturated Reactance:	= _____________________pu
X_{qi}, Synchronous q-axis Unsaturated Reactance:	= _____________________pu
X_{dv}, Synchronous d-axis Saturated Reactance:	= _____________________pu
X_{qv}, Synchronous q-axis Saturated Reactance:	= _____________________pu
X'_{di}, d-axis Unsaturated Transient Reactance:	= _____________________pu

X'_{qi}, q-axis Unsaturated Transient Reactance: = ______________________pu

X'_{dv}, d-axis Saturated Transient Reactance: = ______________________pu

X'_{qv}, q-axis Saturated Transient Reactance: = ______________________pu

X''_{di}, d-axis Unsaturated Subtransient Reactance: = ______________________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

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

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)

R_1, Positive Sequence Resistance: = ____________________pu

R_2, Negative Sequence Resistance: = ____________________pu

R_0, Zero Sequence Resistance: = ____________________pu

I_2^2t 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 in

WECC". These documents are available on the WECC web site under: www.wecc.biz > PCC > MVWG > Approved Documents.

Generator Model:

Generator Model name: = ____________________

Is Generator Model the WECC-Approved One? =____________ (Yes/No)

Is Generator Model's Block Diagram Attached? =____________ (Yes/No)

Are Generator Model's Parameters Attached? =____________ (Yes/No)

Is Generator Instruction Manual Attached? = ____________ (Yes/No)

Excitation System Model:

Excitation System Model name: = ____________________

Is Excitation Model the WECC-Approved One? =____________ (Yes/No)

Is Excitation Model's Block Diagram Attached? =____________ (Yes/No)

Are Excitation Model's Parameters Attached? =____________ (Yes/No)

Is Excitation System Instruction Manual 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)

Is PSS Model's Block Diagram Attached? =____________ (Yes/No)

Are PSS Model's Parameters Attached? =____________ (Yes/No)

Is PSS Instruction Manual Attached? =____________ (Yes/No)

Governor System Model:

Governor System Model name: = ____________________

Is Governor Model the WECC-Approved One? =____________ (Yes/No)

Is Governor Model's Block Diagram Attached? =____________ (Yes/No)

Are Governor Model's Parameters Attached? =____________ (Yes/No)

Is Governor System Instruction Manual 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.

Is O/UEL applicable to your project? =____________ (Yes/No)

O/UEL Model name: = ____________________

Is O/UEL Model the WECC-Approved One? =____________ (Yes/No)

Is O/UEL Model's Block Diagram Attached? =____________ (Yes/No)

Are O/UEL Model's Parameters Attached? =____________ (Yes/No)

Is O/UEL Instruction Manual 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 Z_1 on Self-Cooled kVA Rating: =__________________%

X/R Ratio of Positive Z_1: =____________________

Zero Z_0 on Self-Cooled kVA Rating: =__________________ %

X/R Ratio of Zero Z_0: =____________________

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

I_2^2t 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 =________________V

Generator:
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, VAr 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 in WECC". These documents are available on the WECC web site under: www.wecc.biz > PCC > MVWG > Approved Documents.

Wind Generator Model:

Generator Model name: = ____________________

Is Generator Model the WECC-Approved One? =____________(Yes/No)

Is Generator Model's Block Diagram Attached? =____________(Yes/No)

Are Generator Model's Parameters Attached? =____________(Yes/No)

Is Generator Instruction Manual Attached? =____________(Yes/No)

Pseudo Excitation System Model:

Excitation System Model name:	= ____________________
Is Excitation Model the WECC-Approved One?	=____________ (Yes/No)
Is Excitation Model's Block Diagram Attached?	=____________ (Yes/No)
Are Excitation Model's Parameters Attached?	=____________ (Yes/No)
Is Excitation System Instruction Manual Attached?	=____________ (Yes/No)

Wind Turbine System Model:

Wind Turbine System Model name:	= ____________________
Is the Model WECC-Approved?	=____________ (Yes/No)
Is the Model's Block Diagram Attached?	=____________ (Yes/No)
Are The Model's Parameters Attached?	=____________ (Yes/No)
Is Turbine System Instruction Manual Attached?	=____________ (Yes/No)

Patch Control Model:

Patch Control Model name:	= ____________________
Is the Model WECC-Approved?	=____________ (Yes/No)
Is the Model's Block Diagram Attached?	=____________ (Yes/No)
Are The Model's Parameters Attached?	=____________ (Yes/No)
Is Patch Control Instruction Manual Attached?	=____________ (Yes/No)

Aerodynamic Control Model:

Aerodynamic Control Model name:	= ____________________
Is the Model WECC-Approved?	=____________ (Yes/No)
Is the Model's Block Diagram Attached?	=____________ (Yes/No)
Are The Model's Parameters Attached?	=____________ (Yes/No)
Is Aerodynamic Control Instruction Manual Attached?	=____________ (Yes/No)

Other Control Model:

The Control Model name: = ____________________

Is the Model WECC-Approved? =____________(Yes/No)

Is the Model's Block Diagram Attached? =____________(Yes/No)

Are The Model's Parameters Attached? =____________(Yes/No)

Is the Control Instruction Manual 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

	Primary Winding	**Secondary Winding**	**Tertiary Winding**
The Rated Voltage:	______________kV	______________kV	______________kV
Rating Self-Cooled:	__________MVA	___________MVA	___________MVA
Rating Maximum Forced Cooled:	__________MVA	___________MVA	___________MVA
Winding Connections (Wye, Delta or Grounded Wye…):	______________	________________	_______________
If Grounded WYE, Neutral Resistance:	__________Ohms	__________Ohms	__________Ohms
If Grounded WYE, Neutral Reactance:	__________Ohms	__________Ohms	__________Ohms

Table II

	Primary To Secondary Winding	**Primary To Tertiary Winding**	**Primary To Secondary Winding**
Capacity Base Between Two Windings:	________________MVA	____________MVA	______________MVA
Load Loss @ 75C	_______________Watts	___________Watts	_____________Watts
Positive Sequence Impedance	___________________%	______________%	________________%
Zero Sequence Impedance	___________________%	______________%	________________%
Fixed Taps Available:			
Planned Tap Setting:			

3 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 POWER FACTOR CONTROL:

Power factor control is related to active power/reactive power control of battery energy storage device. 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 +/- %): =________________

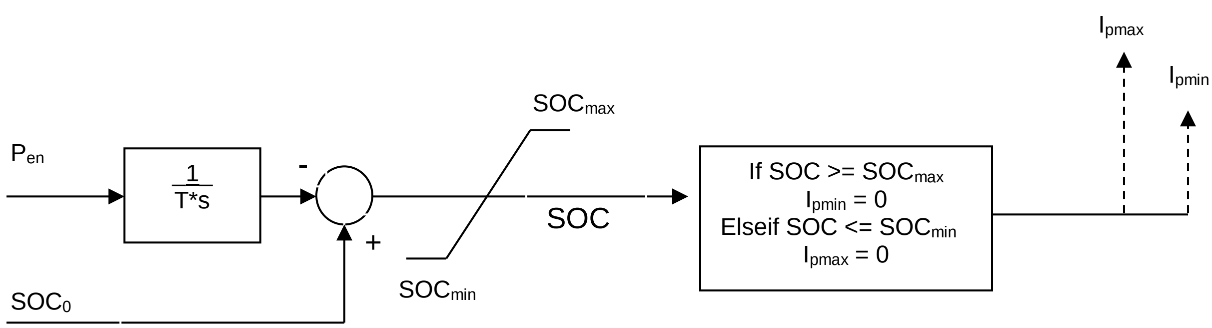
Provide Control Block Diagram: =_________(Yes/No)

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 from Nov 2014 to Jan 2015 to develop generic computer model for battery energy storage systems (BESS). The model called REEC_C was approved in March 2015 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 (SOC_0) and SOC upper, lower limits and etc. In order to use this model, **regc_** model should be ahead of this model in dynamic models table.
The complete control block diagram of REEC_C is shown here:

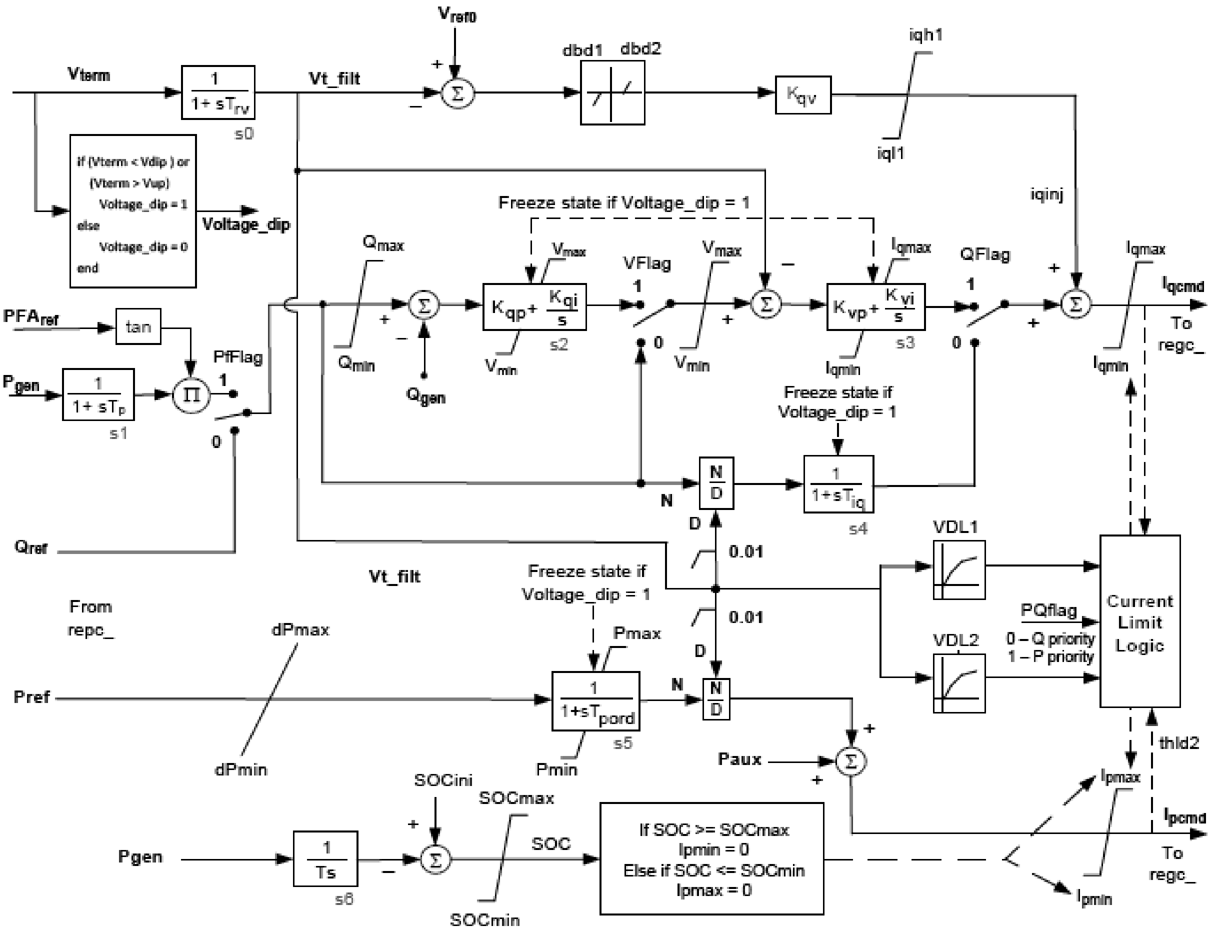


Fig 2: The complete control block diagram of REEC_C

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

The following is data required for BESS Model REEC_C. Interconnection customer is required to fill in this table if they choose this model:

MVA Base: Mvab	=________________MVA
Voltage Dip Threshold: Vdip	=__________________p.u
Voltage Up Threshold: Vup	=__________________p.u
Transducer Time Constant: trv	=___________________s
Deadband In Voltage Error: dbd1	=__________________p.u
Deadband In Voltage Error: dbd2	=__________________p.u
Reactive Current Injection Gain: kqv	=__________________pu/p.u
Maximum Limit of Reactive Current Injection: iqh1	=__________________p.u
Maximum Limit of Reactive Current Injection: iql1	=__________________p.u
Reference Voltage: vref0	=__________________p.u

Initial State of Charge: SOCini	=________________%
Maximum Allowable State of Charge: SOCmax	=________________%
Minimum Allowable State of Charge: SOCmin	=________________%
Discharge Time: T	=________________s
Electrical Power Transducer Time Constant: tp	=________________s
Reactive Power Maximum Limit: qmax	=________________p.u
Reactive Power Minimum Limit: qmin	=________________p.u
Voltage Control Maximum Limit: vmax	=________________p.u
Voltage Control Minimum Limit: vmin	=________________p.u
Proportional Gain: kqp	=_____________p.u/p.u
Integral Gain: kqi	=_____________p.u/p.u
Proportional Gain: kvp	=_____________p.u/p.u
Integral Gain: kvi	=_____________p.u/p.u
Time Constant: tiq	=________________s
Up Ramp Rate on Power Reference: dpmax	=______________p.u/s
Down Ramp Rate on Power Reference: dpmin	=______________p.u/s
Maximum Power Reference: pmax	=________________p.u
Minimum Power Reference: pmin	=________________p.u
Maximum Allowable Total Current Limit: imax	=________________p.u
Time Constant: tpord	=________________s
Power Factor Flag: pfflag	=____________(1 or 0)
Voltage Control Flag: vflag	=____________(1 or 0)
Reactive Power Control Flag: qflag	=____________(1 or 0)
Flag for P or Q Priority Selection on Current Limit: pqflag	=____________(1 or 0)
User Defined Voltages Used to Define VDL1 Function:	=________________p.u
vq1	=________________p.u
vq2	=________________p.u
vq3	=________________p.u
vq4	=________________p.u
User Defined Currents Used to Define VDL1 Function:	=________________p.u
iq1	=________________p.u
iq2	=________________p.u
iq3	=________________p.u
iq4	=________________p.u
User Defined Voltages Used to Define VDL2 Function:	=________________p.u
vp1	=________________ p.u
vp2	=________________p.u
vp3	=________________p.u
vp4	=________________p.u
User Defined Currents Used to Define VDL2 Function:	=________________p.u
ip1	=________________p.u
ip2	=________________p.u
ip3	=________________p.u

ip4 =________________p.u

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

	Primary Winding	Secondary Winding	Tertiary Winding
The Rated Voltage:	____________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

	Primary To Secondary Winding	Primary To Tertiary Winding	Primary To Secondary Winding
Capacity Base Between Two Windings:	_______________MVA	___________MVA	_____________MVA
Load Loss @ 75C	______________Watts	__________Watts	____________Watts
Positive Sequence Impedance	_________________%	_____________%	_______________%
Zero Sequence Impedance	_________________%	_____________%	_______________%
Fixed Taps Available:			
Planned Tap Setting:			

APPENDIX B

THE EXAMPLE TO ILLUSTRATE POWER FACTOR REQUIRMENT AT POI

Here is an example to further explain power factor requirement at Point of Interconnection which is described in Section 3.2.1 on Page 9.

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. Pg + jQg is the real power and reactive power that the generator plans to operate. When Pg + jQg flows though GSU and line, the real power and reactive power became Ps + jQs at POI. Vg is generator's scheduled bus voltage.

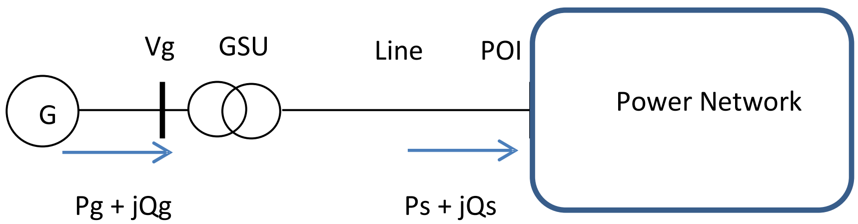


Fig 1: An Example of Generator Connecting to Power Network through its GSU and Short Line

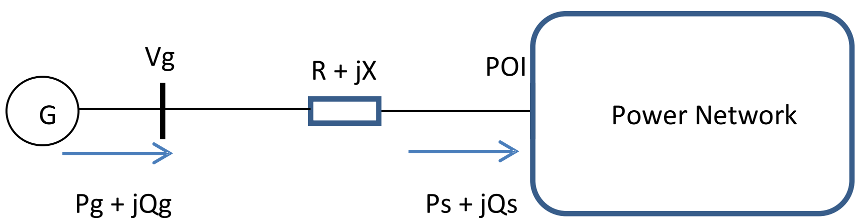


Fig 2: Impedance of Fig. 1

When Pg + jQg 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 Pg + jQg from generator and Ps + jQs 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 100MVA base. And the generator plans to produce the maximum rated 100MW 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 38.22MVar 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 38.22MVar reactive power if generator plans to produce the maximum rated 100MW real power in lagging mode.

In Leading Mode:

(1) The minimum reactive power that generator should absorb is 27.145MVar 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 27.145MVar if generator plans to produce the maximum rated 100MW real power in leading mode.