

DISTRIBUTED ENERGY RESOURCE (DER) INTERCONNECTION POLICY

Facility Connection (Interconnection) Requirements for Distribution Systems 34.5 kV and Below

Engineering Services & Asset Management Policy 138

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1 Introduction

This PacifiCorp Distributed Energy Resource (DER) interconnection policy explains the technical requirements for interconnecting DER facilities to PacifiCorp's distribution power systems. It is based on applicable rules and tariffs crafted by the Federal Energy Regulatory Commission (FERC) and jurisdictional state regulatory agencies. This policy is consistent with safety requirements for PacifiCorp employees and the general public.

This policy addresses technical requirements for establishing and maintaining interconnections as well as certain aspects of cost responsibility. This policy does not cover load service from PacifiCorp. Tariffs and rules filed with FERC and jurisdictional state regulatory agencies address the rates, terms, and conditions under which PacifiCorp provides these services. This policy covers interconnection of inverter and non-inverter-based systems to distribution level assets. Interconnects eligible for net bill applications will be approved and implemented according to the net billing rules of the individual states, using this policy where the net billing rules of the individual states are silent on the issues. PacifiCorp Policy 139 addresses interconnections for transmission systems (46 kV and above). If there are any inconsistencies between this policy and the tariffs and rules, the tariffs and rules shall prevail.

1.1 Definitions¹

PacifiCorp Power System: The PacifiCorp power system is defined as electric transmission and distribution facilities owned by PacifiCorp.

Customer Load: A facility connected to the PacifiCorp power system that only consumes power. Such a facility may be owned or operated by any legal entity with whom PacifiCorp has an agreement for supplying power.

Interconnection Customer: A legal entity owning or operating DER facilities that can interconnect to the PacifiCorp distribution system while generating power. Technical requirements for multi-interconnected and/or network systems (systems interconnected to the PacifiCorp power system in addition to a third-party system) will be determined by PacifiCorp on a case-by-case basis.

Distributed Energy Resource (DER): A source of electric power that is not directly connected to a bulk power system. DER includes both generators and energy storage technologies capable of exporting active power to the area electric power system (EPS).

Electric Power System (EPS): Facilities owned and operated by PacifiCorp that transmit electric power between sources and loads.

¹ See [Glossary](#) for a detailed list of definitions.

1.2 Applicability

This policy applies to all DER facilities interconnecting to the PacifiCorp power system, 34.5 kV and below; including upgrades and contract renewal of existing interconnected DER facilities. Applicability is further defined by the categories below.

1.2.1 New Distributed Energy Resource Projects

All technical requirements described or referred to in this policy apply to new DER projects. New DER projects are facilities that have not been, and are not yet connected with the PacifiCorp power system.

Additional technical requirements may apply to special business arrangements or electrical configurations. All such technical specifications would be documented through the interconnection agreements, i.e., DER interconnection, operation and maintenance agreement, DER interconnection facilities agreement, etc.

1.2.2 Existing Distributed Energy Resource Projects

Existing DER projects are facilities that have an interconnection with the PacifiCorp power system established before the date of service. These installations can operate according to existing contracts. To the extent that changes to this policy contain more stringent requirements than were in place at the time the DER projects initially connected, the existing entity shall be responsible for adhering to current requirements only to the extent that the safety or reliability of the power system, the safety of utility employees, or the public would be jeopardized by not adhering to the current requirements and policies contained herein.

The cost for upgrading to the new policy shall be borne by the Interconnection Customer; except where applicable electric rules and/or the terms of any executed agreements between the Interconnection Customer and PacifiCorp requires PacifiCorp to participate in cost sharing.

1.3 Policy for Interconnection of Distributed Energy Resources

The interconnection procedures for DER facilities are outlined by the appropriate rule or tariff depending on the size and characteristics of the DER facility as well as the potential requested point of interconnection.

1.4 Interconnection Costs

All costs incurred by PacifiCorp to accommodate the interconnection of the customer's DER to PacifiCorp's electrical system will be borne by the customer as specified by agreement, rule, or tariff.

The interconnection study will determine whether PacifiCorp will be required to add to or modify its power system to interconnect the requesting party's DER facility. Parties requesting interconnection are responsible for the cost of these technical studies.

A detailed interconnection study report(s) will include the scope of improvements required to implement the interconnection. Such scope could include improvements that are remote to the site but essential to the project, where the complexity of the proposed project warrants it.

Interconnecting entities must also pay for any additions or modifications to the PacifiCorp power system needed to serve or facilitate the interconnection request.

The specifics of interconnection cost responsibilities will be determined by jurisdictional agreement, rule, or tariff.

1.5 Customer-Owned Equipment Requirements

Interconnection Customers are responsible for designing, installing, operating, and maintaining any DER facility and interconnection equipment within the facility; except metering and communication equipment, which shall remain under the exclusive control of PacifiCorp.

All devices necessary to protect the interconnected entity's facilities are strictly the responsibility of the interconnected entity.

Interconnected entities must satisfy:

- the requirements in this policy as they pertain to the interconnection
- applicable rules and tariffs of jurisdictional state regulatory agencies and/or FERC
- applicable policies of the Western Electricity Coordinating Council (WECC) and the North American Electric Reliability Council (NERC)

PacifiCorp's review and written acceptance of the Interconnection Customer's equipment specifications and plans shall not be construed as confirming or endorsing the interconnected entity's design, nor as warranting the equipment's safety, durability, or in any way relieving the interconnecting entity from its responsibility to meet the above requirements.

PacifiCorp shall not, by reason of such review or lack of review, be responsible for strength, details of design, adequacy, or capacity of equipment built to such specifications, nor shall PacifiCorp's acceptance be deemed an endorsement of such equipment.

The requirements specified in this policy are designed to protect PacifiCorp facilities and maintain grid safety and reliability pursuant to applicable safety and reliability criteria. However, they are not designed to protect the facilities of interconnected DER equipment.

1.6 General Interconnection Requirements

Where there is direct conflict between Section 1.6 of this policy and the applicable rule or tariff, the rule or tariff shall prevail.

1.6.1 Professional Review of Drawings

All one-line diagrams and supporting material for facilities 250 kW and larger shall be stamped by a licensed Professional Electrical Engineer (PE) as part of the detailed project engineering process. The final draft of the one-line diagrams must be received by PacifiCorp's engineering department so they can produce final relay settings. Additionally, no facility will be allowed to be backfed until the final stamped and signed versions of the one-lines have been received.

2 DER Performance Requirements

2.1 Connecting and Disconnecting from the Grid

2.1.1 Entering Service

Requirements are specified in IEEE 1547 clause 4.10. These include the allowable voltage and frequency ranges, and performance during entering service. Settings include required capabilities such as active power requirements and delays to enter service.

2.1.2 Synchronization Limits

Requirements for synchronization are specified in IEEE 1547 clause 4.10.4. These requirements provide maximum voltage step changes when synchronizing and synchronization parameter limits.

2.1.3 Automatic Lockout

Protective functions shall include an automatic means to prevent the DER facility from re-energizing a de-energized EPS.

2.2 Normal Operation

2.2.1 Normal Voltage Operating Range

The normal voltage operating range for a DER unit should be between 0.95 per-unit and 1.05 per-unit voltage. Operation outside of this range is time-limited in nature in accordance with high- and low-voltage ride through requirements.

2.2.2 Normal Frequency Operating Range

Normal operating range for system frequency is between 59.5 and 60.5 Hz. Operation outside of this range is time-limited in nature in accordance with high- and low-frequency ride through requirements.

2.2.3 Power Factor

Unless otherwise specified in the executed contract or activated regulation function, each DER unit in the facility shall operate automatically within a range of a power factor of 0.95 (either leading or lagging) or better at the point of interconnect.

2.2.4 Voltage Regulation Capability

An inverter-based DER facility shall have all of the voltage regulating capability specified by IEEE 1547 clause 5 under “Category B” which includes constant power factor, voltage-reactive power (Volt-VAr), active power – reactive power (Watt-VAr), constant reactive power (Fixed Q), and voltage – active power (Volt-Watt) modes. This functionality is to be disabled by default, but must be activated at the request of PacifiCorp.

A synchronous or induction machine-based DER facility shall have all of the voltage regulating capability specified by IEEE 1547 clause 5 under “Category A” which includes constant power factor, voltage-reactive power (Volt-VAr), and constant reactive power (Fixed Q) modes. This functionality is to be disabled by default, but must be activated at the request of PacifiCorp.

2.2.5 Reactive Power Capability

The inverter-based DER facility should be capable of injecting or absorbing reactive power as required by voltage regulation functions, up to 44% of the kVA nameplate, at any active power output above 20% of the rated active power.

A synchronous or induction machine-based DER facility should be capable of injecting or absorbing reactive power as required by voltage regulation functions, up to 25% (absorbing) and 44% (injecting) of the kVA nameplate, at any active power output above greater than 20% of the rated active power.

2.2.6 Voltage Fluctuation Limits and Light Flicker Limits

The DER facility connected to the PacifiCorp system must comply with PacifiCorp's Engineering Handbook 1C.5.1.

Voltage fluctuation limits depend on both the DER relative size and the strength of the grid (stiffness ratio) at the PCC. The main concerns are rapid voltage changes (RVC) caused by switching large real or reactive power elements, a repeating power fluctuation causing flicker, and power output fluctuations that cause excessive voltage regulator operations. RVC and flicker limits are specified in IEEE 1547 clause 7.2.

In normal operation the DER shall not cause repetitive changes of power output leading to voltage fluctuations. To determine compliance an allocation of the grid's flicker capacity at the PCC is provided to the DER. The allocation is $P_{st} \leq 35$, based on a 10-minute evaluation of DER-caused voltage fluctuations. Compliance can be estimated based on stiffness ratio and plant output variability or can be determined by a measurement using a power quality monitor.

2.2.7 Harmonic Limits

All customers shall comply with the voltage and current harmonic limits specified in the PacifiCorp's Engineering Handbook 1C.4.1. Any harmonic problems shall be handled on a case-by-case basis. A DER facility causing harmonic interference is considered by PacifiCorp as a serious interference with service and is subject to disconnection from the PacifiCorp system until the condition has been corrected. If the cause of the problem is traceable to the Interconnection Customer's facilities, all costs associated with determining and correcting problems shall be at the customer's expense.

2.2.8 DC Injection

Direct current, or a DC-offset, from DERs is restricted because low levels can saturate instrumentation and interconnection transformers causing misoperation of equipment. The DER shall not inject DC current greater than 0.5% of the full rated output current at the reference point of applicability (RPA).

2.2.9 Maintaining Phase-Voltage Balance

All three-phase DER installations shall maintain a balanced power output during normal operations. DER interconnections may not create current unbalance that causes above 3% unbalance in service to other users.

2.3 Responding to Abnormal Grid Conditions

2.3.1 Unintended Islanding Detection

Anti-islanding capabilities are required for all DERs and for all installations. The anti-islanding protection shall trip the DER within two seconds of the formation of an island (loss of grid power). Trip time for DERs on feeders protected with automatic reclosing will need to be coordinated with the reclosing systems. This may require additional equipment such as transfer trip or a suitable alternative.

Additional requirements for anti-islanding protection is specified in IEEE 1547 clause 8.1.

2.3.2 High- and Low-Voltage Ride Through and Trip

The DER facility shall be configured for ride through of abnormal voltages and tripping offline as described by the requirements in IEEE 1547 clause 6.4.2. This functionality shall be enabled by default, unless otherwise specified by PacifiCorp.

2.3.3 High- and Low-Frequency Ride Through and Trip

The DER facility shall be configured for ride through of abnormal frequencies and tripping offline as described in IEEE 1547 clause 6.4. This functionality shall be enabled by default, unless otherwise specified by PacifiCorp.

2.3.4 Frequency Regulation Capability

The DER facility shall be configured for (at a minimum) reducing active power output if the system frequency exceeds the value specified in IEEE 1547 in clause 6, that being 60.036 Hz. This function shall be enabled by default.

2.3.5 Limit Active Power

The DER shall be capable of limiting active power as a percentage of the nameplate active power rating as described in IEEE 1547 clause 4.6.2.

2.3.6 Limits on Transient Overvoltages from DER

DERs shall not, by their design or application, cause transient overvoltages that may exceed utility or customer equipment tolerances. Events leading to overvoltages include interaction of the DER during ground faults, with grid switching transients, or from disconnection of the DER.

Specific limits are defined in IEEE 1547 clause 7.4. If DERs cause objectionable overvoltages then mitigation is required at the DER owner's expense.

2.3.7 Open-Phase Conditions

The DER facility must be able to sense open-phase conditions at the RPA, cease to energize, and trip within two seconds. Note, IEEE 1547 clause 4.1 allows for the RPA to be moved to the high-voltage side of DER transformers that may otherwise break the zero-sequence continuity.

3 Required Equipment and Metering

3.1 Facility Protective Equipment

The Interconnection Customer is solely responsible for the protection of Interconnection Customer-owned DER and interconnection equipment.

The DER facility shall be designed and operated in such a manner that there are no noticeable adverse impacts to system voltage, frequency, harmonics, etc.

If adverse issues are identified, the DER facility must take corrective action at its own expense. If the DER facility does not take corrective action, or continues to operate the equipment causing interference without restriction or limit, PacifiCorp may, without liability, disconnect the DER facility equipment from PacifiCorp's distribution system in accordance with an executed agreement.

3.1.1 All Generators

3.1.1.1 Listed Equipment

Fault interrupting devices located at the point of interconnection must be certified or listed (as defined in the latest edition of the *National Electrical Code*) as suitable for their intended application. This includes being capable of interrupting the maximum available fault current expected at their location.

3.1.1.2 Visible Disconnect

Two manual-operated, unitized load-break disconnect switches located near the POI are required. The switches shall be used to establish visual-open working clearance for maintenance and repair work in accordance with PacifiCorp rules and practices.

The first switch shall be located on the PacifiCorp side of the meter structure (see Figure C1, MDS1). This switch will be owned, operated, and maintained by PacifiCorp.

The second switch, located on the customer side of the meter structure (see Figure C1, MDS2) will be owned and maintained by the customer and operated by PacifiCorp. PacifiCorp personnel shall inspect and approve the installation before parallel operation is permitted. If the disconnect device is in the Interconnection Customer's substation, it shall be located on the substation deadend structure. The second switch must be:

- accessible to PacifiCorp personnel
- capable of being locked in the open position
- located within sight and within 10 feet of the utility meter or at a PacifiCorp-approved location with acceptable signage at the utility meter indicating the location of the disconnect
- chosen from PacifiCorp's list of approved materials
- gang-operated

The manual disconnect switches should not be used to break or make parallel operation between the PacifiCorp system and the Interconnection Customer's DER facility.

During normal operation, PacifiCorp will notify the Interconnection Customer in advance of the operation of either disconnect switch.

In the event of an urgent incident or emergency, PacifiCorp may not be able to notify the customer in a timely fashion that it intends to operate either disconnect switch.

3.1.1.3 Fault-Interrupting Devices

In distribution systems there are two basic types of reclosable, fault-interrupting devices: circuit breakers and reclosers.

The recloser and circuit breaker, with associated protective and automation relays for line protection, are designed to:

- sense overcurrent caused by faults
- interrupt the overcurrent according to a preset time-current characteristic

- reclose to test and to possibly re-energize after a specified time interval

For DER projects connected at primary voltage that also exceed 10% of the EPS's minimum load, PacifiCorp requires the installation of a breaker or recloser with protective relays on the customer side of the interconnection. An example of this is shown in Figure C1 of Appendix C.

The type of fault-interrupting device required for a DER facility must be determined based on the size and type of the DER, the available fault duty, the local circuit configuration, and existing PacifiCorp protection equipment. The fault-interrupting device selected by the Interconnection Customer must be reviewed and approved by PacifiCorp for each particular application.

Devices must be gang-operated to avoid ferroresonance issues. If the Interconnection Customer chooses to install lightning arresters, the arresters must be installed between the transformer and the fault-interrupting device and shall be encompassed by the DER facility's relay protection zone.

All interrupting devices must comply with existing national and regional codes as well as PacifiCorp requirements.

3.1.1.4 Protective Relaying

All relays used in new installations must be multifunction microprocessor based devices. The manufacturers must be in the PacifiCorp list of accepted relay manufacturers (see Appendix C).

The relay associated with the Interconnection Customer's circuit breaker or recloser may contain all the functions for line and transformer overcurrent protection and, in addition, the overvoltage, undervoltage, overfrequency, and underfrequency relay elements mentioned in the next section. Where transfer trip is required, the relay must have the capability to communicate with PacifiCorp devices using the Mirrored Bits protocol.

3.1.1.5 Electromagnetic Interference

IEEE 1547 clause 4.11.1 identifies the DER immunity requirements for DER performance-critical controls and protections.

3.1.1.6 Surge Withstand

Voltage and current surge withstand requirements for the DER are specified in IEEE 1547 clause 4.11.2.

3.1.1.7 Direct Transfer Trip to the Customer's Fault Interrupting Device

When the DER facility capacity exceeds the circuit's minimum load, a direct transfer-trip (DTT) scheme will be implemented. The transfer-trip scheme will operate between the substation and the DER facility and between any upstream line recloser and the DER facility.

The requirement for DTT from the substation or line recloser to the Interconnection Customer's fault-interrupting device will be studied on a case-by-case basis. A reliable, high-speed communication system

will be required to support the transfer trip circuit. This communication circuit will be over fiber optic or microwave radio system. The following are some of the situations that dictate the requirements for the transfer trip:

- The circuit's minimum load is less than the potential generation and high-speed reclosing is being implemented on the circuit's breaker.
- The substation transformer minimum load is less than the potential generation from the DER. The transfer trip will be keyed for detection of transformer faults.
- The aggregated substation minimum load is less than the potential generation from the DER.

3.1.2 Inverter Systems

Utility-interactive inverters do not require separate synchronizing equipment. Inverters shall be UL 1741 certified for interconnection to the utility grid.

3.1.3 Synchronous Generators

The DER facility shall be responsible for properly synchronizing² its generating facility with PacifiCorp's distribution system by means of either a manual or automatic synchronizing function.

Automatic synchronizing is required for all synchronous generating units that have a short-circuit contribution ratio (SCCR) exceeding 0.05. A generating unit having an SCCR exceeding 0.05 shall be equipped with protective functions suitable for detecting loss of synchronism and for rapidly disconnecting the generating facility from PacifiCorp's system.

The DER facility fault interrupting devices shall be three-phase devices with electronic control.

The generating unit must meet all applicable ANSI and IEEE standards.

The prime mover and the generator shall also be able to operate within the full range of voltage and frequency excursions that may exist on the PacifiCorp system without damage to the equipment.

The generating unit must be able to operate through the specified frequency ranges for the time durations listed in Table C1, to enhance system stability during a system disturbance.

3.1.3.1 Synchronizing Relays

Synchronous generators and other generators with stand-alone capability must use one of the following methods to synchronize with the PacifiCorp system.

- Automatic synchronization with automatic synchronizer (device 25).
 - The automatic synchronizing relay must have a slip frequency-matching window of 0.1 Hz or less, a voltage-matching window of $\pm 10\%$ or less, a phase angle-acceptance window of $\pm 10^\circ$ or less, and breaker-closure time compensation.

² Synchronization means that at the time of connection, the frequency difference shall be less than 0.2 Hz, the voltage difference shall be less than 10%, and the phase angle difference shall be less than 10° .

- The automatic synchronizing relay sends a close signal to the breaker after the above conditions are met.
- Automatic synchronization with automatic synchronizer (device 15/25).
 - The automatic synchronizing relay must have a slip frequency-matching window of 0.1 Hz or less, a voltage-matching window of $\pm 10\%$ or less, a phase angle-acceptance window of $\pm 10^\circ$ or less, and breaker-closure time compensation.
 - For an automatic synchronizer that does not have breaker-closure time compensation, a tighter frequency window ($\pm 5^\circ$) with a one-second time acceptance window shall be used to achieve synchronization within $\pm 10^\circ$ phase angle.
 - In addition to the above characteristics, this automatic synchronizer must have the ability to adjust generator voltage and frequency automatically to match system voltage and frequency.
- Manual synchronization with synchroscope and synchro-check relay supervision.
 - The synchro-check relay must have a voltage-matching window of $\pm 10\%$ or less and a phase angle-acceptance window of $\pm 10^\circ$ or less.
 - DER facility with less than a 1,000-kW aggregate nameplate rating may have manual synchronizing relay or automatic synchronizer

3.1.3.2 Frequency/Speed Control

Unless otherwise specified by PacifiCorp, a governor shall be required on the prime mover to enhance system stability.

Governor settings will be provided by PacifiCorp and will require the prime mover to operate unrestrained to help regulate PacifiCorp's system frequency.

3.1.3.3 Excitation System Requirements

As specified by PacifiCorp, the excitation system will be required to regulate voltage or power factor. The control point may not be at the generator terminals.

3.1.3.4 Voltage Regulator Bank

The regulator bank must be able to maintain the generator voltage under steady-state conditions without hunting and within $\pm 0.5\%$ of any voltage level between 95% and 105% of the rated generator.

The voltage sensing point should be at the same point as the PacifiCorp metering.

As determined by the PacifiCorp control center, the generator shall be operated at either a voltage or a power factor schedule.

Depending on interconnection study results, the generating facility may also be requested by the PacifiCorp control center to produce

more or less reactive power than that indicated on the regular schedule to meet the system needs.

Existing regulator banks on the distribution feeder may need to have their existing controls altered or replaced to accommodate bi-directional power flow.

3.1.3.5 Power Factor Controller

The controller must be able to maintain a power factor setting within $\pm 1\%$ of the setting at full load at any set point between 95% lagging and 95% leading. In addition, all power factor controllers for synchronous generators greater than 1 MW must have programmable capability to vary hourly settings.

3.1.3.6 Data Gathering/Event Recorder

DER facilities with capacity greater than 250 kW and with automatic- or remotely initiated paralleling capability may, at PacifiCorp's discretion, have an event recorder to investigate operational difficulties encountered with the DER. The event recorder shall provide PacifiCorp with sufficient information to determine the status of the DER facility during system disturbances. The event recorder must provide remote access from PacifiCorp's control center or engineering offices. The cost of this recorder and its utilization and operation will be borne entirely by the Interconnection Customer. It will be assumed that data-gathering and event-recording devices are only installed to resolve specific incidents that arise relating to the DER facility. They are not intended to be installed on a permanent basis.

PacifiCorp field engineers may request 15-minute data for any DER facility tied to PacifiCorp circuits.

3.1.3.7 Generator Testing

Testing of the generator and excitation system must be performed for generators 10 MW and above according to WECC guidelines to verify proper parameters of the generator and exciter.

Testing shall meet the requirements of the WECC Generator Testing Program. Copies of the test reports with appropriate power flow and stability data parameters identified shall be provided to PacifiCorp.

If a stability model is not available, the Interconnection Customer will be responsible for developing a suitable model for use in PacifiCorp's transient stability program.

3.1.4 Induction Generator

The Interconnection Customer with an induction generator must include protection at their facility to detect self-excitation operation and to disconnect the generator from the EPS.

Any flicker produced in the course of starting an induction generator must not exceed the flicker limits specified in Section 2.2.6.

Due to the reactive power limitations, corrective step-switched capacitors may have to be added at the DER facility. However, the addition of capacitors may cause undesirable ferroresonance.

The cost to install and maintain capacitors and/or other mitigation equipment is the responsibility of the Interconnection Customer.

See Appendix B for specific information on all induction generators on distribution systems.

Induction generators and other generators with no inherent VAR (reactive power) control capability shall be required to provide power at the POI within the range of $\pm 95\%$ power factor as is technically feasible without risk of self-excitation.

The induction generator will provide an amount of reactive power equivalent to that required for a synchronous generator and shall be controllable by voltage.

Specific requirement instructions shall be evaluated on a case-by-case basis and shall be provided in the interconnection agreement.

3.2 Interconnection Transformer

3.2.1 Winding Configurations

The following winding configuration requirements shall apply where a DER interconnection application requires a transformer replacement or an additional transformer.

Acceptable	Grounded Wye / Grounded Wye
	Grounded Wye / Wye
	Grounded Wye / Delta ³
Conditionally Acceptable	Delta / Delta ⁴
	Delta / Wye ⁵
	Delta / Grounded Wye ⁵

3.2.2 Basic Insulation Levels (BIL)

Rating of any new transformer must coordinate with the requirements of the utility system at the PCC. All Interconnection Customer equipment should be designed to the BIL rating of the utility line to which it is being interconnected.

3.3 Grounding Transformer

There are generally two options available to ensure DER facilities do not contribute to transient overvoltage conditions. The first option⁵ is to utilize inverters that comply with the transient overvoltage limits specified in the latest revision of IEEE 1547, section 7.4.2, figure 3. The second option is to utilize a grounding transformer with an associated relay control system. DER facilities connecting to the company's primary system will be limited to the second option.

The grounding transformer can be a wye–delta or a zig–zag transformer. In either case, the connection of the grounding transformer must be configured to ensure the grounding transformer is in service when the DER facility is connected to PacifiCorp's system and is disconnected when the main DER transformer is disconnected.

³ This transformer option may impact the MV protection coordination and require review and potential modifications to settings.

⁴ Acceptable with three-phase overvoltage protection that coordinates with utility equipment temporary overvoltage withstand.

⁵ Applicable only to scenarios where the company's service transformer connected to the DER facility has a wye–wye configuration with the neutral on both sides solidly grounded.

Single-phase DER interconnection facilities are to be connected phase-to-neutral on PacifiCorp's distribution system.

3.4 Metering

The general requirements for metering a DER facility are similar to that of metering electrical retail service from PacifiCorp. The metering requirements are available in the PacifiCorp's Electric Service Requirements (ESR), chapter 9.

Back-up deliveries to the DER facility to support auxiliary loads (bi-directional metering) must be separately recorded from generation and treated as separate transactions under applicable PacifiCorp tariff.

Sites with multiple fueled resources such as wind collectors, solar arrays and energy storage, may be separately metered at the DER including metering at the Point of Delivery.

When energy storage (batteries) are charged both from the PacifiCorp distribution system and a generation solar or wind fuel source, metering will be required to separate the fuel source from the distribution source. That is, metering will be required at the Generation Facility/ Energy Storage Facility and at the Pacificorp Point of Interconnection.

The station service loads will be metered separately and exclusively for both the Storage Facility and Generation Facility. The station service source can be from the local distribution. This requirement would not apply to net billing customers.

3.4.1 California Independent System Operator (CAISO) Compliance

The metering process, specification and requirements can be found in the CAISO Tariff and Business Practice Manual for Metering located on the [CAISO website](#). The criteria for metering ensure operational accuracy and certification of the PacifiCorp CAISO facilities. All generators above 3 MW output and all tie-lines must have a settlement quality meter data (SQMD) plan in place prior to energization. SQMD plans require specific meter and instrument transformer information that is submitted to CAISO for approval. Any changes to the metering configuration at a particular site will require a new SQMD plan to be submitted to CAISO.

3.4.2 Basic Meter Programs

The standard PacifiCorp meter program will include:

- Bi-directional active (MWh) and reactive energy (MVARh)
- Sliding, peak demand (MW) quantities
- Interval MW, MVAR, volt, and amp data

3.4.3 Multiple Generators

When multiple generators are connected at a single PacifiCorp Point of Delivery that is aggregated at a nameplate rating of 3 MW and above, additional real-time telemetry metering is required at the Point of Delivery to the PacifiCorp system. The DER facility shall have each DER unit metered, and in addition the Point of Delivery will also be metered.

3.4.4 Customer Request for Metering Data

Customers will not be approved to interrogate PacifiCorp meters registers and profile channels using cellular or ethernet communications. Customer requests for third-party meter data shall follow company meter engineering Policy 500.

The metering data from PacifiCorp meters shall not be used for customer control purposes. Customer requests for meter data must be negotiated at the beginning of a project.

When requested, PacifiCorp shall provide digital DNP, Modbus, or analog data outputs from revenue meters. Requests for outputs must be made before final metering design and may be written into contract agreements. The metering data from PacifiCorp meters is intended for display purposes only and shall not be used for control.

3.4.5 Metering Requirements for Point of Interconnect Below 600 Volts

PacifiCorp's Electric Service Requirements (ESR) provides the requirements for service termination and metering equipment. Refer to ESR chapter 9 for all secondary direct-connect and instrument-rated requirements.

3.4.6 Primary Metering 2.4 kV through 25 kV Underground Applications

Approved switchgear enclosures for PacifiCorp instrument transformers, meters, and applicable communication equipment are outlined below:

- For medium-voltage applications the customers shall meet minimal requirements of the Electric Utility Service Equipment Requirements Committee, EUSERC Section 400 for metering switchgear equipment. Additional requirements for the underground or overhead assembly, such as a meter plate for the utility compartment, shall be defined during the facility design.
- A clear workspace (per current NEC regulations) is required.
- The metering instrument transformers will be specified by PacifiCorp and shall be installed by the manufacturer of the switchgear.
- Approved metering stations shall be specified by PacifiCorp and shall conform to company material specification ZM 003. All box pads and vaults shall comply with material specifications ZG 421 and ZG 571.
- The location of the meters, including mounting and enclosure facilities, shall be determined during the facility design.

3.4.7 Primary Metering Underground 34.5 kV

The metering requirements for 34.5 kV underground applications will be defined during the facility design.

3.4.8 Primary Metering Overhead Pole-Mounted 2.4 through 34.5 kV

To establish a mutually suitable location for pole-mounted metering, the customer shall consult with PacifiCorp before construction begins. The meter mounting shall conform with PacifiCorp distribution metering overhead construction standards.

The meters may be mounted on the pole in an outside enclosure or inside a control house.

3.4.9 Station Service Power

Depending upon the DER facility's electrical sources, the station service power for connecting substation facilities may require separate revenue metering or may be required to be negotiated for with a foreign utility.

The metering requirements may also require totalization of the gross and auxiliary loads for measured net generation.

3.4.10 Indoor Panels

The DER facility may require installation of a standard 12" × 90" meter panel inside a control house. PacifiCorp will provide and own a standard panel per meter engineering standard requirements.

3.5 Instrument Transformers

3.5.1 Voltage Class - 2.4 kV – 25 kV

The instrument transformers shall comply with PacifiCorp specification EBU IX-S05 and EBU IX-S06.

Voltage instrument transformers are required to be 0.3% and current 0.15% standard metering accuracy class for both ratio error and phase-angle error over the burden range of the installed metering circuit.

Instrument transformers shall be of an approved PacifiCorp design and shall be located within approved enclosures.

3.5.2 Voltage Class - 34.5 kV

For 34.5 kV combination CT/VTs the instrument transformers shall comply with PacifiCorp specification EBU IX-S01.

When applicable, additional 34.5 kV PacifiCorp publications include material specification ZM 004, EBU SI-S02, EBU SI-S03, and EBU SI-S04.

3.6 Real-Time Control Center(s) Meter Data

When required in the facility design, the following distributed network protocol (DNP) real-time digital data is to be delivered to PacifiCorp control, including alternate control centers.

Telemetry shall be implemented for any DER installation with a nameplate rating greater than 3 MW, as well as for any DER installations less than 3 MW on a feeder with distribution automation or a planned DA feeder. Telemetry may be required for DER installations as low as 1 MW, as determined by PacifiCorp. The DER facility shall have each DER unit metered, unless the DER facility is a consolidation of many DER units, each less than 10% of the total capacity. In this case, the DER unit real-time data requirements will be limited to quantities from the collector lines. The following real-time data shall be delivered for each DER unit.

Measurement	Description
Real Power	MW (+/-)
Reactive Power	MVAr (+/-)
Voltage	V for phases A, B, and C
Energy	<ul style="list-style-type: none"> • MWh (delivered) • MWh (received) • MVArh (delivered) • MVArh (received)
Circuit Breaker Status	Real-time status of circuit breakers and circuit switchers that complete the electrical path from PacifiCorp's system to the DER units (except for the consolidation of the outputs of many small DER units,

	in which case the status of DER facility line circuit breakers will be adequate)
Alarm Status	Status of alarms from relay and transfer trip equipment
Wind Speed	Only applicable to wind farms
Global Horizontal Irradiance	Only applicable to solar farms
Barometric Pressure	Only applicable to solar farms
Ambient Temperature	Only applicable to solar farms

In addition to the above data requirements, refer to company grid operations document GCR-001 for creating a points list for the implementation of data into PacifiCorp's EMS SCADA database. GCR-001 addresses PacifiCorp's EMS SCADA data requirements and recommendations for generation facilities (including wind farms and associated substations.)

3.6.1 Facility Monitor and Control with Interface to PacifiCorp

Prior to engineering design completion, the facility's monitoring and control systems (i.e., protocols and interface methods) interfacing with PacifiCorp's control, monitoring, and protection schemes shall be approved by PacifiCorp's metering, protection and control, and the supervisory control and data acquisition (SCADA) engineering departments.

At PacifiCorp's discretion, the facility's monitoring and control equipment shall be tested in a PacifiCorp lab no later than three months prior to the in-service date to verify the control schemes meet PacifiCorp requirements.

3.7 Modifications to Utility-Equipment and New Construction

When a DER is introduced into radial circuits, the following alterations may be necessary to the existing device.

- Change the control to one that is capable of coordinating with the DER facility.
- Add PTs and CTs to install a hot-line block feature and directionality.

3.7.1 Reach and Fault Clearing Time

The overcurrent protection system for radial distribution feeders provided at the PacifiCorp substation is designed to properly detect and clear inter-phase and phase-to-ground faults on the EPS.

The relays at the substation are properly coordinated with fuses and line reclosers to achieve the necessary selectivity. The clearing time under instantaneous element operation is typically between two and three cycles.

The protection system existing before a new DER facility is implemented will be evaluated to determine the need for modifying relay directionality and voltage-supervised reclosing.

The relays associated with the fault interrupting device at the DER facility must be designed to detect faults and to isolate from the EPS. This will provide

protection not only to the EPS but also to the Interconnection Customer's equipment.

3.7.2 Automatic Reclosing

To restore service after a temporary fault, fault circuit reclosing is enabled after the trip. For the automatic reclosing to be successful, all sources of power must be disconnected from the circuit before the circuit is re-energized.

Dead line checks are used to delay reclose of the fault interrupting device. A dead line check must be installed on circuits when:

- The aggregated photovoltaic-based DER systems are greater than 90% of the circuit's minimum daytime load
- The aggregated rotating-based DER systems are greater than 33% of the circuit's minimum load
- The aggregated combined photovoltaic-based DER system and rotating-based DER systems exceeds 33% of the circuit's minimum load

3.7.3 Substation Metering and Monitoring

For PacifiCorp to operate its distribution system in a safe and reliable manner, its distribution engineering, field operations, and system dispatch may need visibility into individual feeder power flows and bi-directional equipment operations.

On many existing circuits, only "Drag Hand" metering is used, which can only measure monthly system load peaks. To effectively integrate a DER, PacifiCorp may require near-real-time data from these circuits, resulting in additional metering requirements at the substation.

3.7.4 Distribution Service Transformer Limits

An existing service transformer may need to be upgraded to resolve voltage or capacity problems. The most common reason is voltage rise due to reverse power. The following criteria shall apply to determine if a DER interconnection application with any existing aggregate DERs requires a change in the service transformer.

- If the DER output is greater than the transformer nameplate rating plus 0.5 kW x all residential premises connected to that transformer and 10% times all commercial customers peak load tied to the transformer, it shall be replaced.
- If the existing service is open wye—open delta banks and the DER is three-phase. And if single-phase DER exceeds 20% of the capacity of the transformer or is expected to create an unbalance in current of more than 20%.

Additional sizing and design requirements are discussed in mitigation options and upgrade requirements are covered later in this section for radial integration of DERs.

3.7.5 Substation Power Transformers Limits

The aggregate of large DER (>250 kVA) will be limited to 50% of the substation transformer normal rating. This usually ensures that the load tap changer (LTC) doesn't operate excessively. Note that small systems (<250 kW) may continue to be interconnected when these distribution transformer limits are reached.

In the case of parallel transformers, aggregate DERs shall not exceed a net reduction of 50% at all operating times. This limit is based on expected DER

output and load profiles that result in the net load. An absolute limit of 50% of the transformer rating (less the safety buffer) applies in cases of substations with multiple transformers and with auto-transfer capability. This ensures that locations with transfer capability can operate safely where one transformer load automatically transfers to the remaining transformer.

Sizing and design requirements are covered in the mitigation options and upgrade requirements section.

4 Telecommunication Requirements for DER Interconnection

4.1 Application

Before a new DER facility is connected to PacifiCorp's EPS, PacifiCorp will specify the protection, metering, SCADA, and electronic communication channels that will be required.

Due to the highly specialized and critical nature of the electronic communication equipment, as well as the safety and reliability considerations involved, PacifiCorp requires that all such equipment, with the exception of the installation of optical ground wire (OPGW) or all-dielectric self-supporting (ADSS), be installed, owned, and maintained by PacifiCorp at the Interconnection Customer's expense.

Considering the critical protection requirements for the interconnection of the DER facility to PacifiCorp's distribution system and the varied PacifiCorp internal electronic communications systems that may be available for the specific DER facility, the electronic communication channels described in Section 4.3 must be defined on a case-by-case basis.

4.2 General Requirements

The DER facility will be responsible for acquiring the communication lines from the local phone company, or multiple phone companies, as required to meet the electronic communications required of the new DER facility with an exception: If protective (requires communications channel) relay channels are needed, PacifiCorp will provide them at the Interconnection Customer's expense.

Due to the critical nature of the protection, metering, SCADA, and electronic communication requirements, PacifiCorp will define the technical requirements and may choose to provide all or portions of the communication channels on its existing internal communication network at the Interconnection Customer's expense.

4.3 Telecommunication Circuit Requirements

4.3.1 New DER Facilities with Communication-Based Protection Requirements

A backup meter for telemetering of the total DER facility's kW output is to be communicated on a separate channel, but in a manner similar to the SCADA channel, to meet requirements for NERC Standard EOP-008-0.

Unless other arrangements are made to use PacifiCorp's installed communications network, PacifiCorp will provide a local phone company MPLS lease from the POI substation to PacifiCorp's closest facility wherein the lease can be connected. The DER will reimburse PacifiCorp for the monthly lease cost. PacifiCorp will install a router at the POI substation.

PacifiCorp will specify the location of the closest communications facility where the leased MPLS will be terminated.

The communications channel for metering equipment, when using PacifiCorp's communications network, may consist of fiber optic systems, microwave radio paths, or a combination of these systems. The alternate metering channel may use the same communications system as the SCADA RTU channel, provided it is not routed through PacifiCorp's control centers.

4.3.2 New DER < 3 MW with No Teleprotection Requirement

Metering requires a cell phone or other data communication connection for use with the PacifiCorp MV-90 remote meter data collection system. An Ethernet connection is approved but not required.

4.3.3 New DER ≥ 3 MW or New DER < 3 MW with Teleprotection Requirement

An Ethernet connection for use with the PacifiCorp MV-90 remote meter data collection system is required.

4.3.4 Dispatch Business Phone Line

A business phone line is required so that operating instructions from PacifiCorp may be given to the designated operator of the DER facility equipment.

Unless other arrangements are made to use PacifiCorp's existing electronic communications network, the Interconnection Customer must provide a local phone number.

4.3.5 Protective Relay Remote Access Business Phone Line

A business phone line is required at the location of the protective relay equipment for remote interrogation of the protective relay equipment.

Unless other arrangements are made to use PacifiCorp's existing electronic communications network, the Interconnection Customer must provide a local phone line.

4.3.6 Protective Relays

PacifiCorp will determine if relays not requiring high-speed communications will be adequate for emergency tripping of the DER facility and/or protection of the distribution system or if high-speed electronic communication-based protection equipment is required.

PacifiCorp will design and provide electronic communication channels suitable for the protective relay package required at the Interconnection Customer's expense.

Local telephone company leased lines are not acceptable for protective relay channels.

Telecommunication channels for protective relay equipment may consist of fiber optic systems, microwave radio paths, or a combination of these systems.

4.3.7 SCADA Remote Terminal Unit (RTU)

Real-time data and/or control via a SCADA RTU is to be electronically communicated to PacifiCorp's control centers.

Unless other arrangements are made to use PacifiCorp's existing electronic communications network, the SCADA circuit will be routed over the PacifiCorp provided MPLS lease. Telecommunication channels for SCADA RTU equipment, when using PacifiCorp's electronic communications network, may consist of fiber

optic systems, microwave radio paths, other radio systems, or a combination of these systems.

4.3.8 Backup Metering

A backup meter telemetering of the total generation facility's kW output is to be electronically communicated on a separate channel, but in a manner similar to the SCADA channel, to meet requirements for NERC Standard EOP-008-0.

Unless other arrangements are made to use PacifiCorp's existing electronic communications network, the backup telemetry circuit will be routed over the PacifiCorp provided MPLS lease to PacifiCorp's control centers.

PacifiCorp will specify the location of the closest communications facility wherein the leased MPLS will be terminated.

The electronic communications channel for the backup metering equipment, when using PacifiCorp's electronic communications network may consist of fiber optic systems, microwave radio paths, or a combination of these systems. The backup metering channel may use the same electronic communications system as the SCADA RTU channel, provided it is not routed through PacifiCorp's control centers.

4.4 Telephone Company Line Equipment

Proper cable and protection equipment may be required at substations and other high-voltage electric facilities for expected ground potential rise (GPR).

The GPR testing required to determine the required telephone line protection may be performed by PacifiCorp at the expense of the Interconnection Customer or may be performed by the Interconnection Customer itself.

The calculated GPR value will determine what grade of phone-cable high-voltage protection equipment is required, as well as the distance from the DER facility at which the telephone company pedestal shall be located.

The local phone company must be informed in advance (up to six months) so outside plant facilities can be engineered to serve the DER facility location.

Some independent telephone companies are not tariffed to provide protection equipment. In this case, the Interconnection Customer DER facility will be required to purchase and install the necessary telephone line protection equipment.

4.5 Communications Operating Procedures

4.5.1 Normal Operating Conditions

The Interconnection Customer shall provide PacifiCorp the information necessary to communicate with the equipment and/or personnel at the DER facility during routine operating conditions. This information shall be updated as soon as a material change becomes available for use by notifying PacifiCorp's grid operations centers in either Salt Lake City, Utah or Portland, Oregon, depending on the facility's operating area.

4.5.2 Emergency Operating Conditions

The Interconnection Customer shall provide PacifiCorp with the information necessary to communicate with the equipment and/or personnel at the DER facility during the loss of the primary communication medium. This would be considered the emergency operating condition. This information is also to be

updated as soon as a material change becomes available for use by notifying PacifiCorp's grid operations centers in either Salt Lake City, Utah or Portland, Oregon, depending on the facility's operating area.

5 Emergency Generator Requirement

There are two major methods of transferring electric power supply between the PacifiCorp source and the emergency generator system: open transition (break-before-make) and closed transition (make-before-break). The open transition method can be accomplished via a double-throw transfer switch or an interlock scheme that prevents the two systems from operating in parallel. The Interconnection Customer's main breaker shall not be allowed to close until the generator breaker opens. This open transition method does not require any additional protection equipment; however, it does cause the Interconnection Customer's load to experience an outage while transferring back to PacifiCorp. The length of this transfer outage depends on the transfer equipment involved.

For DER facilities that cannot tolerate this momentary loss of power, the closed transition (make-before-break) method is intended to provide transfer without interruption. For the closed-transition method, the maximum parallel time with the EPS shall be less than or equal to 0.1 seconds, both to and from the emergency DER source.

The protection requirements for synchronous generators will also apply to emergency generators any time a parallel connection greater than 0.1 seconds is made with the EPS. These requirements would include, but are not limited to, a dedicated transformer and automatic synchronizing.

Emergency systems are routinely tested by the Interconnection Customer under load, usually once a month. With a break-before-make system, the Interconnection Customer's load, or most often a portion of it, is removed from the EPS and the emergency DER system is tested under load conditions. After successful completion of the test, the DER is taken offline and the Interconnection Customer is transferred back to PacifiCorp. This testing procedure results in the test load experiencing two outages (when bringing the emergency DER online and when taking it offline) whenever the system is tested.

PacifiCorp may allow installation of a very sensitive reverse-power relay for emergency DER installations, as an alternative to the normally required voltage, frequency, and ground relays. The reverse power relays shall be set to pick up on transformer magnetizing current with a time delay not to exceed 0.1 seconds. The relay output shall trip the circuit breaker on the PacifiCorp side of the transfer switch. This application can be used when the Interconnection Customer's emergency DER output is expected to be less than the entity's load.

5.1 Notification/Documentation Related to Emergency Generators

The Interconnection Customer must notify PacifiCorp in writing of all new proposed emergency generator installations, or proposed changes to the existing schemes, regardless of method of interconnection or transfer.

Required documentation includes a description of generation and control system operation, one-line diagrams, identification of all interlocks, sequence of events description for transfer operation, and specifications for any PacifiCorp-required protective devices. PacifiCorp may request additional documentation should it be deemed necessary.

Depending on the complexity of the installation, PacifiCorp may require review by a Professional Electrical Engineer from the state in which the generator is to reside.

All documentation must be approved by PacifiCorp engineering prior to installation.

5.2 Operation/Clearances Related to Emergency Generators

For the safety of PacifiCorp personnel and to ensure the proper operation of the PacifiCorp system, it is essential that the Interconnection Customer notify the PacifiCorp control center of all emergency generator installations prior to paralleling.

For operation and clearance purposes, emergency generator installations should be treated the same as any independent DER facility interconnected to the PacifiCorp system. A satisfactory visible open point shall be approved by PacifiCorp.

For all line work and clearances, the emergency generator shall be treated as a power source.

Interconnection Customers using make-before-break transfer schemes are required to notify the PacifiCorp control center of their intent to transfer to their emergency generator and then back to the PacifiCorp source before any transfers are attempted. The notification of the make-before-break transfer scheme is necessary because such actions put another generation source in parallel with the PacifiCorp system. This notification is not essential on break-before-make schemes, but may be desirable in some instances.

5.3 Other PacifiCorp Protection and Control System Changes

5.3.1 Direct Digital Control

Dispatchable DERs larger than 3,000 kW are required to have real-time direct digital control (DDC) of unit output from PacifiCorp's control center. This allows DER units to respond to power system load/frequency changes.

5.3.2 Warning Label for Protective Relays

A warning label shall be affixed within 6 inches of any relay in the Interconnection Customer's control house (or similar enclosure containing protective relays) that affects the operation of PacifiCorp's electrical circuits.

The warning label shall state the following:

Warning !!! Do not alter or change any settings on this relay without first receiving approval from PacifiCorp's Protection and Control Engineering Dept. Failure to give notification to PacifiCorp of this action may result in damaged or destroyed electrical equipment, possible physical injury or fatality, facility disconnection, and/or legal action.

A stock item number is available from PacifiCorp to acquire this warning label. Please contact PacifiCorp to acquire this label.

6 Commissioning and Testing Policy and Inspection Procedure for Interconnection Customers

The customer shall provide full commissioning services for the generation unit in compliance with IEEE 1547 and UL 1741.

The project commissioning and testing plan (hereafter referred to as "the plan") shall be prepared and certified (signed and stamped) by a professional engineer licensed in the state of the installation before being submitted to PacifiCorp. The plan must be submitted at least one month prior to the planned request for backfeed to allow PacifiCorp's engineer time to review and accept as valid for testing.

Projects will not be allowed to backfeed until a valid plan has been received, reviewed, and accepted by PacifiCorp's engineer.

The customer shall provide a plan that takes into account all aspects of the project's potential impacts on the PacifiCorp system. PacifiCorp engineers' review or lack of review by PacifiCorp does not release the Interconnection Customer from sole responsibility in this regard.

The commissioning plan shall consist of three parts:

- Manufacturing and production tests
- Confirmation of proper installation and settings
- Commissioning tests

6.1 Manufacturing and Production Tests

The following are required as part of the manufacturing and production tests.

- The utility voltage and frequency variation test procedure described in UL 1741 Section 68 shall be performed as part of routine production on all inverters used to interconnect generating facilities to PacifiCorp's distribution system. This testing may be performed in the factory or as part of a commissioning test. This testing ensures that the inverter ceases to deliver power to the grid within specified times for specified conditions.
- A demonstration that the failure of a single generation system component will not cause a safety or power quality problem on the distribution system.
- The manufacturing and production commissioning tests as specified in Appendix D must be completed, and two copies of the test reports must be submitted to the PacifiCorp project management group responsible for delivery at least 15 working days ahead of the requested initial commissioning date.

6.2 Confirmation of Proper Installation and Settings

Confirmation of proper installation and settings must be performed once the DER has been installed in the field. Inspections must be performed to verify:

- The installation is built as planned according to initial design reviewed and accepted by PacifiCorp
- Inverter and external relay settings are set according the requirements in section 2
- Required protective equipment and metering are installed as specified in section 3
- Telecommunication requirements are met according to section 4

6.3 Commissioning Tests

Commissioning tests shall be performed by the Interconnection Customer under the supervision of a professional engineer after installation and settings have been confirmed. PacifiCorp shall be given the opportunity to witness the testing process. However PacifiCorp's involvement will not relieve the Interconnection Customer from the customer's sole responsibility to verify the proper operation of the interconnection system.

If equipment performance is found to be satisfactory, the final certification will be issued by the Interconnection Customer’s professional engineer. Following this final certification, the DER may begin operation.

The following commissioning tests are required for systems greater than 25 kW:

- **Single-Phase Open:** The DER shall follow open-phase condition requirements in IEEE 1547 clause 6.2.2.
- **All-Phase Open:** The DER shall follow the cease to energize performance requirement in IEEE 1547 clause 4.5.
- **Return to Service:** The DER shall follow the return to service criteria in IEEE 1547 clause 6.6. and IEEE 1547 clause 4.10.

For larger systems, at least 250 kW or more, additional commissioning tests shall be performed:

- **Verify Fixed Reactive Power:** The DER shall provide voltage regulation capability by changes of reactive power according to IEEE 1547 clause 5.3. The fixed power factor mode may be tested if required, as specified in IEEE 1547 clause 5.3.2.
- **Long-Term Monitor Power Quality (required at PacifiCorp’s discretion):** Power quality shall be monitored a week prior to, and a week following, the commissioning test date. Power quality requirements are specified in IEEE 1547 clause 7.
- **Verify Telemetry Data:** Telemetry data shall be monitored per requirements in section 3.6 for systems greater than or equal to 3 MW.

Test	DER Size		
	25 – < 250 kW	250 kW – < 3 MW	≥ 3 MW
Single-Phase Open	✓	✓	✓
All-Phase Open	✓	✓	✓
Return to Service	✓	✓	✓
Verify Fixed Reactive Power		✓	✓
Long-Term Monitor Power Quality (Optional)		✓	✓
Verify Telemetry Data			✓

These tests may be waived or include more stringent test requirements where special conditions warrant at PacifiCorp’s discretion.

6.4 Pre-Witness Testing Meeting

Following the approval of the commissioning and testing plan, a pre-witness testing meeting shall be held for DERs of 1 MW and above.

The pre-witness testing meeting shall include, as a minimum, the Interconnection Customer’s contractor and all contracted testing firms, the PacifiCorp engineer, the

PacifiCorp project manager, district substation operations, metering, and the district lineman.

The purpose of the pre-witness testing meeting will be to review the plan and ensure all parties understand their roles and responsibilities.

6.5 Establishing the Commissioning Date

The requirements of this section apply to generators of 1 MW or larger in size.

The 'Initial Commissioning Date' shall be the date on which the Interconnection Customer test synchronizes and performs a load-test on the DER.

The 'Final Commissioning Date' shall be the date on which the Interconnection Customer is granted written permission to begin commercial operation.

The Interconnection Customer shall give the PacifiCorp project manager a minimum advance notice of 60 calendar days of their proposed Initial Commissioning Date. This date shall not be considered to be scheduled until the following are satisfied.

- The Interconnection Customer shall submit their completed manufacturing and production commissioning paperwork to the PacifiCorp project manager a minimum of 15 working days before the requested Initial Commissioning Date.
- The Interconnection Customer shall submit a report from their project engineer certified with a professional seal, covering all aspects of the commissioning and testing plan to be completed before commissioning with the following statement: "I have reviewed the installation of this project and its protection and control system and find it to be ready to perform settings verification and commissioning tests." This report shall be submitted to PacifiCorp project management at least five working days before The Initial Commissioning Date for review and approval.
- Following settings verification and commissioning tests of the Interconnection Customer's project, their project engineer shall review the performance of the equipment, and if satisfied, complete the commissioning report. This final report shall state the following: "I have reviewed commissioning test results of this project and find it to be ready to enter commercial operation." This statement shall include a professional seal and be submitted to PacifiCorp project management at least five working days before the Final Commissioning Date for review and approval.
- Should PacifiCorp identify any incomplete or unsatisfactory items in the engineer's submittals, it shall inform the Interconnection Customer in writing and the project submittal timeline would reset.

6.6 Equipment Changes

Any changes to PacifiCorp-required protection equipment or major substation equipment (transformer, breaker, etc.) must be submitted to a PacifiCorp representative for review and approval by the appropriate PacifiCorp engineer prior to the changes being made.

6.7 Pre-Certified Equipment

Interconnection Customers may seek blanket certification for commercially available equipment types. Should this be desired, the Interconnection Customer needs to provide PacifiCorp with information regarding the proposed equipment and all relevant factory testing data.

The field installation of pre-approved equipment requires only the following tests:

- Underfrequency
- Overfrequency
- Undervoltage
- Overvoltage
- Anti-islanding function, if applicable
- Non-export of power function, if applicable

6.8 Design Changes after Final Commissioning

Any modification to the DER facility requiring PacifiCorp protective relaying and interlocks after final commissioning must be reviewed and approved by PacifiCorp prior to implementing any changes.

Demonstration of relay calibration, trip tests, and online tests may be required depending on the extent of the design change.

Setting changes of any interconnection protection or synchronizing device must be approved by PacifiCorp with a copy of the changes forwarded to relay technical support and field operations.

Any field modification or as-built AC/DC protection and synchronizing schematics associated with any PacifiCorp-required interconnection device must be forwarded to the designated PacifiCorp representative.

7 Ownership Policy

7.1 Ownership and Operation of Interconnection Facilities and Equipment

All meters and instrument transformers will be provided, owned, and maintained by PacifiCorp at the customer's expense. At customer-owned facilities, the customer will provide, own, and maintain all mounting structures, conduits, metering transformer cabinets, and switchboard service sections of the size and type approved by PacifiCorp.

PacifiCorp will design, procure, own, and maintain all communication equipment used for revenue metering. The communication requirements will be written into the specific project's scoping documentation. The communication equipment shall be located near the metering. Typically the primary and backup meters will directly supply a DNP output to the EMS.

For new DER facilities, PacifiCorp shall not own, operate, or maintain any of the interconnection equipment that is electrically located on the generation side of PacifiCorp's meter. It is assumed that this equipment is owned, operated, and maintained by the Interconnection Customer. This equipment commonly includes the transformer, breaker, relay and other protection devices.

PacifiCorp will install, own, operate, maintain, and test any protective device on the EPS to accommodate the DER facility. All costs shall be borne by the Interconnection Customer as specified in the interconnection and/or construction agreements.

For new DER facilities, PacifiCorp will design, test, install, own, operate, and maintain, all communication equipment including the communications circuit from PacifiCorp's facilities to the Interconnection Customer's facilities if the circuit is a technology other

than land line-wire. If agreed by PacifiCorp, land line-wire circuits may be owned/leased, operated, and maintained by an entity other than PacifiCorp (either the Interconnection Customer or a communication company).

For DER facilities where transfer trip is required, PacifiCorp will own, operate, and maintain all communication equipment necessary to perform this function as per the language of the interconnection agreement. Communication equipment will be installed and tested as recommended in the interconnection study. The Interconnection Customer will own, upgrade (if necessary), and maintain the same equipment installed on the generation side from the point of interconnect (change of ownership) i.e., relay(s), breaker(s), etc.

See Appendix C for information on ownership of a typical DER project.

7.2 Interconnection Customer Construction of PacifiCorp Facilities

PacifiCorp facilities being built by the customer shall be subject to PacifiCorp inspection at customer's cost. Unless explicitly allowed by jurisdictional rules governing the interconnection agreement, PacifiCorp will determine, at its sole discretion, any of its facilities that it will allow the Interconnection Customer to design or construct.

No more than 30 days prior to the completion of construction (or longer depending on PacifiCorp requirements), the Interconnection Customer shall provide PacifiCorp with a complete set of design drawings reflecting any revisions. In addition, the Interconnection Customer shall be responsible for obtaining SAP equipment numbers and equipment memorandum forms from PacifiCorp, and for completing the equipment memorandums for all major equipment identified by PacifiCorp as requiring setup in SAP for asset management purposes.

No more than 30 days after the project is completed and energized the Interconnection Customer shall provide PacifiCorp with a complete set of as-builts and final updated drawings to the PacifiCorp project manager.

7.3 Specification/Approval of the Interconnection Customer's Facilities and Equipment

PacifiCorp retains the right to electrically disconnect any DER facility that does not acquire and/or retain PacifiCorp reviewed/approved interconnection equipment of the following types: relays, disconnect devices, transformers, or RTUs. The standards for this equipment are contained in this policy document. It shall be the responsibility of the Interconnection Customer to comply with this requirement.

At PacifiCorp's direction, based on rule or tariff, the customer will submit to PacifiCorp documentation signed by a licensed Professional Engineer. The PE signature shall indicate compliance with the applicable interconnection agreement. PacifiCorp will issue written notice to the Interconnection Customer upon learning of a breach in this regard, and give the Interconnection Customer time to correct the issues raised in the notice. Failure to comply with this notice will result in electrical disconnection and potentially breach of contract.

7.4 Operating Log

The Interconnection Customer must maintain an operating log at each generating facility of 1 MW and above indicating changes in operating status (available or unavailable), maintenance outages, trip indications, or other unusual conditions found upon inspection.

7.5 Communications with PacifiCorp Grid and Field Operations

The PacifiCorp project manager will provide the DER facility with the names, email addresses, and telephone numbers of the PacifiCorp control center and operations coordination personnel responsible for the PacifiCorp system at the POI.

The Interconnection Customer will provide PacifiCorp with the names and telephone numbers of the personnel with responsibility for operating the DER facility.

DER facility contacts should include at least one telephone number that can be used 24 hours a day, seven days a week. Contacts should be able to provide information on equipment status, explanation of events on the equipment, and relay target/alarm information when asked to do so by PacifiCorp personnel.

PacifiCorp may choose to waive some of the communications requirements for smaller DER facilities. In addition, the DER facility operations person shall contact PacifiCorp whenever:

- Problems with the DER are detected that could result in misoperation of DER protection or other DER equipment
- The DER has tripped off-line during parallel operation with the PacifiCorp system
- DER equipment problems result in an outage to a portion of the PacifiCorp system
- The operator of the DER facility intends to initiate switching to parallel the DER unit(s) and the PacifiCorp system, or
- The operator of the DER facility intends to initiate switching to break the parallel interconnection between DER unit(s) and the PacifiCorp system

7.6 Parallel Operation Policy

The PacifiCorp representative shall contact the PacifiCorp control center at least 72 hours before the initial commissioning testing and shall obtain a clearance for parallel operation. The PacifiCorp representative shall provide the control center with a drawing indicating which PacifiCorp circuit the DER facility will be connected to and which PacifiCorp-operated disconnect will be identified with a PacifiCorp-designated number.

Upon a successful initial commissioning the DER facility may, at PacifiCorp's discretion, be allowed to operate in parallel with PacifiCorp for testing purposes only. This should not be mistaken as an official release for parallel operation. Once testing-only permission is granted, the DER unit may operate in accordance with the interconnection agreement. Please review the project-specific DER interconnection and operations and maintenance agreement for details.

At the end of this period, if the Interconnection Customer has not received written permission from PacifiCorp to operate in parallel, the entity must isolate from PacifiCorp until written permission is received. A written notification of permission to parallel shall be sent to the Interconnection Customer via U.S. first class mail or via email from PacifiCorp transmission customer service. This shall be done after PacifiCorp has verified the following:

- All proper contracts and documents have been executed and are in place.
- The initial commissioning test has been passed.
- The final commissioning test has been passed.

- All other outstanding issues have been resolved, including rights-of-way, deeds of conveyance, insurance verification, and operating agreements.
- PacifiCorp has received final certified copies of the one-line diagram and elementary diagrams that show as-built changes made during construction, as well as a completed finalized DER data sheet.
- If applicable, firm capacity performance testing of new DER unit(s) cannot begin until the Interconnection Customer receives written permission from PacifiCorp to parallel.

7.7 Coordination with Local Government Agencies

It is the sole responsibility of the Interconnection Customer to coordinate with local government agencies and determine and obtain all applicable permits, inspections, and approvals within the required timelines

8 Maintenance Procedures

The Interconnection Customer shall be solely responsible for ownership and maintenance of DER equipment, on the customer side of the POI. A maintenance procedure shall be required for DER projects that include protection schemes such as a recloser, relay, transfer trip, or anything that includes a battery.

A maintenance procedure shall follow best utility practices and be submitted to PacifiCorp 60 calendar days prior to the issuance of a release of the DER for operation. This plan will be reviewed and approved by the customer's professional engineer and include a statement from the engineer that they certify that the maintenance plan was prepared by, or under their supervision using best utility practices. Per IEEE 1547, the Interconnection Customer or their successor in interest shall ensure routine testing is performed on all interconnection-related protective functions and associated batteries at intervals specified by the manufacturer.

Once the Interconnection Customer's DER is operational, PacifiCorp may, at its discretion, audit the site to ensure the maintenance procedure is being properly followed. If a particular site has been selected for audit, PacifiCorp will notify the Interconnect Customer 14 days before inspection to allow the Interconnect Customer to gather the appropriate documents and to set up a site visit. Failure to provide proof adhering to the maintenance procedure schedule could result in the de-energization of the DER from the Utility until the maintenance procedure has been verified to be up-to-date.

Maintenance records shall be retained for the previous two maintenance cycles on all equipment.

9 Spot and Grid Network System Interconnection Policy

The interconnection of distribution-class voltage generators on networked electrical systems within PacifiCorp's service territory shall comply with the most recent version of IEEE 1547. Interconnection of spot and grid network systems shall follow the requirements specified in IEEE 1547 clause 9.

10 Accounting Policy and Procedure

PacifiCorp will have on file within the transmission customer service unit (or subsequent transferee department(s)) copies of each Interconnection Customer's interconnection agreement for use by PacifiCorp's field personnel and accounts receivable department.

Glossary

A

ANSI: American National Standards Institute.

Alternating Current (AC): That form of electric current that alternates or changes in magnitude and polarity (direction) in what is normally a regular pattern for a given time period called frequency.

All-dielectric self-supporting (ADSS): Type of optical fiber cable that is strong enough to support itself between structures without using conductive metal elements. ADSS cable is designed to be lightweight and small in diameter to reduce the load on tower structures due to cable weight, wind, and ice.

Ampere: The unit of current flow of electricity. This is analogous to quantity per unit of time when referring to the flow of water. One ampere is equal to a flow of one coulomb per second.

Applicable Reliability Criteria: The reliability policies established by NERC, WECC, and local reliability criteria as amended from time to time, including any requirements of the NRC which are applicable to the particular type of generator and prime mover.

Automatic: Self-acting, operated by its own mechanism when actuated by some impersonal influence as, for example, a change in current strength; not manual; without personal intervention.

Automatic Control: An arrangement of electrical controls that provide for opening and/or closing in an automatic sequence and under predetermined conditions; the switches that then maintain the required character of service and provide adequate protection against all usual operating emergencies.

Automatic Generation Control (AGC): Generation equipment that automatically responds to signals from the EMS control in real time to control the power output of electric generators within a prescribed area in response to a change in system frequency, tie-line loading, or the relation of these to each other, so as to maintain the target system frequency and/or the established interchange with other areas within the predetermined limits.

Automatic Reclosing: A feature of some circuit breakers that allows them to reclose automatically after being tripped under abnormal conditions.

Automatic Tripping or Automatic Opening: The opening of a circuit breaker under predetermined conditions without the intervention of an operator.

Automatic Voltage Regulation (AVR): Generation equipment that automatically responds to signals from the EMS control in real time to control voltage.

B

Balanced Load: An equal distribution of load on all phases of an alternating current circuit.

Balancing Authority: The responsible entity that integrates resource plans ahead of time, maintains load-interchange-generation balance within a Balancing Authority Area, and supports Interconnection frequency in real time.

Boost: To increase voltage.

Bundled Service or Bundled Utility Service: Traditional PacifiCorp service: transmission and distribution capacity for delivery, energy, and ancillary services.

Breaker: A switch which can open a circuit, usually designed for automatic operation.

C

Capacitance: Capacitance is developed when two charged or energized conductors are separated by a dielectric. An excess or deficiency of electrons is maintained on opposite plates of a charged capacitor. It may be said to be the property of an electrical circuit that opposes any change of voltage.

Capacity: The number of amperes of electric current a wire will carry without becoming unduly heated; the capacity of a machine, apparatus, or devices is the maximum of which it is capable under existing service conditions; the load for which a generator, turbine, transformer, transmission circuit, apparatus, station, or system is rated. Capacity is also used synonymously with capability.

Capacity Factor: The ratio of average load on a generating resource to its capacity rating during a specified period of time, expressed in percentages.

Circuit: A conducting part through which an electric current is intended to flow.

Circuit Breaker: A device for interrupting a circuit between separable contacts under normal or fault conditions.

Circuit Switcher: A device for interrupting a circuit between separable contacts under normal or fault conditions.

Class A Telephone Circuit: Service performance objective classification for a circuit which is non-interruptible before, during, and after a power fault condition.

Class B Telephone Circuit: Service performance objective classification for a circuit which is non-interruptible before and after a power fault condition exists.

Clearance: Permission to contact or to come in close proximity to wires, conductors, switches, or other equipment that normally might be energized at electrical, hydraulic, or pneumatic potential dangerous to human life. Conditions that must prevail before such permission can be granted are, in general, that the equipment or lines be completely isolated from all possible power sources and be tagged with properly filled out "man on line" tags.

Cogeneration: The sequential production of electricity and heat, steam, or useful work from the same fuel source.

Conductor: Material that can be used as a carrier of an electric current.

Control, Supervisory: A system for selecting control and automatic indication of remotely located units by electrical means, over a relatively small number of common transmission channels.

Control Switch: A switch controlling the circuit through circuit breakers or other switches which are magnetically operated.

Current: The part of a fluid (air, water, etc.) flowing in a certain direction. A flow of electric charge measured in amperes.

Current Transformer (CT): A transformer intended for metering, protective, or control purposes that is designed to have its primary winding connected in series with a circuit carrying the current to be measured or controlled. A current transformer normally steps down current values to safer levels. A CT secondary circuit must never be open-circuited while energized.

D

DER Facility: A plant in which electric energy is produced from some other form of energy by means of suitable converting apparatus. The term includes the generation apparatus and all associated equipment owned, maintained, and operated by the Interconnection Customer.

DER Unit: The physical electrical equipment that produces electric power. Sometimes used as a brief reference to an interconnection customer.

Deadend Structure: The structure on which the last span of PacifiCorp-owned conductors terminates. This is also called a landing structure. From the interconnection requester's point of view, it is sometimes called the take-off structure.

Delta-Connected Circuit: A three-phase circuit with three source windings connected in a closed delta (triangle). A closed delta is a connection in which each winding terminal is connected to the end (terminal) of another winding.

Demand: The rate at which electric energy is delivered to or by a system; normally expressed in kilowatts (kW), megawatts (MW), or kilovolt amperes (kVA).

Direct Access: Service election allows customers to purchase electric power and, at the customer's election, additional related services from non-utility entities known as ESPs.

Direct Current (DC): A unidirectional current in which the changes in value are either zero or so small that they may be neglected. (As ordinarily used, the term designates a practically non-pulsating current, such as the output of an electric battery.)

Disconnect: (noun) A device used to isolate a piece of equipment. A disconnect may be gang-operated (three operated together) or individually operated.

Dispatchability: Ability and availability of a generating facility to operate so that a utility can call upon it to increase or decrease deliveries of capacity to any level up to contract capacity.

Distributed Network Protocol (DNP): Also known as DNP3. A set of communications protocols used to achieve open, standards-based interoperability between substation computers, RTUs, intelligent electronic devices (IEDs) and master stations (except inter-master station communications) for the electric utility industry.

Distribution Control Center: This center directs, coordinates, and implements routine and emergency switching activities on the PacifiCorp distribution system within its geographical jurisdiction.

Disturbance: Trouble (e.g., fault, sudden loss of load or generation, breaker operations, etc.) on the PacifiCorp power system resulting in abnormal performance of the system. See also *System Emergency*.

Droop: The slope of the prime mover's speed power characteristic curve. The speed droop, typically 5%, enables interconnected generators to operate in parallel with stable load division.

E

Electric Circuit: A path or group of interconnected paths capable of carrying electric current.

Electric Generator: See Generator.

Electric Substation: An assemblage of equipment for purposes other than generation or utilization, through which bulk electric energy is passed for the purpose of switching or modifying its characteristics. Service equipment, distribution transformer installations, and transmission equipment are not classified as substations.

End-Use Customer or End User: A purchaser of electric power who purchases such power to satisfy a load directly connected to the electrical power grid and who does not resell the power.

Energize: To apply voltage to a circuit or piece of equipment; to connect a de-energized circuit or piece of equipment to a source of electric energy.

F

Fault Indicator: A device attached to lines which provides visual or remote indication when the current through the line exceeds the device setting.

Feeder: A circuit having the distribution of electric energy as its primary purpose.

FERC: Federal Energy Regulatory Commission.

Firm Capacity: Power committed to be available at all times during the period covered, except for forced outages and scheduled maintenance.

Forced Outage: Any unplanned outage resulting from a design defect, inadequate construction, operator error, or breakdown of the mechanical or electrical equipment that fully or partially curtails the delivery of electricity between a load and the PacifiCorp power system.

Frequency: The number of cycles occurring in a given interval of time (usually one second) in an electric current. Frequency is commonly expressed in Hertz (Hz).

Fuse: A short piece of conducting material of low melting point that is inserted in a circuit and will melt and open the circuit when the current reaches a certain value.

G

Grid-Critical Protective Systems: Protective relay systems and remedial action schemes (RAS) that may have a direct impact on the ability to maintain system security.

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

Ground: A term used to refer to the earth as a conductor or as the zero of potential. For safety purposes, circuits are grounded while any work is being done on or near a circuit or piece of equipment in the circuit; this is usually called protective grounding.

Ground Bank: A secondary transformer bank installed on delta-connected winding to provide a path to ground for relaying purposes.

Ground Fault: An unintentional electric current flow between one or more energized conductors and the ground.

Ground Potential Rise: A calculated value of the highest expected voltage due to a line-to-ground fault at or near the station (power switchyard). The value is calculated as follows:

$$GPR = 1.2 \text{ (DC Transient Factor)} \times 1.4 \times \text{Ground Fault Return Current (rms)} \times \text{Ground Resistance}$$

H

Hertz (Hz): The term denoting cycles per second or frequency; named after Heinrich Hertz, the pioneering German scientist who performed research on electrical power.

I

IEC: International Engineering Consortium.

IEEE: Institute of Electrical and Electronic Engineers.

Inductance: The property of an electric circuit that produces a voltage by electromagnetic induction when the current in the circuit changes or varies. It opposes any change of circuit current.

Induction Generator: Typically, an induction motor that is being driven by a prime mover at a speed faster than the synchronous mechanical speed to generate electric power. It typically depends on the host system for its excitation and speed regulation.

Interconnection Agreement (IA): An agreement between the utility and the interconnection customer specifying and outlining the terms and conditions of the interconnection of the DERs to PacifiCorp's electrical system.

Interconnection Customer: An entity interconnected to the PacifiCorp power system that has DER facilities (including back-up generation in parallel) on its side of the point of interconnection with the PacifiCorp power system.

Interconnection Facilities: All means required and apparatus installed to interconnect and deliver power from a load or Interconnection Customer facility to the PacifiCorp power system including, but not limited to, connection, transformation, switching, metering, communications, and safety equipment, such as equipment required to protect: 1) the PacifiCorp power system and the load or Interconnection Customer from faults occurring at the load or generation, and 2) the load or DER facility from faults occurring on the PacifiCorp power system or on the systems of others to which the PacifiCorp power system is directly or indirectly connected. Interconnected facilities also include any necessary additions and reinforcements by PacifiCorp to its system required as a result of the interconnection of a facility to the PacifiCorp power system.

Interconnection Study Agreement (ISA): An agreement between the Interconnection Customer and PacifiCorp specifying what is to be done in the engineering interconnection study to interconnect the DER to PacifiCorp's system. This agreement specifies not only the items to be studied but the timeframe in which the study will be completed, and the report results submitted to the Interconnection Customer.

Interconnection Study: Those studies performed in conjunction with an interconnection request to determine the facilities needed to interconnect the load or Interconnection Customer in accordance with applicable reliability requirements.

Interrupting Capacity: The amount of current a switch or circuit breaker can safely interrupt.

Interruption: A temporary discontinuance of the supply of electrical power.

K

Kilovolt (kV): 1,000 volts.

Kilovolt Ampere (kVA): The product of kilovolts times amperes; used to refer to high voltage alternating current systems.

Kilovolt Ampere Reactive (kVAR): A measure of reactive power required to regulate system voltage.

Kilowatt (kW): An electrical unit of power that equals 1,000 watts.

Kilowatt-hour (kWh): 1,000 watts of energy supplied for one hour. A basic unit of electric energy equal to the use of one kilowatt for a period of one hour.

L

Lagging Power Factor: Occurs when reactive power flows in the same direction as real power. Stated with respect to the DER, lagging power factor occurs when the DER is producing VARs.

Leading Power Factor: Occurs when reactive power flows in the opposite direction to real power. Stated with respect to the DER, leading power factor occurs when the DER is absorbing VARs.

Line Losses: Electrical energy converted to heat in the resistance of all transmission and/or distribution lines and other electrical equipment (i.e., transformers) on the system.

Load-Only Entity or Customer Load: An entity interconnected to the PacifiCorp power system at a transmission or distribution voltage level that does not have generation of its own in parallel with the PacifiCorp power system and is not interconnected with any source of generation other than PacifiCorp's.

Log: A computer file, book, or loose-leaf sheets for recording all station operations, clearances, readings, ratio reports, and other pertinent active daily data.

M

Maximum Torque Angle (MTA): The phase angle between the relay measured quantities at which the relay is the most sensitive.

Metering Services: Services consisting of removal, ensuring of meter design specifications, installation, calibration, and ongoing testing and maintenance of meters.

Meter Service Agreement (MSA): The agreement issued by PacifiCorp concerning meter services.

Megawatt (MW): One million watts.

Megger: An ohm meter device used to measure the ability of insulation to withstand voltage, as well as measuring the insulation resistance. A poor megger test would mean that the insulation is breaking down.

MES: Meter engineering standard.

N

Nameplate Rating, Facility: Output rating information appearing on a DER nameplate or other electrical device, in accordance with applicable industry policies.

NEMA: National Electrical Manufacturers Association.

NERC: North American Electric Reliability Council.

Net Energy Output: The DER facility's gross output in kilowatt hours, less station use, to the point of delivery into the PacifiCorp power system.

Net Sale: The DER facility's gross output, in kW and kWh, less station use, to the point of delivery into the PacifiCorp power system.

Network System: An electrical distribution system designed with special transformers and protection devices such that more than one radial three-phase circuit can be connected to serve load.

Network Protector: A special electrical device connected to a network transformer which trips load on reverse flowing current.

Network Transformer: A special transformer designed to accommodate the connection of more than one three-phase circuit to allow for enhanced reliability.

Network Relay: A special relay connected to a network transformer designed to trip the unit of line for excess fault currents.

Neutral: The common point of a star-connected transformer bank, a point which normally is at zero potential with reference to the earth.

No-Sale: The Interconnection Customer desires to operate in parallel and not sell power to PacifiCorp.

O

Ohm: The unit of resistance of an electric circuit.

One-Line Diagram: A diagram in which several conductors are represented by a single line and various devices or pieces of equipment are denoted by simplified symbols. The purpose of such a diagram is to present an electrical circuit in a simple way so that its function and configuration can be readily grasped.

Operating Procedures: Policies and procedures governing the operation of the transmission grid as PacifiCorp, the WSCC, or the NERC may from time to time develop as applicable to the particular type of generator and prime mover.

Operational Control: The rights of PacifiCorp to operate their transmission lines, facilities, and other electric plant equipment affecting the reliability of those lines and facilities for the purpose of affording comparable non-discriminatory transmission access and meeting applicable reliability criteria and policies.

Optical Ground Wire (OPGW): An optical ground wire (also known as an OPGW or, in the IEEE standard, an optical fiber composite overhead ground wire) is a type of cable that is used in the construction of electric power transmission and distribution lines. Such cable combines the functions of grounding and communications.

Outage: A condition existing when a line or a substation is de-energized.

Output: The energy delivered by a DER facility during its operation.

Overload: A load in amperes greater than an electric device or circuit is designed to carry.

Overvoltage: Voltage higher than that desired or higher than that for which the equipment in question is designed.

P

PacifiCorp Control Center: The PacifiCorp location, manned 24 hours a day that has been assigned operational jurisdiction over a load or Interconnection Customer's substation.

Parallel (verb): To connect electrically a DER or energized source, operating at an acceptable frequency and voltage, with an adjacent DER or energized system, after matching frequency, voltage, and phase angle.

Parallel Operation: As used in this manual, the operation of a non-utility owned DER while connected to the utility's grid. Parallel operation may be required solely for the interconnection customer's operating convenience or for the purpose of delivering power to the utility's grid.

Peaking: The operation of generating facilities to meet maximum instantaneous electrical demands.

Permissive Overreach Transfer Trip Scheme (POTTS): A very secure line protection scheme for insuring that a fault is within the protected line section. It requires the presence of both a trip signal from a remote terminal and a trip signal from the local relay before tripping the local breaker.

PacifiCorp Power System: The electric transmission and distribution wires, and their related facilities owned by PacifiCorp.

Point of Interconnection (POI): The point where the load or interconnection customer's conductors or those of their respective agents meet the PacifiCorp power system (point-of-ownership change).

Point of Delivery: A location that the Transmission Service Provider specifies on its transmission system where an Interchange Transaction leaves, or a Load-Serving Entity receives its energy.

Potential Transformer (PT): A transformer intended to reproduce in its secondary circuit, in a known proportion, the voltage of the primary circuit; also known as a voltage transformer.

Power: The time rate of transferring or transforming energy.

Power Factor (PF): The ratio of real (MW) power to apparent power (MVA). Power factor is the cosine of the phase angle difference between the current and voltage of a given phase.

Power Purchase Agreement (PPA): An agreement/contract between the utility and interconnection customer whereby the amount for the purchase of power has been determined and is contractually binding on both parties.

Primary: Normally considered as the high-voltage winding of a substation or distribution transformer; any voltage used for transmission of electric power in reasonably good-sized blocks and for some distance, as contrasted with low voltage for the immediate supply of power and light locally, such as the distribution within a building. The lowest voltage considered as a primary voltage is 2.4 kV although this is also used for some heavy-power requirements over short distances.

Primary System: A system of alternating current distribution for supplying the primaries of transformers from the generating station or distribution substation.

Prime Mover: The mechanical means of turning the generator's rotor to convert fuel into useful work.

Protection: All of the relays and other equipment used to open the necessary circuit breakers to clear lines or equipment when trouble develops.

Protective Relay: A device whose function is to detect defective lines or apparatus, or other power system conditions of an abnormal or dangerous nature, and to initiate appropriate control circuit action.

Protocol: A specification that describes the rules and procedures products should follow to perform activities on a network, such as transmitting data.

Pst: Perception of light flicker in the short term. Short term is defined as a 10-minute interval.

Pumping: A condition present on a network protector whereby the device turns on and off very quickly due to deviant circuit conditions. These conditions can be introduced with the interconnection of generation on the circuit. Pumping is to be avoided on the protector so that it can properly perform its protective function.

R

Reactance: In an alternating current circuit, the opposition to the flow of current attributable to the inductance and capacitance of the circuit.

Reactive Component of Current: That part of a current that does no useful work because its phase is 90 degrees leading or lagging the voltage.

Reactive Load: In alternating current work, a load whose current is not in phase with the voltage across the load.

Reactor: A coil with no secondary winding provided. The primary use is to introduce inductance into the circuit for purposes such as starting motors, paralleling transformers, and controlling current. A current limiting reactor is a reactor for limiting the current that can flow in a circuit under short circuit conditions.

Reclose: To again close a circuit breaker after it has opened by relay action.

Recloser: A protective device designed to: 1) sense overcurrents, 2) time and interrupt the overcurrent according to a preset characteristic, and 3) reclose to test and possibly reenergize the line after a specified time interval.

Reference Point of Applicability (RPA): The location, either the point of common coupling or the point of DER connection, where the interconnection and interoperability performance requirements specified in IEEE 1547 apply.

Remedial Action Scheme (RAS): Protective systems that typically utilize a combination of conventional protective relays, computer based processors, and telecommunications to accomplish rapid, automated response to unplanned power system events; also refers to details of RAS logic and any special requirements for arming of RAS schemes or changes in RAS programming that may be required.

Remote Station Alarms: Alarms received at an attended location from unattended stations or plants.

Remote Terminal Unit (RTU): Remotely located equipment used for collecting data and/or for supervisory control via communication channel.

Residual Current: The current that flows in the neutral or wye-connected current transformers when the current in the three phases of a line are unbalanced.

Resistance: Anything placed or already located in an electric circuit that opposes the flow of electric current.

Resistor: A device whose primary purpose is to introduce resistance into an electric circuit. An adjustable resistor is one so constructed that its amount of resistance can be readily changed.

Retail Service: Electric sales to PacifiCorp's end-use or retail customers. Such service is regulated by the jurisdictional state regulatory agencies.

S

Schematic: A diagram showing the essential features of a piece of equipment or a control system.

Secondary: The winding of a transformer which is normally operated at a lower voltage than the primary winding.

Secondary Distribution System: A low-voltage alternating current system that connects the secondaries of distribution transformers to the consumer's services.

Self-Excited: A term to describe an electric machine in which the field current is secured from its own armature current. In the case of induction generators, it refers to the condition in which the induction generator is separated from its normal excitation source and is unintentionally excited by the power factor correction capacitors in the vicinity.

Separately Excited: Use of an exciter for sending current through the field windings of an electric machine in place of taking the field current from its own armature current.

Service Reliability: The time an entity or group of entities is served compared to the amount of time the entity or entities are without service over a given time period.

Service Restoration: The switching procedure a system operator directs or executes to restore services to entities following an outage.

Setting: The values of current, voltage, or time at which a relay is adjusted.

Short Circuit Current Ratio (SCCR): For a given fault near the DER facility, the total fault current has contributions from different sources. The magnitude of the contribution from the DER of interest divided by the magnitude of the total fault current is called Short Circuit Current Ratio [IEEE 1547.7]

Single-Phase Circuit: A circuit in which all current can be represented by only one regular sine-wave pattern. Differs from a three-phase circuit, where when all circuit current is plotted, it produces three regular sine-wave patterns 120 electrical degrees apart.

Special Facilities: Those additions and reinforcements to the PacifiCorp power system which are needed to accommodate the receipt and/or delivery of energy and capacity from and/or to the entity's facility(ies), and those parts of the interconnection facilities which are owned and maintained by PacifiCorp at the entity's request, including metering and data processing equipment.

Standby Capacity: The lesser of: 1) net generation capacity, 2) connected loads to DER, or 3) 80% of main switch rating.

Star-Connected Circuit (Wye-Connected Circuit): A term applied to the manner in which a motor's windings or a transformer's windings are connected, (i.e., star-connected armature having one end of each of the coils connected to a common junction). A star-connected transformer is one in which the primaries and secondaries are connected in a star grouping.

Station Use: Energy used to operate the generating facility's auxiliary equipment. Auxiliary equipment includes but is not limited to: forced and induced draft fans, cooling towers, boiler feed pumps, lubricating oil systems, power plant lighting, fuel handling systems, control systems, and sump pumps.

Step-Down Transformer: A transformer in which the secondary winding has fewer turns than the primary, so that the secondary delivers a lower voltage than is supplied to the primary.

Step-Up Transformer: A transformer in which the secondary winding has more turns than the primary, so that the secondary delivers a higher voltage than is applied to the primary.

Supervisory Control: A system by which equipment is operated by remote control at a distance using some type of code transmitted by wire or electronic means.

Surplus Sale: The DER's gross output, in kW and kWh, less any plant load and transformation and transmission losses, delivered to the PacifiCorp system.

Switch: A device for making, breaking, or changing the connections in an electric circuit.

Switch, Air: A switch in which the arc interruption of the circuit occurs in the air.

Switch, Alarm: A form of auxiliary switch which closes the circuit to a bell or other audible signaling device upon automatic opening of the circuit breaker or other apparatus with which it is associated.

Switch, Auxiliary: A switch actuated by some main device such as a circuit breaker for signaling, interlocking, or other purpose.

Synchronism: The condition across an open circuit wherein the voltage sine wave on one side matches the voltage sine wave on the other side in frequency and without phase angle difference.

System: The entire generating, transmitting, and distributing facilities of an electric utility.

System Emergency: Conditions beyond the normal control that affect the ability of the control area to function normally, including any abnormal system condition which requires immediate manual or automatic action to prevent loss of load, equipment damage, or tripping of system elements which might result in cascading outages or to restore system operation to meet the minimum operating reliability criteria.

System Protection Facilities: The equipment required by the utility to protect: 1) the PacifiCorp power system from faults occurring at a load or interconnection customer' facility, and 2) the load or interconnection customer's generating facility from faults occurring on the PacifiCorp power system or on the system of others to which it is directly or indirectly connected.

T

Telephone Working Limit: A voltage potential of 300 V or less, so personnel can work on the telephone cable without rubber gloves.

Telemetry: Measurement, with the aid of a communication channel that permits power metering measurements to be interpreted at a distance from the primary detector.

Transfer Trip (TT): A form of remote trip in which a communication channel is used to transmit the trip signal from the relay location to a remote location.

Transformer: An electric device without continuously moving parts in which electromagnetic induction transforms electric energy from one or more other circuits at the same frequency, usually with changes in value of voltage and current.

Transformer Efficiency: Ratio of the electric power of the current going into a transformer to the power of the secondary circuit from the transformer.

Transformer Loss: The difference between the input power to a transformer and the output power of the transformer.

Transformer Ratio: The ratio of the voltage secured from a transformer to the voltage supplied to that transformer.

Transmission Line: A line used for electric power transmission. A transmission line is distinguished from a distribution line by voltage. Lines rated 46 kV and higher are transmission lines.

Transmission Control Center: This center implements switching operations on the PacifiCorp transmission system within a specific geographical area.

U

UL: Underwriters Laboratories.

Undervoltage Protection: Upon failure or reduction of voltage, the protection device interrupts power to the main circuit and maintains the interruption.

Undervoltage Release: Upon failure or reduction of voltage, the protective device interrupts power to the main circuit but does not prevent again completing the main circuit upon return to voltage.

Unity Power Factor: A power factor of 1.000 which exists in a circuit wherein the voltage and current are in phase. There are no VARs in this condition, only watts.

Unintended Island: An unplanned islanding condition in which a portion of an Area EPS is energized solely by one or more Local EPSs through the associated POIs while that portion of the Area EPS is electrically separated from the rest of the Area EPS.

V

VAR: A unit of measurement of reactive power. It is an expression of the difference between current and voltage sine waves in a given circuit; short for volt amps reactive.

$$VA^2 = (Watts)^2 + (VARs)^2$$

Volt: The unit of electrical pressure similar to the pounds per square inch pressure on a steam gauge.

Volt Ampere: A unit of apparent power in an alternating current circuit. A Volt Ampere is equal to the product of volts and amperes without reference to the phase difference, if any. At unity power factor, a volt ampere equals a watt. Whenever there is any phase difference between voltage and current, the true power in watts is less than the apparent power in volt amperes.

Voltage Drop: The difference in voltage level between one point and another in a circuit (see line voltage drop).

Voltage Loss: The drop of potential in an electric circuit due to the resistance and reactance of the conductor. This loss exists in every circuit.

Voltage Ratio of Transformer: The ratio of the effective primary voltage to the effective secondary voltage of a transformer.

Voltage Transformer: See potential transformer.

W

Watt: A unit of electric power.

Watts AC = volts x amperes x power factor (single phase circuits)

Watt Hour: A measure of electric power. The power of one watt used for one hour.

Watt Hour Meter: An electrical measuring instrument that indicates power in watt hours.

WECC: Western Systems Coordinating Council or its successor.

Wholesale Customer: A person wishing to purchase energy and ancillary services at a bulk supply point or a scheduling point for resale.

Wholesale Sales: The sale of energy and ancillary services at a bulk supply point or a scheduling point for resale.

Wholesale Service: Electric sales to wholesale customers for resale. Such service is regulated by FERC.

"Wye"-Connected Circuit: A three-phase circuit which is star-connected, meaning the windings of all three phases have one common connection that may be connected to ground.

WREGIS – Western Renewable Energy Generation Information System.

Appendix A List of Important Contacts

For Reference Documents and Information

Entity	Example Documents	Who to Contact
California Public Utilities Commission (CPUC)	Retail Tariffs Electric Rules	Energy Division California Public Utilities Commission 505 Van Ness Avenue San Francisco, CA 94102 (415) 703-2782 http://www.cpuc.ca.gov/energy/
Idaho Public Utilities Commission (IPUC)	Retail Tariffs Electric Rules	Idaho Public Utilities Commission P.O. Box 83720 Boise, ID 83720-0074 (208) 334-0300 http://www.puc.idaho.gov/
Oregon Public Utility Commission (OPUC)	Retail Tariffs Electric Rules	Oregon Public Utility Commission 201 High St SE, Suite 100 E Salem, Oregon 97310-1380 (503) 378-6600 https://www.puc.state.or.us/
Utah Public Service Commission (UPSC)	Retail Tariffs Electric Rules	Utah Public Service Commission Heber M. Wells Building, 4 th Floor 160 East 300 South Salt Lake City, UT 84111 (801) 530-6716 https://www.psc.utah.gov/
Washington Utilities and Transportation Commission (WUTC)	Retail Tariffs Electric Rules	Washington Utilities and Transportation Commission P.O. Box 47520, Mail Stop: FY-11/7250 Olympia, WA 98504-7250 (360) 664-1160 https://www.utc.wa.gov/
Wyoming Public Service Commission (WPSC)	Retail Tariffs Electric Rules	Wyoming Public Service Commission 2515 Warren Avenue Hansen Bldg., Suite 300 Cheyenne, WY 82002 (307) 777-7427 http://psc.state.wy.us/
Federal Energy Regulatory Commission (FERC)	Code of Federal Regulation Orders	Federal Energy Regulatory Commission Public Reference & Files Maintenance Branch 888 First Street, NE, Room 2-A Washington, DC 20426 (866) 208-3372 https://www.ferc.gov/
North American Electric Reliability Council (NERC)	National Reliability Standards	North American Electric Reliability Council North Tower, Atlanta, GA 30326 (404) 446-2560 https://www.nerc.com/
PacifiCorp (PPW)	Tariffs Standards Interconnection Handbook	PacifiCorp, Inc. 825 NE Multnomah Portland, Oregon 97232 (503) 813-5731 https://www.pacificorp.com
Western Electricity Coordinating Council (WECC)	Western Reliability Standards	Western Electricity Coordinating Council 155 North 400 West, Suite 200 Salt Lake City, UT 84103 (801) 883-6879 https://www.wecc.biz

Note: This list is modified periodically. Consult your local PacifiCorp representative for the most current version.

Appendix B Wind-Collector Feeders

In addition to the requirements of the main document, this appendix contains additional requirements specific to PacifiCorp-owned wind-collector feeders (34.5 kV).

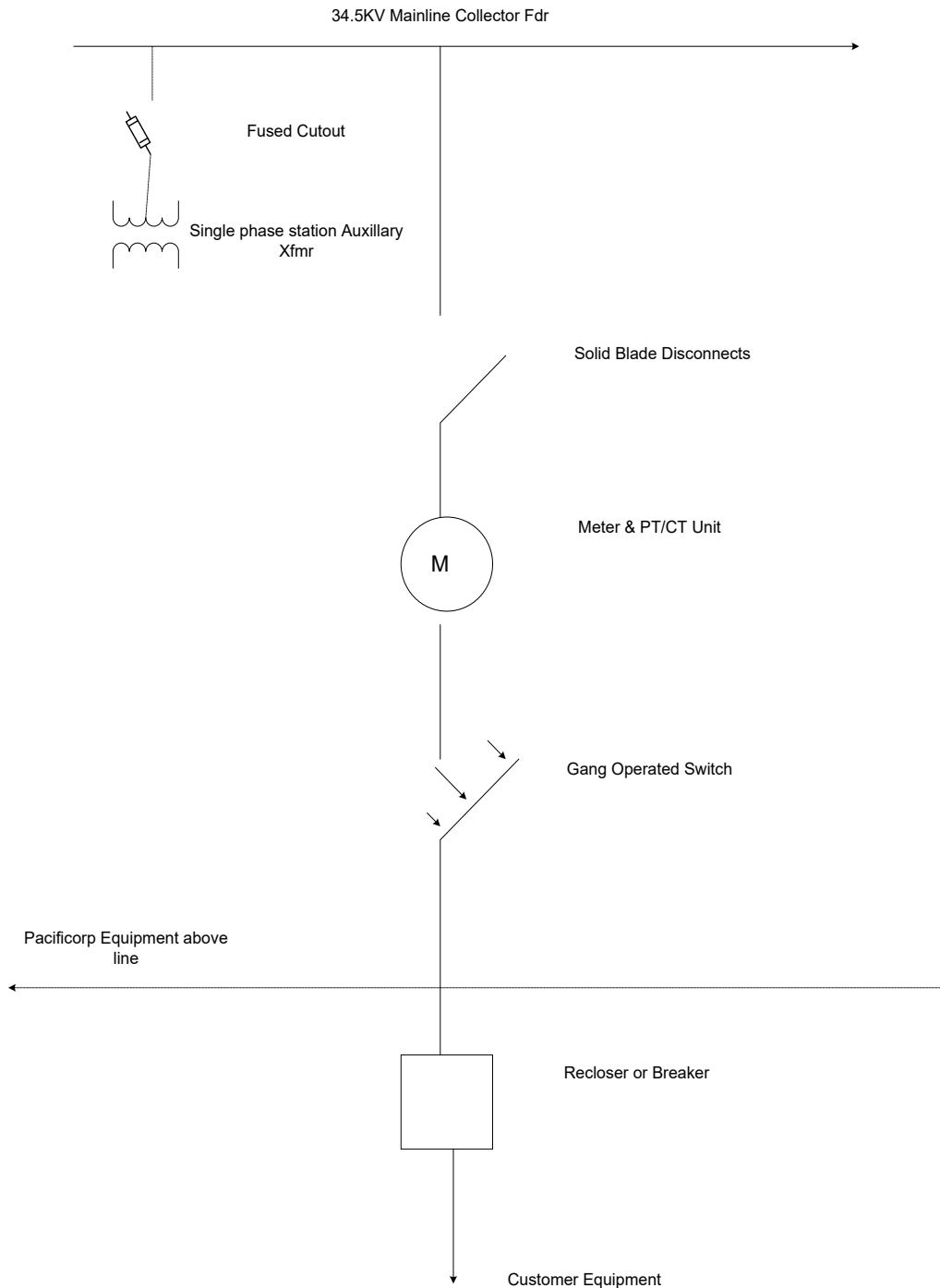


Figure B1—Generator Interconnection One-Line for Dedicated 34.5 kV Wind-Collector Feeders with Recloser or Breaker Protection

B.1 Fault Clearing Requirements

All interconnections located less than six conductor miles from the originating PacifiCorp substation shall be protected with either a fuse, or a fault interrupting device with instantaneous tripping enabled. Faults located in this region must be cleared quickly to minimize the impact to PacifiCorp's system. For the available fault-current levels at the six-mile point on the feeder, the customer's fuse or fault interrupting device must clear the fault in a maximum clearing time of five cycles. If the customer's fuse cannot meet this requirement, the customer must install a recloser with protective relays to meet the five-cycle maximum clearing time requirement.

Interconnections located past the six-mile point on the feeder will be allowed to have fuses or reclosers that clear faults within 15 cycles at the available fault current level at the tail end of the customer's collector system.

PacifiCorp reserves the right to modify the future configuration of these collector feeders. Future reconfigurations that result in an interconnection being located within six conductor miles of the originating substation will require the customer to meet the fault-clearing requirements listed above.

Customers that have a recloser as their fault-clearing device must, upon request from PacifiCorp, provide fault records in a timely manner. If these fault records are required to troubleshoot an operating problem, these records will be needed within 48 hours of being requested.

B.2 Automatic Reclosing

PacifiCorp's substation feeder breaker will be set to issue one automatic reclose approximately 15 to 30 seconds after it opens. The customer's equipment must be designed to handle this automatic reclose without incurring damage to the wind generators.

Appendix C Protection and Control Policy

This section describes the main protection and control requirements for the electrical system associated with interconnection installations. In general, protective relaying principles for electrical power systems are:

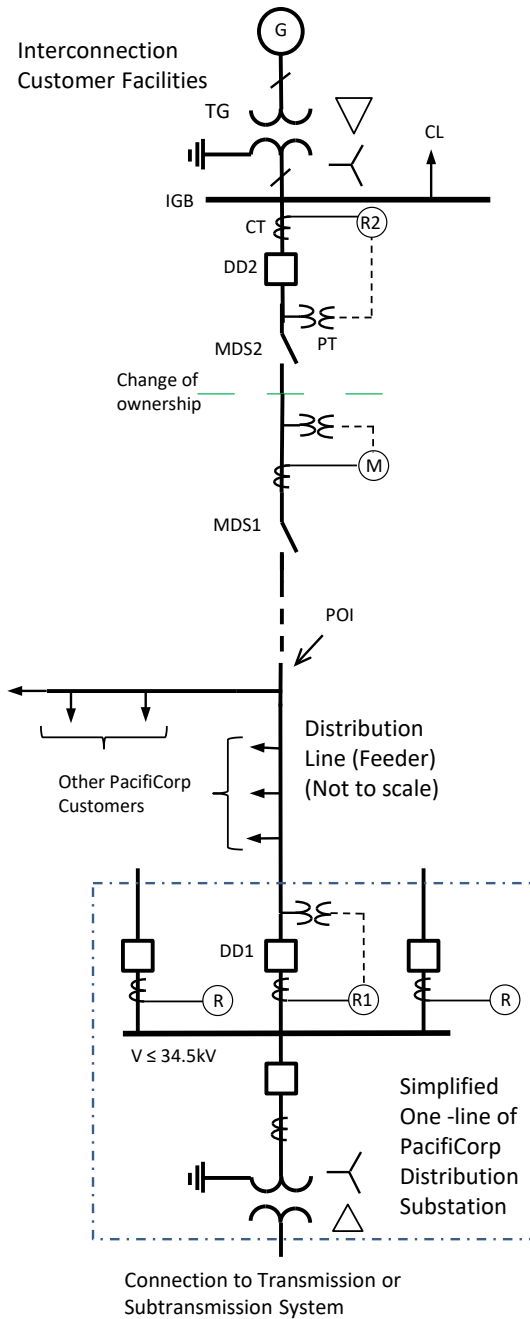
- The electrical system must be primarily designed to avoid hazards to customers, PacifiCorp personnel, and the general public
- Damage to PacifiCorp and its customers' assets must be minimized in case of faults in the interconnected installations
- The quality and reliability of service to customers in terms of voltage magnitude, voltage distortion, frequency, and service continuity must be kept within accepted industry tolerances

The application of these principles follows these minimum design criteria:

- Use relays and interrupting devices to meet fault clearing and restoration times
- Use overvoltage and undervoltage relay elements to disconnect equipment
- Use overfrequency and underfrequency relay elements to disconnect equipment
- Ensure that the neutral grounding is in agreement with PacifiCorp policies regarding insulation, personnel safety, other electrical customers' voltage quality and ground-fault protection

The principles and design criteria listed in the previous paragraphs use the recommendations in the latest revision of IEEE 1547, as well as PacifiCorp standards, as a basis.

The one-line diagram shown below is an example. The policies here described, which must be used in the design, construction, inspection, and testing of protective devices and associated controls to ensure it is consistent with all PacifiCorp standards and good utility practice.



Legend

- G: Interconnection customer generation unit (s)
- TG: Generation facility transformer (s)
- CL: Interconnection customer load
- M: Meter
- R, R1, R2: Multifunction microprocessor-based protective relays
- DD1, DD2: Recloser or circuit breaker
- MDS1 and MDS2: Manual load-break disconnect switches
- IGB: Interconnection customer bus
- POI: point of interconnection
- CT: Current transformer
- PT: Potential (or voltage) transformer

Notes

- This is an example; specific cases require specific studies and requirements.
- DD1 and similar may require replacement if its interrupting capacity is exceeded due to the new generation.
- R1 may be required to be directional in some applications.
- R2 is required to be directional and may contain not only line protection elements but also voltage and frequency elements to disconnect the generation when those quantities fall out of range (Tables I and II).
- R1 almost always has very fast reclosing over DD1.
- The reclosing over DD1 can only take place when the line is de-energized (the facility power plant must be disconnected).
- Depending on the real power ratio between the other PacifiCorp loads and the customer generation, high-speed direct transfer trip from R1 to R2 may be needed.
- TG must always be in solidly-grounded-wye connection on the PacifiCorp side and with at least another winding in delta connection. If this connection is not possible, an additional grounding transformer shall be installed at the interconnection customer bus to keep the neutral solidly grounded.
- Depending on the size of the added generation, more changes may be needed in the P&C systems of the substation.

Figure C1—One-Line Diagram, Example

C.1 Basic Requirements for Protection and Control Equipment

Existing PacifiCorp-owned protection and control equipment may need to be replaced or modified to accommodate the DER facility.

C.1.1 Protective Relays

The following are the most relevant aspects of DER systems as they relate to relays:

- All relays used in new installations must be multifunction microprocessor-based devices. The manufacturers must be in the PacifiCorp list of accepted relay manufacturers (see C.5).
- The relay associated with the Interconnection Customer's circuit breaker or recloser may contain all the functions for line and transformer overcurrent protection and, in addition, the overvoltage, undervoltage, overfrequency, and underfrequency relay elements mentioned in the next section. Where transfer trip is required, the relay must have the capability of direct communications.
- Existing PacifiCorp-owned fault interrupting devices and protective relays may need to be replaced or modified to accommodate the DER facility.

C.2 Relay and Control Settings

Any modifications of control and/or relay settings without review and acknowledgement of acceptance by PacifiCorp will be considered a breach of interconnect agreement and could lead to permanent disconnection from the PacifiCorp system.

Should the customer require modification to the settings associated with control/protective devices connected to the distribution and/or transmission system they will contact PacifiCorp and provide in writing the justification and/or need for the proposed modifications. This will allow PacifiCorp time to analyze and ensure there are no negative impacts to the associated connected systems and customers.

The Interconnection Customer must allow PacifiCorp to hold all Level 2 relay passwords for any control and/or protective device within their control at the POI and/or customer facility which directly impacts PacifiCorp's distribution and/or transmission systems. Level 2 passwords are those which allow actual modifications to control and/or relay settings. This will ensure PacifiCorp is aware of and approves any changes being made by the customer. Furthermore, this will ensure there are no negative impacts to PacifiCorp's distribution system, transmission system, or existing customer base.

C.3 Basic Relay Requirements

The Interconnection Customer must declare an operating intention as outlined below. The protection requirements for the facility will be determined starting with the less complex protection scheme and ending with the most complex protection scheme that would permit maximum flexibility in the operation of the DER facility.

Case 1: Emergency-only operation

Emergency-only operation occurs when:

- The on-site generation will operate isolated from PacifiCorp's network, carrying only the customer's load

OR

- During transitions, the generation is paralleled with the network less than or equal to 0.1 seconds.

For these configurations, no additional protective relays are required.

Case 2: Parallel operation, but without power fed into the PacifiCorp network

In this case, the DER facility will operate in parallel with PacifiCorp's network longer than 0.1 seconds, but will not feed power into the PacifiCorp network. This parallel operation can be continuous:

- The customer's protective relaying will include a three-phase, reverse power function. The device with this function will monitor the current and voltage on the Interconnection Customer's side of the transformer.
- The function will be set to operate if real power in excess of the power losses of the transformer flows back toward PacifiCorp's network for greater than 0.1 seconds. If this occurs, either the DER facility breakers or the main tie breakers will be tripped, as determined by the customer.

Case 3: Parallel operation with restriction only by the physical and contractual limitations of the PacifiCorp network

In this case, the DER will operate in parallel with the PacifiCorp network greater than 0.1 seconds, and the power fed into the PacifiCorp network is limited by the physical and/or contractual limitations.

The protective relaying requirements will depend on the following issues.

- The rated AC power output of the electrical equipment at the DER facility.
- The minimum Interconnection Customer load with which the DER facility could be isolated, upon the operation of fault-interrupting equipment.
- The configuration and voltage level of the network at the POI.
- The line protection and communication system in use on the network prior to the installation of the DER facility.
- At a minimum, voltage magnitude and frequency protection, monitored at the POI, is required as per Table C1 and Table C2.
- PacifiCorp shall approve the tripping scheme and the commissioning test results shall be provided upon request.

Table C1—Frequency Settings

Frequency Pick-Up (hertz)	Time Delay to Trip (seconds)	Condition/Type of Element
61.6	Instantaneous	Overfrequency
60.5	0.5	Overfrequency
59.5 < f < 60.5	No trip required	Band of tolerance
59.5	0.5	Underfrequency
58.4	Instantaneous	Underfrequency

Table C2—Voltage Relay Element Settings

Voltage Pick-Up (per unit)	Time Delay to Trip (seconds)	Condition/Type of Element
1.500	0.1	Overvoltage
1.10	2.0	Overvoltage
1.051	120	Overvoltage
0.95 < V < 1.05	No trip required	Band of tolerance
0.949	120	Undervoltage
0.900	2.0	Undervoltage
0.671	0.1	Undervoltage

C.4 Other Protection and Control Changes Required in the Substation and the Transmission System

The interconnection study may identify required modifications to PacifiCorp's protection and control systems in the substation and the transmission system.

The protection and control system modifications are in addition to any distribution system upgrades identified in the interconnection study.

The following is a partial list of protection system modifications that may be required.

- For DER facilities greater than 1 MW aggregate nameplate rating, fault interrupting devices shall be capable of three-phase operation. All existing single-phase, fault-interrupting devices located in series between the DER facility and PacifiCorp's substation shall be replaced with three-phase interrupting devices.
- Additional protective devices may be needed at the substation level (low and high voltage) to detect and clear faults in the transmission system that can be fed from the DER facilities.
- Installation of transfer trip from the high-side circuit breaker/circuit switcher, as well as the distribution breaker and any line reclosers, to the DER facility may be required if deemed necessary by circuit conditions.

C.5 Relays Approved by PacifiCorp

PacifiCorp is familiar with all major utility-grade relay manufacturers. Below is a listing of major vendors; it is intended to be a sample and not an exhaustive listing.

- ABB
- Areva
- Beckwith
- Basler
- Eaton
- GE
- Schweitzer
- Siemens

PacifiCorp will accept any utility-grade relay or combination of relays from this list provided that all required relay elements are fulfilled.

PacifiCorp approval does not indicate the quality or reliability of a product or service, and endorsements or warranties shall not be implied.

Appendix D Tests

D.1 Manufacturing and Production Commissioning Tests

1. **Insulation Resistance Tests:** Transformers winding-winding and winding-ground; Circuit breakers pole-pole and pole-ground as applicable to the equipment; buses and cables- phase-phase and phase-ground; dielectric test on insulating medium (gas or oil).
2. **Power Transformers:** Turns ratio testing.
3. **Circuit Breakers and Circuit Switchers:** Successful trip at 70% rated DC control voltage; contact resistance testing, trip and close timing tests.
4. **Current Transformers and Current Circuits:** CT saturation test, check CT polarity, verify excitation test data against manufacturer curves, prove CT ratios, current injection testing to achieve a five amp secondary current, single-phase burden check on each phase, megger check with ground lifted to verify single ground point.
5. **Potential Transformers:** Check PT polarity, check turns ratios, verify single ground point.
6. **Relay Check-Outs:** Minimum pickup, time delay tests at at least three test points to verify time delay characteristic curve, phase angle characteristic of directional relay, impedance pickup points at maximum torque angle and $\pm 30^\circ$, slip frequency voltage matching phase-angle acceptance and breaker compensation time for synchronizing relays, communications signal level checks on pilot relays.
7. **Primary Disconnect Switch:** Description and labeling.
8. **Functional Tests Post-Energization Pre-Parallel:**
 - a. Check the operation of protective relays on their circuit breakers. Jumpering across contacts at the rear of the relay is not acceptable.
 - b. Check for proper secondary voltage on all voltage and frequency relays.

- c. Check the synchronizing meter, synchronizing equipment, and phasing panel (if used) with the paralleling breaker closed and the generator offline. This typically requires lifting the generator leads. The equipment should show an 'in-phase' condition.
- d. Check the generator phase rotation (PacifiCorp's phase rotation is typically A B C counterclockwise). All three phases must be checked using hot sticks with a phasing tool or phasing panel provided by the Interconnection Customer. The synchronizing equipment typically checks one phase only. Interconnection customer to consult with PacifiCorp for area-specific phase rotation information.

D.2 Example of Non-Exporting Test Procedure

Depending upon the interconnection agreement, a non-export requirement may be applicable to the project. Should this non-export requirement be applicable to the project, the engineer shall specify the test procedure, and submit it for review and approval by PacifiCorp. For illustration purposes only, the following is a series of tests that together constitute a generic non-export test plan.

Power Flow Test

1. Determined the appropriate secondary pickup current for the trip-point export flow.
2. Apply nominal system voltage and apply current in the zero phase angle tripping direction until the relay trips.
3. Compare the design and field trip-points, which should be within 2%.
4. For relays with adjustable settings, repeat test at midpoint and maximum settings.
5. Repeat steps 1-4 at phase angles of 90°, 180°, and 270° angles. Verify that the relay does not operate.

Leading Power Factor Test

1. Apply rated voltage with a minimum pickup current setting for a leading power factor load current in the non-tripping direction (say 135°).
2. Increase current to relay rated current and verify that the relay does not operate.
3. For relays with adjustable settings, repeat the test for minimum, mid-point, and maximum settings.

Minimum Power Factor Test

4. At nominal voltage and with the field trip point determined in the Power Flow Test, adjust the current phase angle to 84° or 276°.
5. Increase the current level to pick up and verify the relay operates.
6. Repeat for current phase angles of 90°, 180°, and 270° and verify that the relay does not operate.

Negative Sequence Voltage Test

7. At nominal voltage and with the field trip point determined in the Power Flow Test, adjust the current phase angle 180° out of phase on all phases ($I_a = 180^\circ$, $I_b = 300^\circ$, $I_c = 60^\circ$).
8. Remove V_a voltage and observe that the relay does not operate.
9. Repeat for V_b and V_c .

Load Current Test

10. Using the pickup settings from the Power Flow Test, apply the rated voltage and current at 180° from the tripping direction, to simulate normal load conditions ($I_a = 180^\circ$, $I_b = 300^\circ$, $I_c = 60^\circ$). Observe that the relay does not operate.

Unbalanced Fault Test

11. Using the pickup settings from the Power Flow Test, apply rated voltage and twice rated current to simulate an unbalanced fault in the non-trip direction (use $V_a = 0^\circ$, $V_b = V_c = 180^\circ$, $I_b = 0^\circ$, and $I_c = 180^\circ$). Observe that the relay does not mis-operate.

Time Delay Settings Test

12. Using the pickup settings from the Power Flow Test, apply settings and set time delay to the minimum setting. Adjust the current source to the appropriate level to determine operating time, and compare against calculated values.
13. Verify the timer stops when the relay trips.
14. Repeat at midpoint and maximum delay settings.

Dielectric Test

15. Perform the dielectric test described in IEC 414 using 2 kV RMS for one minute.

Surge Withstand Test

16. Perform the surge withstand test described in IEEE C37.90.1. or IEEE/ANSI C62.45.

Appendix E Network System

E.1 Spot and Network System Interconnection Policy

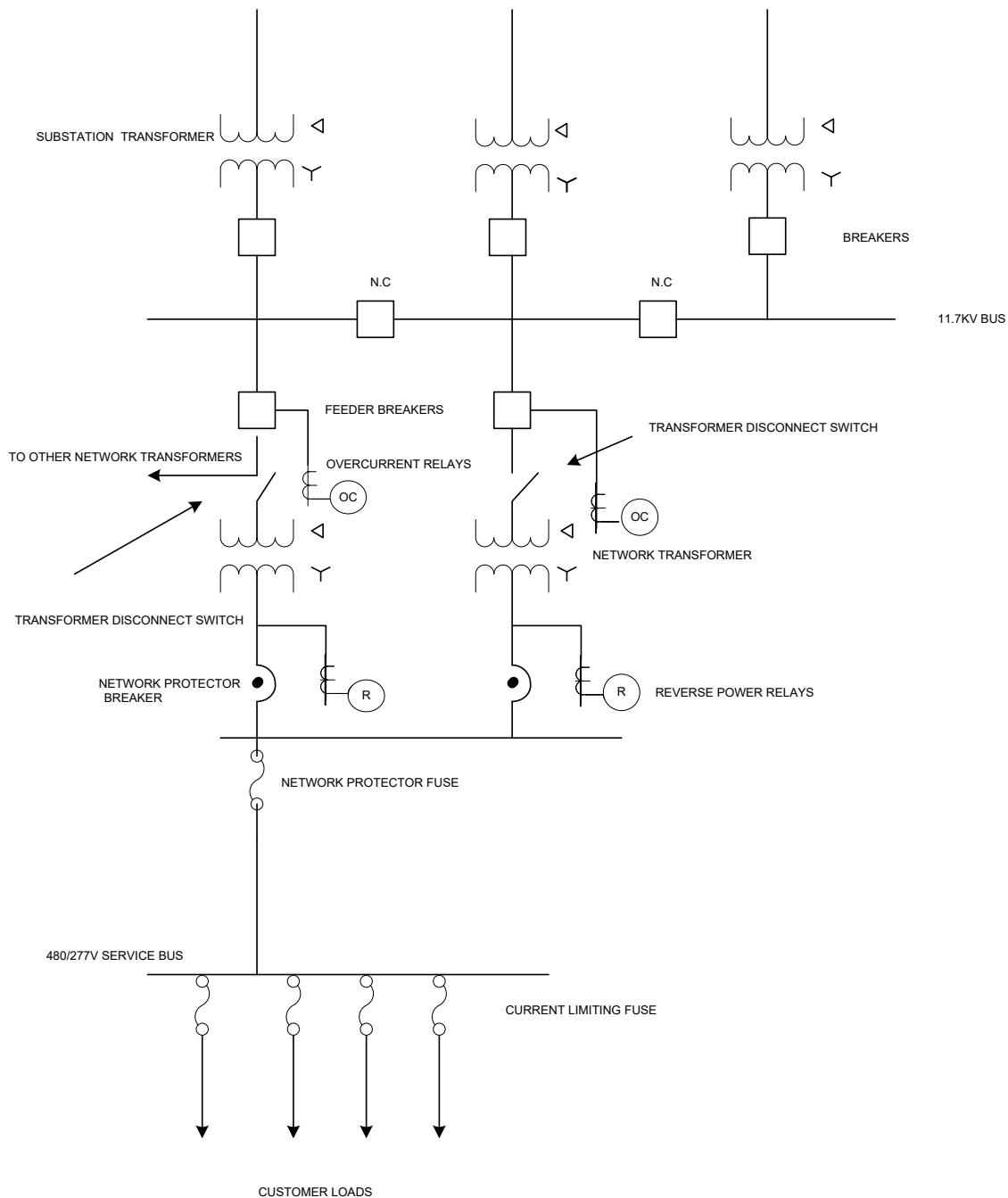


Figure E1—Typical Spot Network Electrical System Configuration

The figure above depicts the configuration of a typical spot network electrical system. It consists of five major components: network transformers, network protectors, network reverse power relays, high voltage transformer disconnect switch, and network protector fuse. PacifiCorp's network distribution system is 11.7 kV and it is only located in Portland, Oregon.

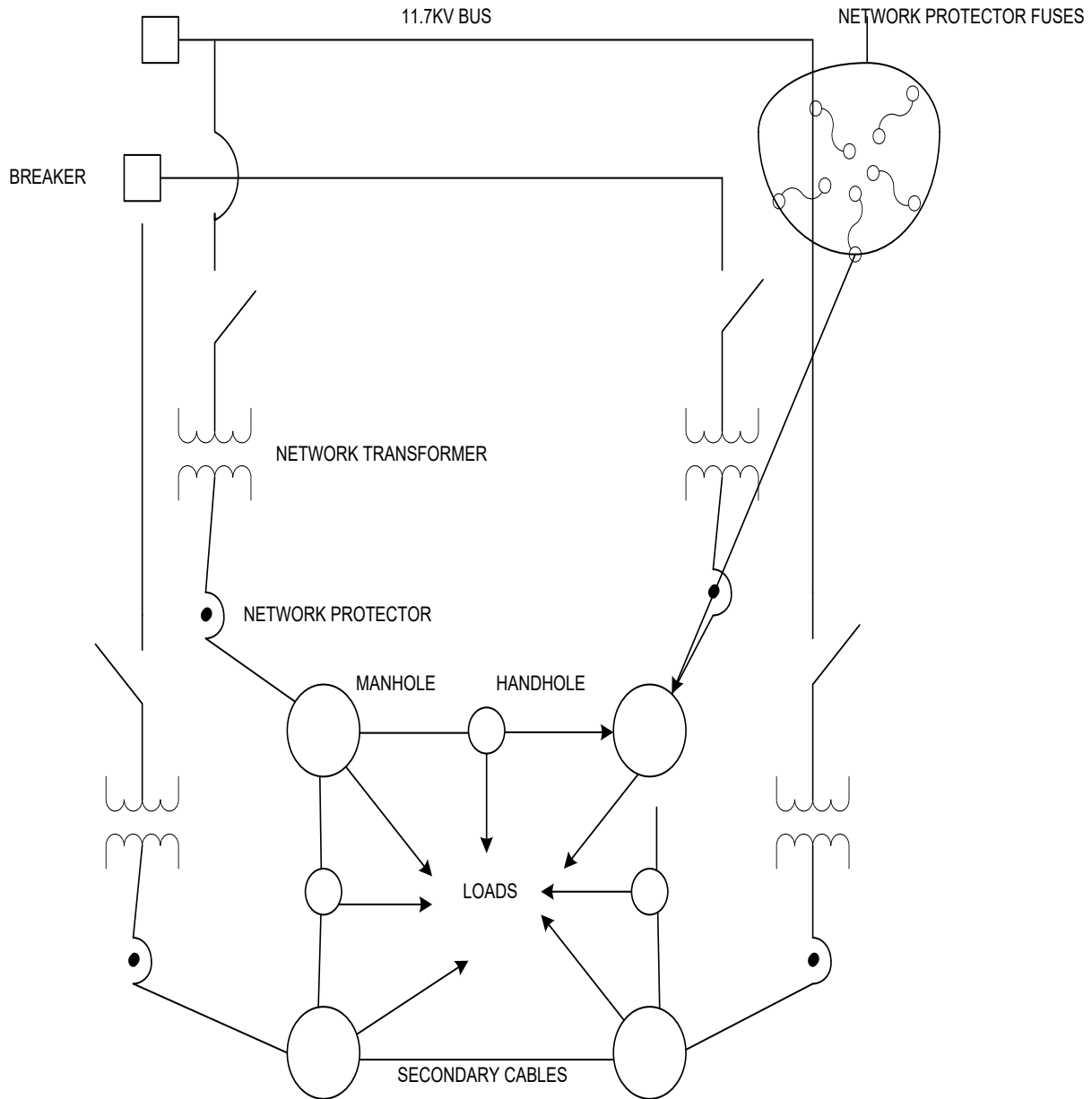


Figure E2—Typical Protective and Control Devices on a Grid Network System

The figure above depicts the typical protective and control devices on a grid network system. The primary components of a grid network are as follows: network transformers, network protector reverse power relays, network protector fuses, network protectors, transformer disconnect switch, and street main secondary cable.

E.2 Network Distribution Systems

Network distribution systems are the most complex distribution systems in existence. When they were designed early in the 20th century, they were intended to improve the reliability of electrical service to densely-populated urban areas. They were designed with the goal of connecting several feeders to transformers such that when one feeder goes out of service, the remaining feeders still serve the load. **Network Distribution Systems from their inception were not designed for interconnection with generators** and consequently, this presents a challenge for any Interconnection Customer who wants to introduce generation into this type of electrical system.

To date, equipment manufacturers of the components of the network electrical system (shown in Figure E1 and Figure E2) are developing and testing modifications to the equipment such that generation can be introduced into this type of circuit. The existing network system electrical components are very expensive compared to the conventional radial distribution system components which comprise the predominant portion of electrical circuits. The cost of the revised network system units will be even more expensive (likely the most expensive of any kind of electrical system components available on the market) than the conventional radial units. This means **the cost of the generation interconnection for the customer will likely be substantially more than that of a radial electrical system.**

The following are the main components of the network system:

Network Protectors: A specially designed low-voltage air circuit breaker that is controlled by its internal reverse-power network relays. With the introduction of generation, reverse current becomes more likely and thus any interconnected generation must not cause reverse current to flow through the network protector, resulting in the operation of the protector.

Network Relay: This is a relay that contains a master and a phasing relay that work in conjunction to trip the protector upon a reverse power-flow condition and to close the protector when the power flow will be into the network. No provision or arrangement has been incorporated into the design to accommodate generation.

Network Transformers: This basic building block of electrical circuits was designed in this scenario to provide for significantly enhanced circuit reliability with several three-phase circuits tied to the unit rather than the conventional technique of a single, radial, three-phase circuit. With the introduction of generation into the distribution circuits, the design of the transformer may need review and subsequent revision and alteration.

Transformer High Voltage Disconnect Switch: A three-position (open-close-ground) oil switch that connects the primary feeder to the network transformer. This is a non-load-break switch used in part to isolate the transformer from the primary distribution system.

Network Protector Fuses: The sole purpose of these fuses is to serve as a last line of protection during a fault condition. The fuses are designed to operate if the network protector fails to open during a fault. Fuses are sized at the nameplate rating of the network protector.

With the introduction of generation in the network system, the following issues may arise:

1. “Pumping” or “chattering” of network protectors. This is when the protector opens and closes repeatedly, exhibiting traits of a pump.
2. Increase of X-to-R ratios (on newer transformers) to 12 to 14 from a traditional value of five will necessitate at a minimum the review of relay settings and in the worst case scenario a changeout of the relay (on older models). It will be unable to be set within an acceptable value to trip on watts since those values are not present on the device to address this condition.
3. Increasing the transformer size could alter the impedance and cause the network relay to search for values which are not present on the device. This renders it ineffective as a protective unit.
4. Phase-to-ground faults on delta–wye transformers will be harder to detect by the relays because of the impedance change. This in and of itself may necessitate a changeout of the relay. Using a different configuration transformer (wye–wye network transformer) could solve this issue, however PacifiCorp prefers not to implement this option since it is not a standard transformer connection for DER installations and would require replacing all of PacifiCorp’s network transformers to wye–wye transformers. It would also reintroduce zero sequence fault currents which create difficulties for the relay protection schemes.
5. Older model network protectors do not have the fault closing capability of the newer models. In some cases, this feature will be needed, thus necessitating a changeout of the protector.
6. Low-level faults from adjacent feeders, if not cleared by the protector, could develop to become multi-phase faults. If the protector is not capable of detecting these faults because of the introduction of a DER which alters the impedance of the circuit, it will necessitate a changeout to a newer unit.
7. Network protector relays are not designed for frequency detection, thus synchronizing will not be possible until new technology is developed and the device is upgraded.
8. The introduction of DER affects the detection of arc faults thus necessitating a review of the settings for this condition. **While workers are in the vaults, sensitive ground fault protection settings must be activated.** It is possible that a changeout of the relay will be required if the settings are not available on the unit to detect and trip under arc fault scenarios.

These and other issues are addressed in detail in IEEE 1547.6.

Appendix F Additional Information on Metering

F.1 Metering Electricity Supplied by the DER

The following classifications describe the detailed requirements for metering electricity supplied by the DER units connected to the PacifiCorp EPS:

- **Surplus-Sale Operation Co-Generation:** The internal generation is used to offset customer internal loads, the excess generation produced is sold to PacifiCorp at the POI. Additional metering is typically required at the DER for Balancing Authority, operational, and potential future contract changes.
- **Net-Sale Operation:** The customer sells all generation produced minus its parasitic generator load to PacifiCorp. Typically metering will be located at the high side of the generator step-up transformer or the POI to PacifiCorp. When WREGIS certifications are required, metering is typically located to separate the parasitic generator loads from other internal customer loads.
- **No-Sale Operation:** When generation does not exceed internal load, the customer is required in the interconnection agreement to install reverse relays to block generation to PacifiCorp. PacifiCorp shall also supply load to customer with meters programmed bi-directionally, as used both for billing and as a check to ensure compliance for no-flow to PacifiCorp.
- **Wheeling Service:** Metering the generation and transmission at point of delivery as PacifiCorp is not purchasing generation and is only providing transmission service. Wheeling may be required when the customer is outside the retail service territory of PacifiCorp and backfeed is provided via the PacifiCorp transmission system.