OTTER TAIL POWER COMPANY TECHNICAL STANDARDS MANUAL FOR MINNESOTA DISTRIBUTED ENERGY RESOURCES

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1 Introduction

This manual provides the technical requirements and specifications unique to Otter Tail Power Company (Otter Tail) for the interconnection and interoperability of Distributed Energy Resources (DER) connected to the Otter Tail distribution system in Minnesota. This document works in conjunction with the Minnesota DER Technical Interconnection, Interoperability Requirements (TIIR) and the TIIR Interim Implementation Guideline Addendum. This manual does not address generation systems that are interconnected to the Transmission Power System.

Although this manual is intended to work in conjunction with the TIIR, its primary intent is to outline Otter Tail's specific technical requirements. Please read the companion documents MN DIP and TIIR for the description of the state required procedures, forms, and statewide technical requirements needed for interconnection to Otter Tail's distribution system.

This Technical Specifications Manual (TSM) document is based upon the IEEE 1547 standards and other applicable national standards. The intent of this document is to provide Interconnection Customers (IC) and installers a clear set of technical requirements for the common interconnection of DER with the Area EPS. If the TSM does not provide guidance for a specific type or style of interconnection or if there are questions about the requirements, it is recommended that you contact Otter Tail.

Additionally, familiarity with the Otter Tail tariffs is a crucial part of a DER interconnection request. However, rates and costs associated with the tariffs are not covered in this manual. It is important to recognize that the earlier an IC involves Otter Tail in the planning and design process of their project, the more efficient and timelier it is for all parties.

The IC shall be responsible for complying with all applicable local, independent, state and federal codes such as building codes, National Electric Code (NEC), National Electrical Safety Code (NESC), reliability requirements, OSHA, security, testing, etc. As required by Minnesota State law, the IC is required to provide the Area EPS proof of compliance with the National Electrical Code before interconnection is made, through approval by an electrical inspector recognized by the Minnesota State Board of Electricity. It is the responsibility of the IC to obtain all permits and approvals of the governing bodies.

The IEEE 1547-2018 standard has been approved and is available for use as the national standard for interconnection and interoperability of DER with electric power systems. However, not all the equipment used to provide the interconnection has been certified to meet the requirements of the new 2018 version of the IEEE 1547 standard. This is especially true for grid-tie inverters. This document has been written such that the requirements for interconnection assume that the equipment being used complies with the IEEE 1547-2014 requirements. This document also provides guidance to support the use of equipment that meets the requirements of the new IEEE 1547-2018 standard.

As stated in the TIIR "At such time certified equipment first becomes available, the Area EPS Operator and the DER owner may mutually agree to utilize the certified equipment and functionalities in conformance with the requirements of IEEE 1547-2018." If the equipment used can meet some or all the new 2018 requirements, Otter Tail requests that the equipment be configured and programmed to meet the requirements of the 2018 version of the IEEE 1547 standard. However, until IEEE 1547-2018 equipment is "readily available" some portions of the TIIR will not go into statewide effect. Therefore, Otter Tail will be following the TIIR Interim Implementation Guidance Addendum until such time as the certified inverter equipment is readily available.

Otter Tail's approval of the proposed interconnection and design only ensures that Otter Tail has reviewed the interconnection and does not relieve the IC from any design or operation items. Otter Tail will not assume any liability or responsibility for any IC owned equipment.

If you have any questions about interconnecting a DER to Otter Tail's distribution system, please email the Otter Tail Power Company Interconnection Coordinator at InterconnectionCoordinator@otpco.com.

2 Common Terms – Acronyms and Definitions

Authority Governing Interconnection Requirements (AGIR)^: A cognizant and responsible entity that defines, codifies, communicates, administers, and enforces the policies and procedures for allowing interconnection of DER to the Area EPS. This may be a regulatory agency, public utility commission, municipality, cooperative board of directors, etc. The degree of AGIR involvement will vary in scope of application and level of enforcement across jurisdictional boundaries. This authority may be delegated by the cognizant and responsible entity to the Area EPS operator or TPS operator.

Area Electric Power System (Area EPS)*: The electric power distribution system connected at the Point of Common Coupling.

Area Electric Power System Operator (Area EPS Operator)*: An entity that owns, controls, or operates the electric power distribution systems that are used for the provision of electric service in Minnesota.

Capacity Limiting DER: A DER Unit that operates in parallel and is used to reduce the potential demand of the Local EPS.

Closed Transition^^: This type of transfer has the load always being supplied by the Area EPS or the Distributed Generation. To accomplish this, the DER is synchronized with the Area EPS prior to the transfer occurring. The transition operates parallels with the Area EPS for a short time (100 msec. or less) and then the DER and load is disconnected from the Area EPS.

Distributed Energy Resource (DER)^: A source of electric power that is not directly connected to a TPS. DER includes both generators and energy storage technologies capable of exporting active power to an EPS. An interconnection system or a supplemental DER device that is necessary for compliance with this standard is part of a DER. For the purposes of this manual, the DER includes the IC's Interconnection Facilities but shall not include the Area EPS Operator's Interconnection Facilities.

Distributed Energy Resources Operator (DER Operator)^: The entity responsible for operating and maintaining the DER.

Distributed Energy Resource Unit (DER Unit)^: An individual DER device inside a group of DER that collectively forms a system.

Energize^: Active power outflow of the DER to an EPS under any conditions (e.g., steady state and transient).

Enter Service^: Begin operation of the DER with an energized Area EPS.

Electric Power System (EPS)^: Facilities that deliver electric power to a load. This may include generation units.

Energy Storage System (ESS):** An electric system that stores active power for later injection into the Local EPS or Area EPS.

Inadvertent Export: A DER that operates in parallel and does not export more than ten percent of the Nameplate for more than 30 seconds for any single event.

Interconnection Agreement*: The terms and conditions between the Area EPS Operator and Interconnection Customer (Parties). See MN DIP Section 1.1.5 for when the Uniform Statewide Contract or MN DIA applies.

Interconnection Customer (IC)*: The person or entity, including the Area EPS Operator, whom will be the owner of the DER that proposes to interconnect a DER(s) with the Area EPS Operator's Distribution System. The Interconnection Customer is responsible for ensuring the DER(s) is designed, operated and maintained in compliance with the Minnesota Technical Requirements.

Interconnection Facilities*: The Area EPS Operator's Interconnection Facilities and the Interconnection Customer's Interconnection Facilities. Collectively, Interconnection Facilities include all facilities and equipment between the DER and the Point of Common Coupling, including any modification, additions or upgrades that are necessary to physically and electrically interconnect the DER to the Area EPS Operator's System. Some examples of Customer Interconnection Facilities include supplemental DER devices, inverters, and associated wiring and cables up to the Point of DER Connection. Some examples of Area EPS Operator Interconnection Facilities include sole use facilities, such as, line extensions, controls, relays, switches, breakers, transformers and shall not include Distribution Upgrades or Network Upgrades.

Interconnection^: The result of the process of adding DER to an Area EPS, whether directly or via intermediate Local EPS facilities.

Interoperability^: The capability of two or more networks, systems, devices, applications, or components to externally exchange and readily use information securely and effectively.

Island^: A condition in which a portion of an Area EPS is energized solely by one or more Local EPSs through the associated PCCs while that portion of the Area EPS is electrically separated from the rest of the Area EPS on all phases to which the DER is connected. When an island exists, the DER energizing the island may be said to be "islanding".

Local Electric Power System (Local EPS)^: An EPS contained entirely within a single premise or group of premises.

Minnesota DER Interconnection Agreement (MN DIA)*: The Minnesota Distributed Energy Resource Interconnection Agreement. See MN DIP Section 1.1.5 for when the Uniform Statewide Contract or MN DIA applies.

Minnesota DER Interconnection Process (MN DIP)*: The Minnesota Distributed Energy Resource Interconnection Process which is statewide interconnection standards for regulated utilities.

Non-Exporting DER: A DER that operates in parallel with the Area EPS to limit the amount of energy produced so that energy does not flow back onto the Area EPS. A Non-Exporting DER could be designed to operate as an Inadvertent Export system.

Open Transition^^: The load and DER are first disconnected from the Area EPS and then connected to the DER.

Point of Common Coupling (PCC)*: The point where the Interconnection Facilities connect with the Area EPS Operator's distribution system. Equivalent, in most cases, to "service point" as specified by the Area EPS Operator and described in the National Electrical Code and the National Electrical Safety Code.

Point of Connection (PoC)*: When identified as the Reference Point of Applicability, the point where an individual DER is electrically connected in a Local EPS and meets the requirements of the TIIR standard exclusive of any load present in the respective part of the Local EPS (e.g. terminals of the inverter when no supplemental DER device is required.) For DER unit(s) that are not self-sufficient to meet the requirements without (a) supplemental DER device(s), the Point of Connection is the point where the requirements of the TIIR standard are met by DER in conjunction with (a) supplemental DER device(s) exclusive of any load present in the respective part of the Local EPS.

Reference Point of Applicability (RPA)*: The location, either the PCC or the PoC, where the interconnection and interoperability performance requirements specified in IEEE 1547 apply. With mutual agreement, the Area EPS Operator and Interconnection Customer may determine a point between the PCC and PoC.

Regional Transmission Operator (RTO):** The functional entity that maintains the real-time operating reliability of the bulk electric power within a reliability coordinator area or the entity that has been granted functional control of the TPS.

Soft Loading Extended Parallel^^: The DER is paralleled with the Area EPS in continuous operation.

Soft Loading Limited Parallel^^: The DER is paralleled with the Area EPS for a limited amount of time (generally less than 1-2 minutes) to gradually transfer the load from the Area EPS to the Generation System.

Supplemental DER Device^: Any equipment that is used to obtain compliance with some or all of the interconnection requirements of this manual or the TIIR.

NOTE—Examples include capacitor banks, STATCOMs, harmonic filters that are not part of a DER unit, protection devices, plant controllers, etc.

System Impact Study*: A study that identifies impacts that would result if the proposed DER were interconnected without project modifications or electrical system modifications. This study shall evaluate the impacts of the proposed interconnection on the reliability of the electrical system.

Transmission Power System (TPS): Any transmission facility that has been designated as such according to the Minnesota Boundary Guidelines.

Technical Interconnection and Interoperability Requirements (TIIR):** The supplemental set of DER interconnection and interoperability requirements document.

Table 1: Origin of Defined Terms

Document of origin for definition	Symbol
IEEE 1547 - 2018	^
Minnesota Distributed Generation Interconnection Requirements - 2004	^^
Minnesota Interconnection Process and Agreement (MN DIP/MN DIA) - 2018	*
Minnesota Statewide Interconnection Technical Standards (TIIR)	**
Otter Tail specific definition	None

3 Performance Categories and Assignment

Otter Tail has no additional requirements for performance categories other than those provided in the TIIR. Performance Category Assignment will not be enforced until such time as equipment that is certified to meet the IEEE 1547-2018 standard are readily available. The appropriate regulatory agency will set the cutover date once equipment is available.

Performance criteria outside of those defined in the TIIR will require mutual agreement between Otter Tail and the IC. Should abnormal operating conditions arise as a result of Interconnection Facilities, then mitigation may be required at the expense of the responsible IC.

4 Reactive Power Capability and Voltage/Power Control Performance

The DER shall be capable of maintaining the required power factor to help mitigate the impact the DER may have on the Area EPS and TPS. This section provides the default and expected capabilities of a DER on the Area EPS.

4.1 Constant Power Factor Control

The voltage and reactive power control for a DER will greatly depend on the size and location of the DER within the Area EPS. Otter Tail's expectation for DER is to maintain a steady power factor at the RPA or as agreed upon in the MN DIA. Otter Tail's default settings for power factor control are as follows:

Table 2: Default Power Factor Settings

DER System (kVA AC)	Power Factor	Reactive Power Control
< 40 kVA	0.98	Absorbing reactive power
40 kVA to < 250 kVA	0.98	Absorbing reactive power
250 kVA to < 5 MVA	0.98*	Absorbing reactive power
5 MVA to 10 MVA	0.98*	Absorbing/providing active power

*The DER shall be capable of being adjusted within the range of 0.95 to 1.0 PF

During normal operation of the DER the power factor shall never be below 0.90 at the RPA.

4.2 Voltage and Active Power Control

Otter Tail's standard for voltage and active power control shall be disabled unless mutually agreed upon by Otter Tail and the IC.

4.3 Voltage and Reactive Power Control

Otter Tail's standard is for volt-var power control shall be disabled unless mutually agreed upon by Otter Tail and the IC.

5 Response to Abnormal Conditions

At this time, all DER shall disconnect when the Area EPS experiences abnormal frequency or voltages to avoid unintentional islanding. All DER shall trip for any abnormal voltage or abnormal frequency with clearing times as shown in the TIIR.

5.1 Voltage Ride-Through and Tripping

Reference the IEEE 1547 standard and the TIIR to determine default clearing time settings.

5.2 Frequency Ride-Through and Tripping

Reference the IEEE 1547 standard and the TIIR to determine default clearing time settings.

5.3 Transfer-Trip Systems

Transfer-trip functions may affect the ride-through capabilities of a DER. See Section 6 (Protection Requirements) for more details.

5.4 Dynamic Voltage Support

Otter Tail does not currently allow dynamic voltage support by the DER system.

6 Protection Requirements

6.1 Location of Disconnect, Fusing and other Protection

All DER are required to have protection furnished by the IC up to the PCC. Double-lugged meters shall have overcurrent interrupting protection for both sets of conductors connected to the revenue meter.

6.1.1 DER Utility AC Disconnect

A DER Utility AC Disconnect shall be furnished by the DER operator and installed on all DER to safely isolate from the Area EPS. The DER Utility AC Disconnect shall provide a visible air gap, be lockable, and be accessible to Otter Tail personnel with 24/7 unescorted access. The DER Utility AC Disconnect shall be located within 10 feet of the PCC.

Should Otter Tail agree to locate the DER Utility AC Disconnect outside the 10 foot boundary, a permanently affixed weatherproof placard meeting NEC standards shall be located within 10 feet of the revenue meter indicating the DER Utility AC Disconnect location. The placard shall include a mapped representation of the property with the location of the DER Utility AC Disconnect clearly denoted.

6.2 Protection Coordination

Overcurrent protection requirements shall meet the NEC requirements for all DER. The first protective device on the IC side of the PCC shall coordinate with Otter Tail's protective device(s).

6.3 Protection Requirements

6.3.1 General Relay Information

6.3.1.1 The majority of Otter Tail's distribution facilities utilize automatic reclosing and therefore this should be assumed by the IC when designing their DER.

6.3.1.2 For DER utilizing a UL 1741 SA certified inverter, a Professional Electrical Engineer is not required to review, test and approve the protective functions or settings of the inverter, unless required by the MN DIP.

6.3.1.3 For all other DER requesting interconnection to the Area EPS, the protective functions and relay settings shall be reviewed, tested and approved by a Professional Electrical Engineer, registered in the State of Minnesota.

6.3.1.4 A copy of the proposed protective relay settings shall be supplied to Otter Tail for review to ensure proper coordination between the DER and the Area EPS.

6.3.2 Relaying

6.3.2.1 All equipment providing relaying functions shall meet or exceed ANSI/IEEE Standards for protective relays, i.e., C37.90, C37.90.1, and C37.90.2.

6.3.2.2 Required relays that are not "draw-out" cased relays shall have test plugs or test switches installed to permit field testing and maintenance of the relay without unwiring or disassembling the equipment.

6.3.2.3 All protective relays must have DC power supplies powered by station class batteries and charging systems. The battery system shall be equipped with a DC-undervoltage detection alarm or be monitored by a 24/7/365 monitoring facility. For DER larger than

250kW the DC voltage level must be provided to Otter Tail monitoring system.

6.3.2.4 Three-phase interconnections shall utilize three-phase power relays, which monitor all three phases of voltage and current.

6.3.2.5 All relays shall be equipped with setting limit ranges at least as wide as specified in IEEE 1547, and meet other requirements as specified in the Area EPS System Impact Study. Setting limit ranges are not to be confused with the actual relay settings required for the proper operation of the installation. At a minimum, all protective systems shall meet the requirements established in IEEE 1547.

6.3.2.6 Over-current relay (IEEE Device 50/51 or 50/51V) shall operate to trip the protecting breaker at a level to ensure protection of the equipment and at a speed to allow proper coordination with other protective devices. For example, the over-current relay monitoring the interconnection breaker shall operate fast enough for a fault on the customer's equipment, so that no protective devices will operate on the Area EPS. 51V is a voltage restrained or controlled over-current relay and may be required to provide proper coordination with the Area EPS.

6.3.3 Types of Relaying

6.3.3.1 Over-voltage relay (IEEE Device 59) shall operate to trip the DER per the requirements of IEEE 1547.

6.3.3.2 Under-voltage relay (IEEE Device 27) shall operate to trip the DER per the requirements of IEEE 1547.

6.3.3.3 Over-frequency relay (IEEE Device 81O) shall operate to trip the DER off-line per the requirements of IEEE 1547.

6.3.3.4 Under-frequency relay (IEEE Device 81U) shall operate to trip the DER off-line per the requirements of IEEE 1547. For DER with an aggregate nameplate greater than 30kW, the DER shall trip off-line when the frequency drops below 57.0-59.8 Hz. Typically, this is set at 59.5 Hz, with a trip time of 0.16 seconds, but coordination with the Area EPS is required for this setting.

6.3.3.5 The Area EPS will provide the reference frequency of 60 Hz. The DER control system must match this reference frequency. The DER protective relaying shall maintain the frequency of the output.

6.3.3.6 Reverse power relays (IEEE Device 32) (power flowing from the DER to the Area EPS) shall operate to trip the DER off-line for

power flow back onto the system with a maximum time delay of 2.0 seconds.

6.3.3.7 Lockout relay (IEEE Device 86) requires a manual reset of the lockout before the device can be reclosed. Lockout relays shall automatically block the closing of breakers or transfer switches on to a de-energized Area EPS.

6.3.3.8 Transfer Trip – All DER shall disconnect from the Area EPS when the Local EPS is disconnected from its source to avoid unintentional islanding. DER that remain in parallel with the Area EPS may require a transfer trip system to sense the loss of the Area EPS source. The size and type of the DER and the capacity or minimum loading on the feeder will determine the need for transfer trip installation. The Area EPS System Impact Study will identify the specific requirements.

6.3.3.9 If the Area EPS is capable of sectionalizing, then more than one transfer trip system may be required. The System Impact Study will identify the need for a transfer trip system.

6.3.3.10 Parallel limit timing relay (IEEE Device 62PL) shall be set at a maximum of 120 seconds for Soft Loading Limited Parallel installations and no longer then 500ms for Closed Transition installations. Power for the 62 PL relay must be independent of the transfer switch control power.

6.3.4 Open Phase Protection

6.3.4.1 For DER that elect not to use the original DER manufacturer's protective functions for open-phase detection, special consideration will need to be given to the methodology used to detect and trip for an open phase event.

6.3.4.2 Typical configurations that require additional relaying include configurations with zig-zag or grounded wye-delta grounding banks as well as delta winding transformers.

6.3.4.3 There are many methods for achieving open phase conditions. Otter Tail does not allow positive-sequence phase balance, zero-sequence detection, or undervoltage relaying protective schemes.

6.3.5 Single-phase on Multiphase Services

6.3.5.1 The aggregate nameplate rating for single-phase DER on a multi-phase system cannot exceed 10 percent of the distribution transformer rating that is supplying the service.

6.3.5.2 When multiple single-phase DER Units connect to a multi-phase service to form a three-phase source, the DER must trip off when there is a loss of a single individual phase on the Area EPS.

6.3.5.3 DER which is connecting to an existing two-phase open delta-wye or open wye-delta secondary must be single-phase or the voltage of the service shall be converted to a three-phase 120/208 or 277/480 volt system.

6.4 Types of Interconnections

6.4.1 Open Transition

This type of transition requires UL approved transfer switch, with mechanical interlock between the two source contacts that drop the Area EPS source before the DER is connected to the load. To qualify for Open Transition, mechanical interlocks are required between the two source contacts to ensure one of the contacts is always open. If the mechanical interlock is not present, the protection requirements are as if the switch is a closed transition switch.

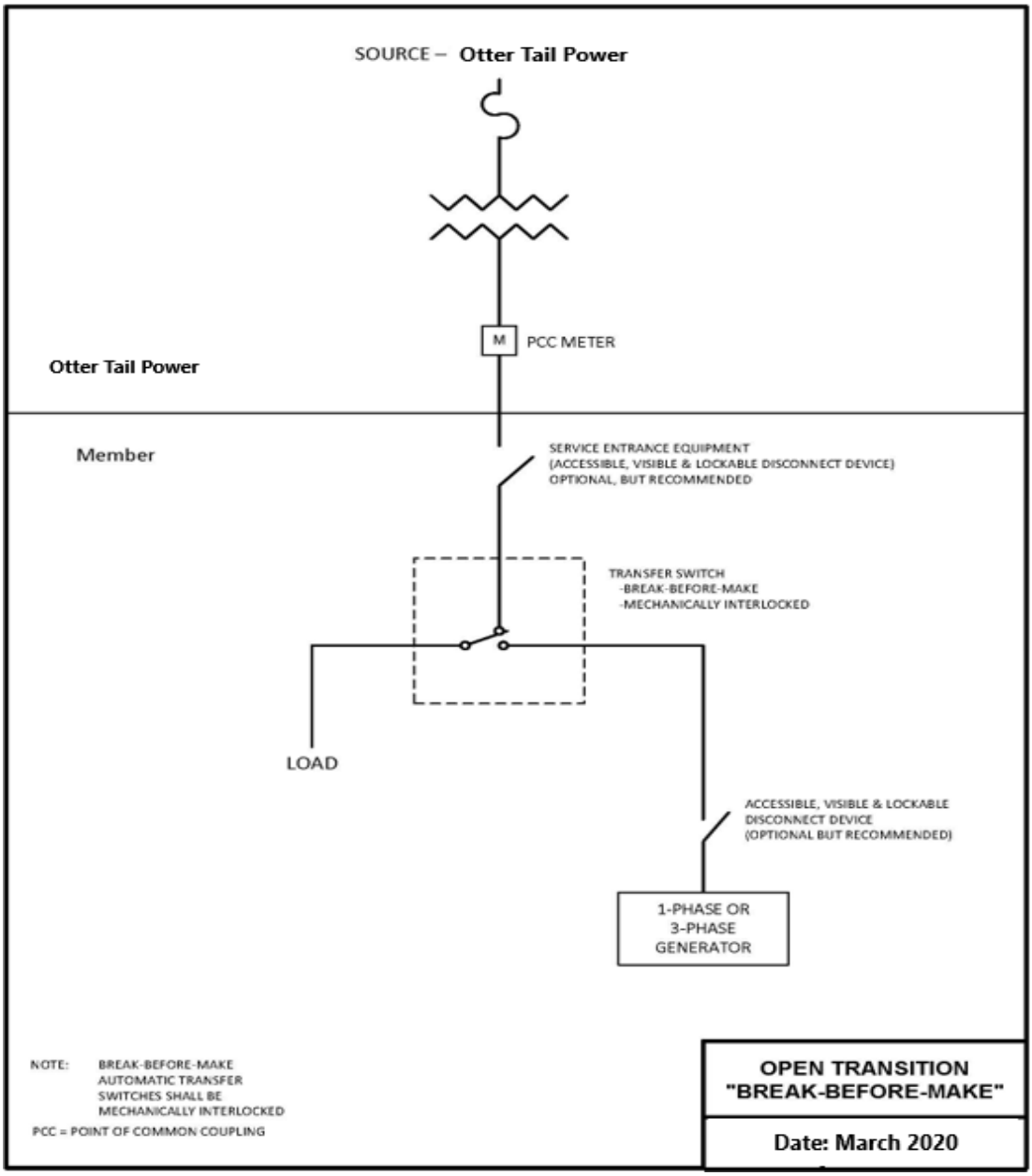

Figure 1 - General Open Transition One-Line Diagram

6.4.2 Closed Transition

To qualify for a Closed Transition, the closed transition switch must include a separate parallel time limit relay, which is not part of the DER PLC and trips the DER from the Area EPS for a failure of the transfer switch and/or the transfer switch controls.

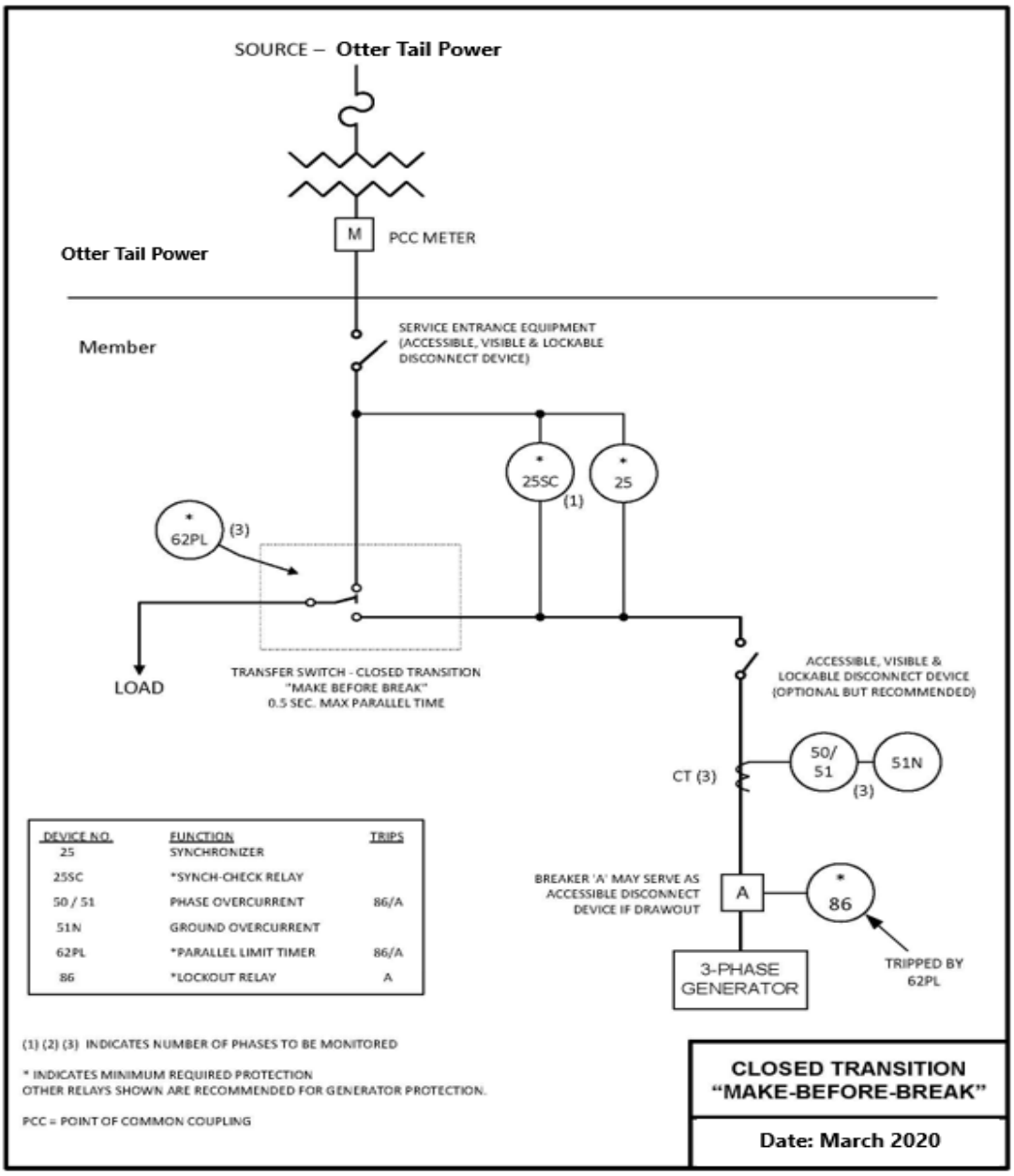

Figure 2 – General Closed Transition One-Line Diagram

6.4.3 Soft Loading Limited Parallel

To qualify for Soft Loading Limited Parallel operation, the maximum parallel operation shall be controlled via a parallel timing limit relay (62PL). This parallel time limit relay shall be a separate relay and not part of the DER PLC.

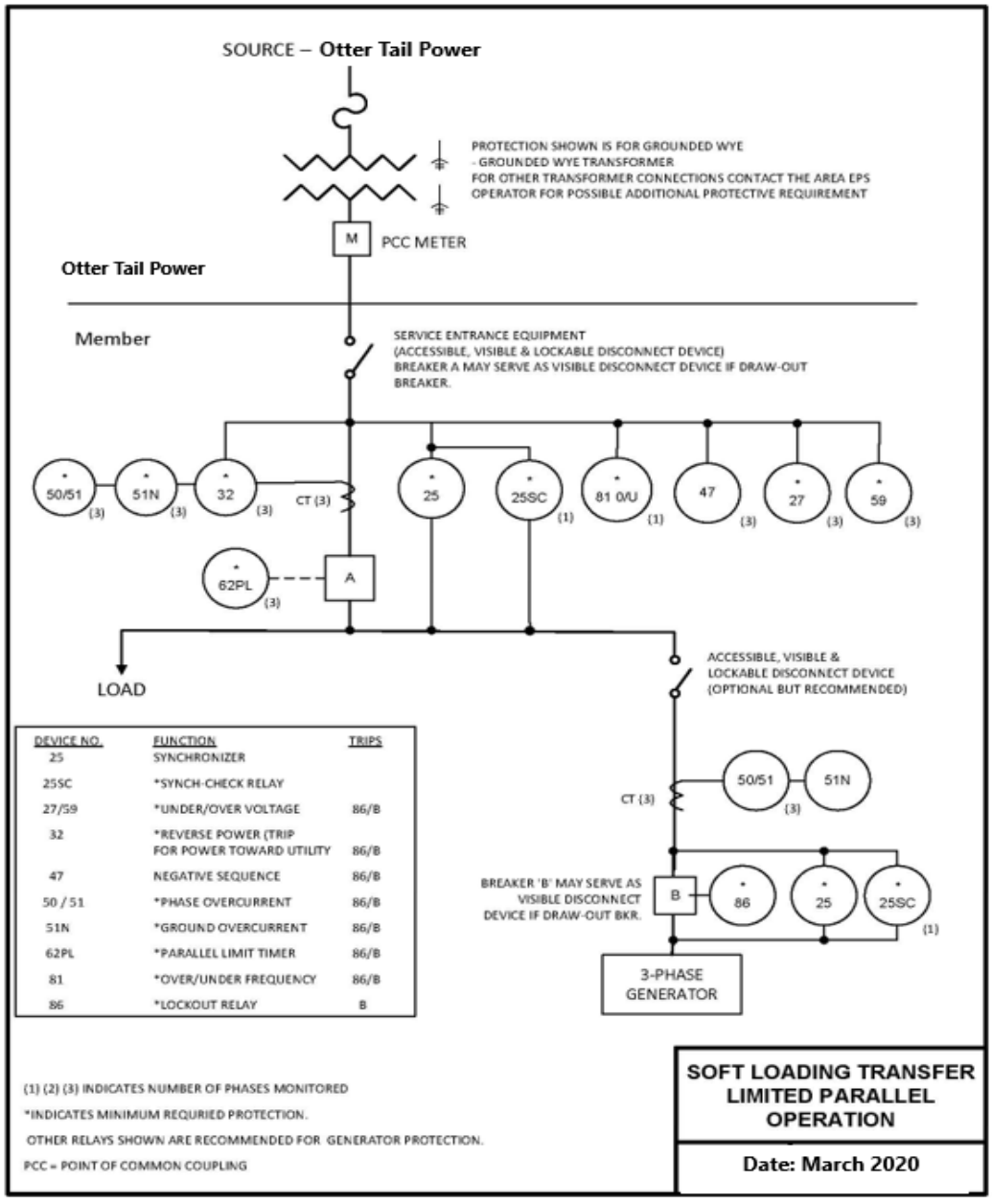

Figure 3 - General Soft Loading Limited Parallel One-Line Diagram

6.4.4 Soft Loading Extended Parallel

Special design, coordination, and agreements are required before any Soft Loading Extended Parallel operation will be permitted. The Area EPS interconnection study will identify the issues involved.

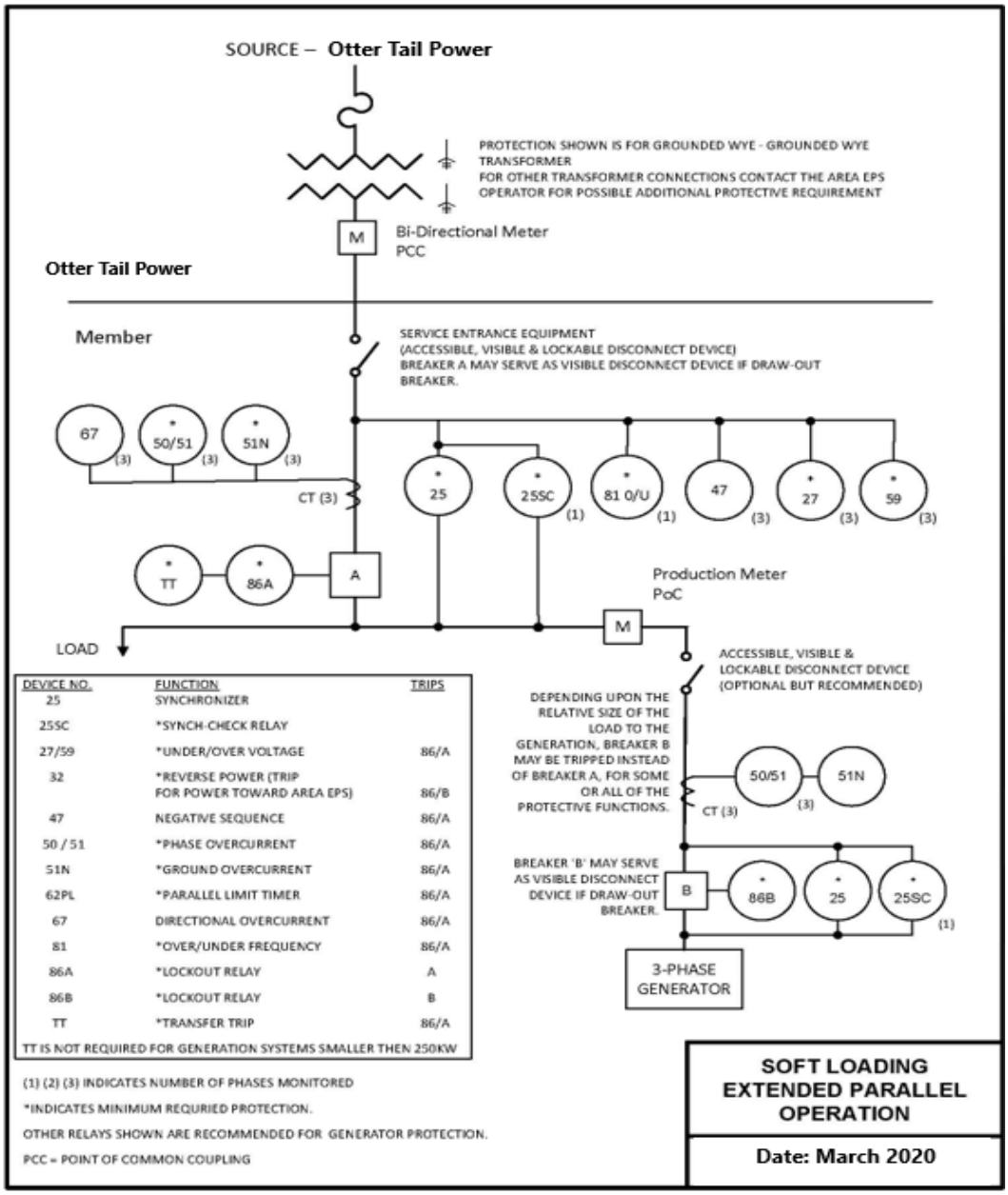

Figure 4 - Soft Loading Extended Transition One-Line Diagram

6.5 Interconnections Transformers

6.5.1 Wye-Wye Transformation

For a wye-wye transformation, both the primary and secondary sides of the transformer shall be grounded.

6.5.2 Wye-Delta Transformation

For a wye-delta transformation, the wye side of the transformation shall be grounded. High side voltage monitoring is required to sense single phase faults on the primary side of the transformer. All issues with zero sequence injections into the Area EPS from the grounded wye winding shall be addressed. Documentation shall be provided to the Otter Tail for review.

6.5.3 Delta-Wye Transformation

This transformer configuration is not allowed by Otter Tail.

6.6 Grounding

The grounding of DER shall be of sufficient size to handle the maximum available ground-fault current. This grounding system shall also be designed and installed to limit step and touch potentials to safe levels.

6.6.1 Wye-Wye Interconnections

For wye-wye transformer configurations, both the primary and secondary sides of the transformer shall be grounded.

6.6.2 Wye-Delta Interconnections

For wye-delta transformer configurations, the wye side shall be grounded. Otter Tail requires high side voltage monitoring to sense the loss of a phase on the primary side of the transformer. The IC shall also address zero-sequence injections into the Area EPS from the grounded wye winding.

6.6.3 Delta-Wye, Open-Delta, and Delta-Delta Interconnections

Delta-wye, open-delta, and delta-delta transformer configurations are not allowed by Otter Tail for DER systems.

7 Operations

7.1 Periodical Testing & Record Keeping

All interconnection related protection and control systems shall be periodically tested and maintained by the IC at intervals specified by the manufacturer, system designer, or within the Operating Agreement, but in no case shall they exceed 5 years. Periodic test reports and a log of inspections shall be maintained by the IC and made available to Otter Tail upon request. Otter Tail shall be notified with sufficient notice prior to the testing of the protective and control systems to witness the testing. The procedure for the re-test should be a functional test of the protection and control systems.

Any system that relies on a battery for trip/protection power shall be checked and logged once per month for proper voltage.

7.2 System Voltage

Operation of the DER shall not cause the voltage at the PCC to go outside of ANSI Range A under normal operations. Operation of the DER that causes voltages to go outside the ANSI Range A voltage values may be cause for disconnection until the reason can be identified and corrected.

Any sudden voltage changes caused by the DER which adversely affect other customers shall not be allowed. It is the IC's responsibility to resolve adverse voltage changes caused by the operation of their DER.

7.3 Use of Single-Phase Inverters

Due to the potential to cause system imbalance issues, a three phase DER shall not be operated as a single phase device for any reason without prior consent from the Area EPS Operator.

7.4 Power Ramp Rates

As part of the System Impact Study, Otter Tail reviews the potential for step changes in load or energy production that may create operational problems on the Area EPS. During this study, Otter Tail will review to see if any power quality issues would be expected from the interconnection and operation of the proposed DER. As a part of this study, Otter Tail will use a maximum of a 3% voltage step change for a step-change in DER output. If the DER causes the Area EPS voltage to go outside of the ANSI range A voltage levels, mitigation measures will be needed.

7.5 Enter Service and Synchronization

When entering service, the DER shall not energize the Area EPS until voltage and system frequency are within the ranges specified in the TIIR and IEEE 1547.

8 Power Control Systems

8.1 General

8.1.1 General

Power control systems shall be NRTL certified.

8.1.2 Documentation

To operate as a Capacity Limiting DER or Inadvertent Export DER, Otter Tail will need enough information to understand how the control system will operate. To assist in this, the IC, at a minimum, shall provide a manual describing the control mode intended to be used, a relay one-line diagram, and logic diagrams to Otter Tail for review during the application phase.

8.2 Real-time telemetry

Real-time telemetry will be required when the DER installed capacity exceeds the minimum loading on the source transmission to distribution transformer. This telemetry system shall be used to support TPS visibility and real-time analysis.

9 Interoperability

All DER shall have provisions for a local DER interface capable of communicating to support the information exchange requirements specified in this manual for all applicable functions that are supported in the DER. The decision to use a local DER interface or to deploy a communication system shall be determined by Otter Tail.

9.1 Monitoring

Otter Tail requires Supervisory Control and Data Acquisition (SCADA) and monitoring capability for DER over 250 kW. System monitoring shall be provided to the appropriate control centers for the purpose of providing real-time remote monitoring and control of the generator/inverter. The communications medium shall provide reliable communications and not traverse the internet nor include a publicly available service. The communication system shall contain the appropriate firewall to allow only permitted exchange of information. Local and/or regional telecommunication companies may be leveraged to provide point-to-point services to the Otter Tail's control centers.

9.1.1 Points List Requirements

Point list requirements will be addressed in the Operations Agreement and shall minimally include access to all points defined in the inverter manufactures datasheet.

9.2 Communications Method

When communication is required to the DER and/or the applicable meter(s), the DER Operator may be responsible for furnishing the communication channel from the DER and/or the meters to Otter Tail's applicable system(s). The form of communication (Cellular, Radio, etc.) shall be determined by Otter Tail. Communication performance requirements, such as latency of exchanged information, periodicity, reliability of communication channels, and volumes of data, may be defined by this TSM or in an operating agreement.

9.2.1 Preferred Utility Protocol

Otter Tail will determine the preferred protocol during the Interconnection Agreement phase. Open standard communication protocols are supported as referenced in Table 41 of the IEEE 1547 document. Due to Federal Regulations, specific protocols cannot be called out in this document. Please contact Otter Tail for additional information.

9.2.2 Communications Transfer Rates

All communication transfer rates shall be less than or equal to 30 seconds.

9.3 Security

9.3.1 Physical and Front Panel

It is the responsibility of the IC to maintain physical security for equipment and all communication interfaces at the DER site. The configuration settings for all DER equipment that provide protection or control shall be password protected to allow access only to qualified personnel.

9.3.2 Network Security

Physical security protections shall be identified by the IC and approved by Otter Tail.

10 Energy Storage

10.1 General

ESS is unique in that it can operate as a load or generator. When the ESS is operating as a load, it shall abide by the applicable Otter Tail tariff. When the ESS is operating as a generator, it shall abide by the applicable Otter Tail tariff.

10.2 Emergency Power

This control mode is designed so the ESS provides energy to the Local EPS during a power outage but will not provide energy to the Local EPS at other times. It can be designed to operate as a Closed Transition or Open Transition system.

10.3 Capacity Limiting

Under this type of control mode, the DER is operating in parallel with the EPS and shall provide the necessary documentation per section 8.1 and follow the security requirements in section 9.2.

10.4 Non-Exporting

Under this control mode, the IC shall provide the necessary documentation per section 8.1 and follow the security requirements in section 9.2.

10.5 Enter Service

After the loss of voltage from the Area EPS, the ESS shall follow IEEE 1547 requirements to recharge and follow Section 7.3 of this manual to generate.

10.6 Modification of Control Modes

The IC shall not change the type of control mode that has been studied and approved by the Area EPS Operator. Should the IC elect to change the type of control mode, it shall inform the Area EPS Operator of the intended change.

11 Metering Requirements

11.1 Metering Requirements Factors

11.1.1 General Requirements

Metering requirements shall depend on the type of DER, the applicable tariffs, the method of interconnection, and the size of the DER.

11.2 Location and access of metering

Metering shall be accessible 24/7 and shall not be inside any buildings or structures.

11.3 Production Meter

The need to install a production meter will depend on the tariff selected by the IC. Please refer to the applicable tariff. The location of the production meter shall be within 10 feet of the PCC.

11.4 Types of Metering Configurations

See Sample One-Line Diagrams in Section 14 of this TSM.

12 Signage and Labeling

12.1 General

All signage and labeling shall meet all necessary NEC Requirements.

12.2 AC Disconnect

The Utility AC Disconnect shall be labeled as “DER Utility AC Disconnect”.

In the event Otter Tail would agree to locate the DER Utility AC disconnect beyond 10 feet of the PCC, such as the Local EPS serves a large campus of buildings and is primary metered, a permanently affixed weatherproof placard shall be located within 10 feet of the revenue meter indicating the DER Utility AC Disconnect location. The placard shall include a mapped representation of the property with the location of the DER Utility AC Disconnect clearly denoted.

12.3 Production Meter

Any production meter installed shall be labeled as “Production Meter”. In cases where multiple production meters exist on the load side of the main meter, each production meter shall be labeled to identify the DER unit being metered.

13 Test and Verification Requirements

13.1 Procedure

The IC shall provide a testing procedure to Otter Tail per the MN DIP criteria. This criteria can be found in the Testing Sections 13.2 and Section 13.2.2.

13.2 Testing Criteria for non-Simplified Process DER

13.2.1 Pre-Energization Documentation and Testing

Prior to scheduling the Commissioning testing, the IC shall perform the following tests and provide the following documentation to the Otter Tail.

13.2.1.1 Grounding

Grounding shall be verified to ensure that it complies with the TIIR, TSM, NESC and the NEC.

13.2.1.2 Fault Current

Fault current characterization information is required in IEEE 1547, subclause 11.4. This is required for synchronous and induction generation and electronically coupled DER with the aggregated rated capacity of 500 kVA or larger.

13.2.1.3 CTs & VTs

Current transformers (CT's) and voltage transformers (VT's) used for metering, monitoring, and protection shall be tested to ensure correct polarity, ratio, and wiring.

CT's shall be visually inspected to ensure that all grounding and shorting connections have been removed where required.

13.2.1.4 Breakers

All breakers and switches should be verified that they cannot be operated with interlocks in place or the breaker or switch cannot be automatically operated when in manual mode.

13.2.1.5 Relays

All protective relays shall be calibrated and tested to ensure the correct operations of the protective element.

Protective relaying shall be functionally tested to ensure the correct operation of the complete system. Functional testing requires that the complete system is operated by the injection of current and/or

voltage to trigger the relay element and proving that the relay element trip the required breaker, lockout relay or provides the correct signal to the next control element. Trip circuits shall be proven through the entire scheme.

13.2.1.6 Remote Control

All remote control functions and remote monitoring points shall be verified operational. In some cases, it may not be possible to verify all analog values prior to energization. Where appropriate, those points may be verified during the energization process.

13.2.1.7 Phase Tests

Phase tests shall be completed with the Area EPS Operator to ensure proper phase rotation of the generation and wiring.

13.2.1.8 Synchronization Tests

The synchronization test shall be done across an open switch or racked out breaker. The switch or breaker shall be in a position that it is incapable of closing between the generation system and the Otter Tail system for this test. This test shall demonstrate at the moment of the paralleling-device closure, the frequency, voltage, and phase angle are within the required ranges, as stated in IEEE 1547. This test shall also demonstrate that for any parameters outside the ranges stated that the paralleling-device shall not close. For inverter-based interconnected systems, this test may not be required unless the inverter creates fundamental voltages before the paralleling device is closed.

13.2.2 Commissioning Test Criteria

13.2.2.1 Anti-islanding

An anti-islanding testing procedure shall be provided to Otter Tail. The test procedure shall include at a minimum, the following components:

1) Steps to energize the DER including specific devices that are being operated or verified. The device names should match those in the one-line.
2) Steps to verify the DER is energized and generating, including the method used for verification.
3) Steps to simulate the loss of a utility source for each phase and for simultaneous three-phase, including specific devices names for each device being operated. The device names should match those in the one-line.
4) Steps to re-connect DER.
5) Steps to verify the DER delays energization for at least 5 minutes including measurement method and location.

6) IC signature on the commissioning test report stating that the procedure has been properly completed and the system passed the test.

13.2.2.2 Control Modes

The IC shall provide a testing plan for the Area EPS Operator to review due to the many types of configurations available.

13.2.2.3 Enter Service

13.2.2.3.1 The DER shall be started and connected in parallel with the Area EPS.

13.2.2.3.2 The AC Utility Disconnect switch or breaker shall be open. The disconnect operated shall test all anti-islanding protection devices simultaneously.

13.2.2.3.3 For multi-phase DER, the loss of all phases and loss of each single-phase shall be tested.

13.2.2.3.4 Protection schemes using negative sequence, zero sequence, or other imbalance detection relays to detect open phase conditions shall demonstrate that this scheme has no non-detection zone prior to testing.

13.2.2.3.5 The DER shall either separate with the local load or stop generating.

13.2.2.3.6 The AC Utility Disconnect switch or breaker shall be closed and the DER shall not produce any energy for at least 5 minutes.

13.2.3 Post-Energization Documentation

The IC shall provide the following documentation as part of its written test report:

- Grounding equipment nameplate drawing.
- Ground referencing calculations.
- Drawing of ground referencing equipment protection schemes.
- Written verification that grounding equipment meets NEC and NESC.
- Verification that the correct PT's and CT's are installed.
- Verification that the CT's shorts and ground have been removed when applicable.
- Details on main site protection.
- Verification that all breakers, switches and associated controls function properly.

- Signed verification of relay calibration and testing.

13.3 Testing Criteria for DER Utilizing the Simplified Process

The general process for field inspection and testing of inverter-based DER and approved through the Simplified Process is contained in the TIIR.

13.4 Failure Protocol

If the DER system fails testing and verification, the IC shall correct outstanding issues and provided updated documentation to Otter Tail. The IC shall schedule a testing and verification date with the Otter Tail and if necessary, a revised testing procedure.

14 Sample Documents for Simplified Process

14.1 One-line Diagrams

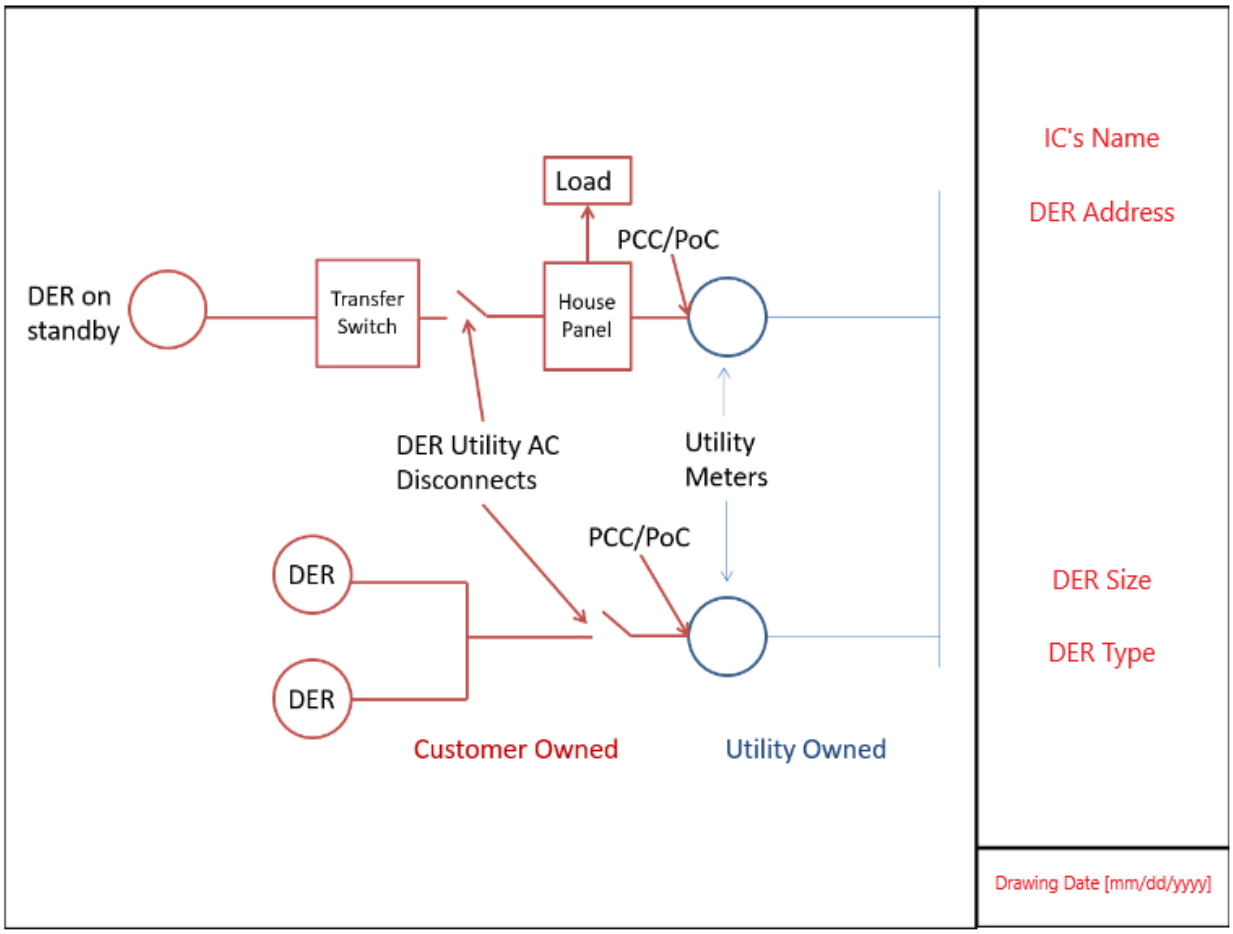

Figure 5 - One-line for Load with a Separate Parallel DER Interconnection

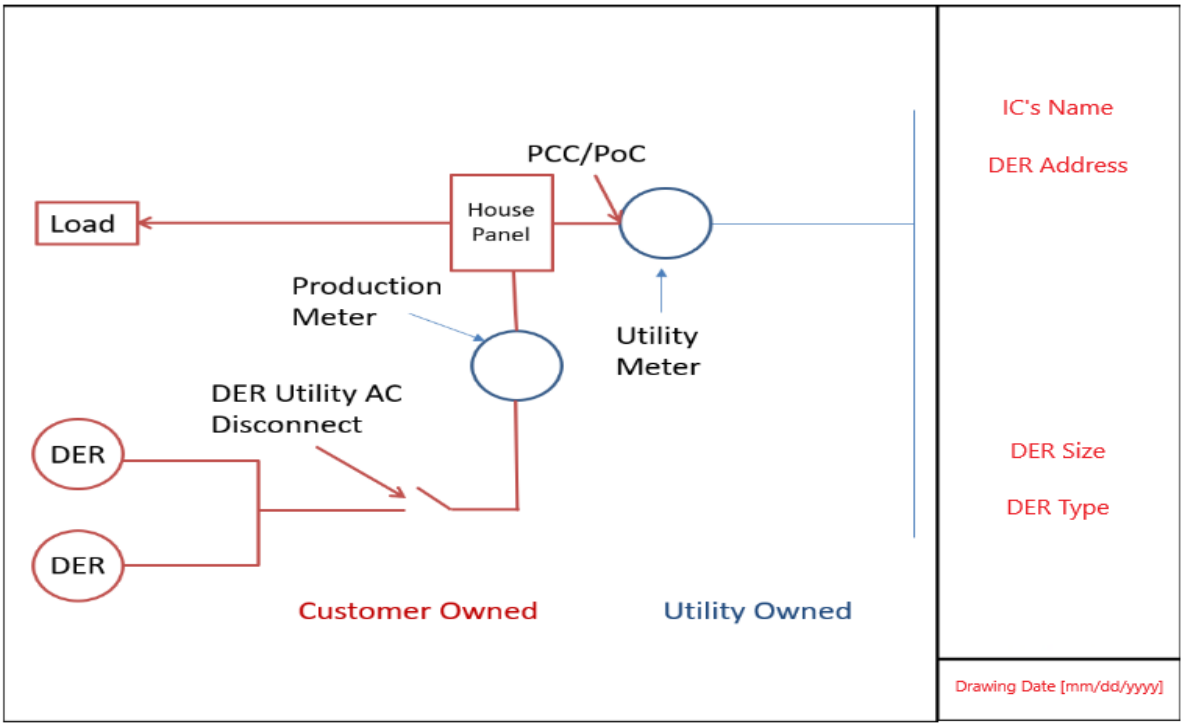

Figure 6 - One-line for Net Meter DER

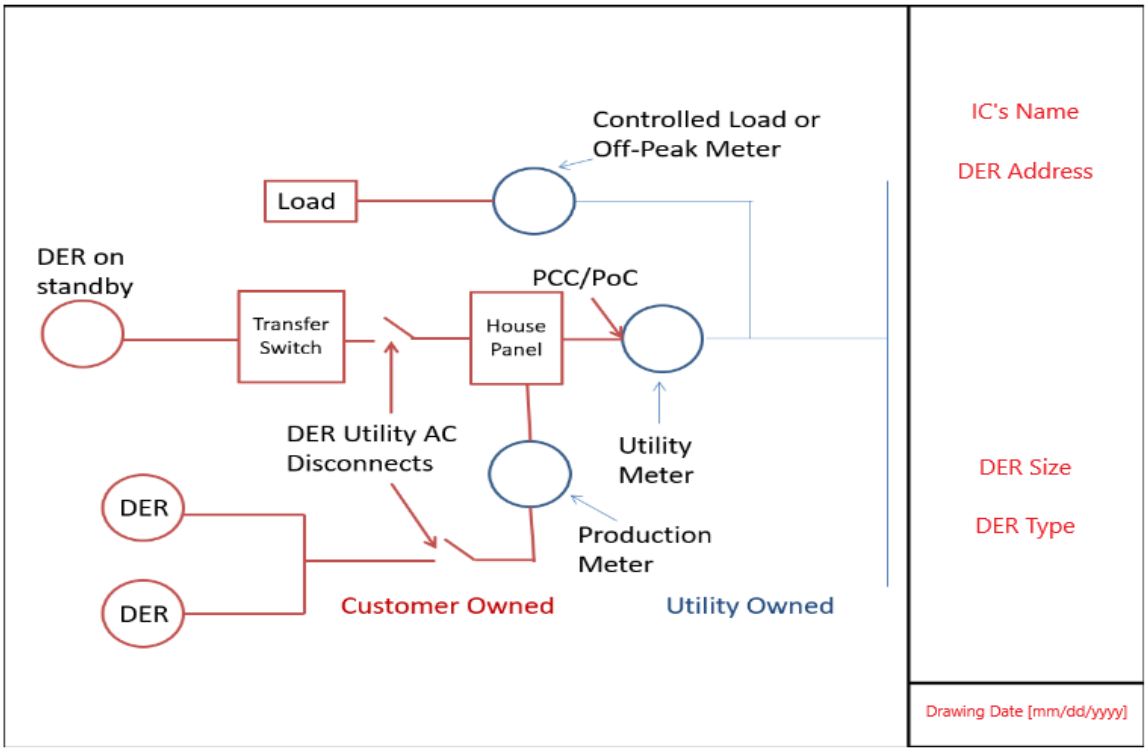

Figure 7 - One-line for DER with Controlled Load or Off-peak Meter Load

14.2 Site diagram

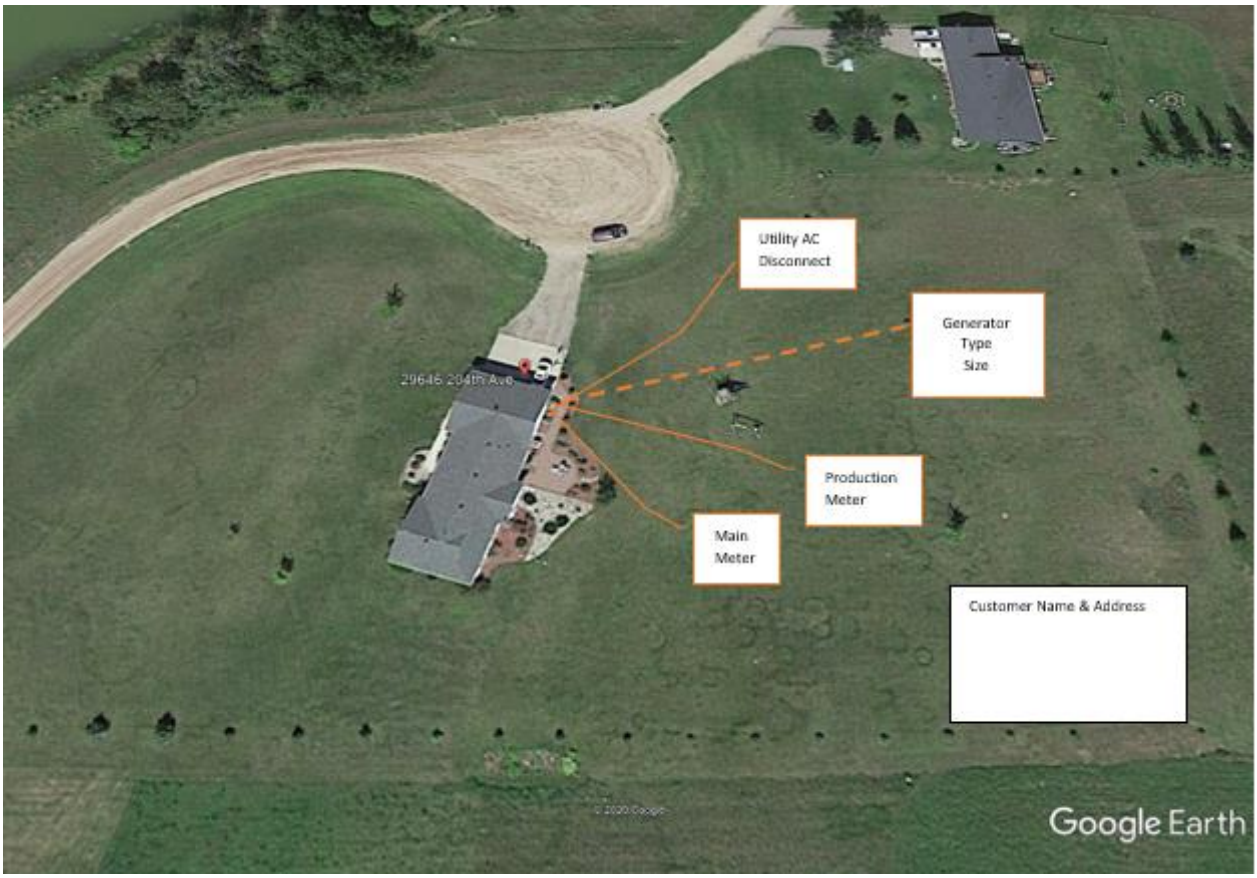

Figure 8 - Site Diagram Example