OTTER TAIL POWER COMPANY TECHNICAL SPECIFICATIONS MANUAL (TSM) 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 and Interoperability Requirements (MN TIIR). 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 MN TIIR, its primary intent is to outline Otter Tail's specific technical requirements. Please read the companion documents MN DIP and MN 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 1547-2018 standard, the IEEE 1547a-2020 amendment, and other applicable national standards. The intent of this document is to provide Interconnection Customers (IC) and DER installers a clear set of technical requirements for the common interconnection of DER with Otter Tail's 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 Otter Tail 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.

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 during 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 interconnect the DER physically and electrically 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 MN 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 MN 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 1547-2018 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 MN 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 (SIS)*: 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.

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

Utility Required Profiles (URPs):** Established, commonly formatted settings files for the Area EPS Operator to inform a DER Operator or Installer of the required control settings of the DER system.

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 (MN TIIR) - 2023	**
Otter Tail specific definition	None

3 IEEE 1547-2018 & Autonomous Smart Inverter Status

The IEEE 1547-2018 standard, as well as its new amendment, IEEE 1547a-2020, has been approved and implemented for use as the national standard for interconnection and interoperability of DER with the electric power system.

Starting January 1st, 2024, Otter Tail will be requiring the use of advanced inverters which conform to the new IEEE 1547-2018 standard and its new amendment, IEEE 1547a-2020, for all new DER interconnection applications received on or after that cutover date. These advanced inverters will be labeled as tested and certified under UL 1741 SB standards.

Prior to the cutover date of January 1st, 2024, Otter Tail will allow the use of inverters which have not been certified to the latest UL 1741 SB standard. However, the requirement

remains that all inverters proposed to be used for the interconnection of DER systems are certified as tested under UL 1741 standards.

This version of the TSM has been harmonized with the IEEE 1547-2018 Standard and its amendment, IEEE 1547a-2020, for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces for advanced, autonomous smart inverter functions.

The settings presented in this TSM are required to be installed on all inverter systems interconnecting in parallel with Otter Tail's Area EPS. The settings are presented in the EPRI Common File Format for DER Settings Exchange and Storage[1], also referred to as the Utility Required Profile (URP) format. Section 16 has examples of Utility specific settings (URP-SS) and installer Applied Settings (URP-AS) URP files. They are intended to conform with IEEE 1547-2018 and its amendment standard, IEEE 1547a-2020, and any use of inverter settings other than those listed in this document are subject to review and approval by Otter Tail. Note, the use of UL 1741 SA certified or older inverter(s) is not allowed by Otter Tail for DER interconnections submitted and filed January 1st, 2024, for the readily available UL 1741 SB certified advanced inverters.

Please note that for all inverter replacements, whether due to age, condition, or otherwise, which currently are UL 1741 SB certified and configured to the requirements of this TSM, it is required that Otter Tail be notified of the model number and configuration (settings) which have been programmed into the replacement inverter to ensure a "like for like" replacement. Notification to Otter Tail is necessary and required so that it can correctly understand and model the response of all of the DER systems during disturbances to ensure safe and reliable operation of the Area EPS. If a "like for like" conversion is not possible or if the inverter(s) being replaced are legacy systems not certified to UL 1741 SB, then the IC will inform Otter Tail and request a Material Modification[2].

For all Material Modification[2] requests of DER system inverter(s), the use of advanced inverter(s) certified to UL 1741 SB with the settings outlined in this TSM is required, unless mutually agreed upon by both parties.

Table 2: Default Activation Status of Autonomous Functions

Autonomous Function	Default Status

[1] EPRI Common File Format for DER Settings Exchange and Storage – Version 2.0. 2022 Technical Update. Is Publicly available on the EPRI website: https://www.epri.com/research/programs/067418/results/3002025445

[2] Material Modification is defined in the MN TIIR and includes, but may not be limited to, a modification from the approved Interconnection Application that: (1) changes the physical location of the point of common coupling; such that it is likely to have an impact on technical review; (2) increases the nameplate rating or output characteristics of the Distributed Energy Resource; (3) changes or replaces generating equipment, such as generator(s), inverter(s), transformers, relaying, controls, etc., and substitutes equipment that is not like-kind substitution in certification, size, ratings, impedances, efficiencies or capabilities of the equipment; (4) changes transformer connection(s) or grounding; and/or (5) changes to a certified inverter with different specifications or different inverter control settings or configuration.

Constant Power Factor	Disabled
Voltage-Reactive Power Control (Volt-Var)	Enabled
Voltage-Active Power Control (Volt-Watt)	Enabled
Active Power-Reactive Power Control (Watt-Var)	Disabled
Constant Reactive Power Control	Disabled
Voltage Disturbance Ride-Through	Enabled
Frequency Disturbance Ride-Through	Enabled
Enter Service	Enabled
Enter Service Ramp Rate	Enabled
Anti-Islanding	Enabled

4 Performance Categories and Assignment

Otter Tail has no additional requirements for performance categories and assignments other than those provided in the MN TIIR.

Performance criteria outside of those defined in the MN 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.

5 Reactive Power Capability and Voltage/Power Control Performance

This section provides the default and expected capabilities and performance control settings of a DER interconnecting in parallel with Otter Tail's Area EPS.

5.1 Reactive Power Capability of the DER

DER reactive power capability shall be available for use by Otter Tail and compliant with IEEE 1547-2018 Section 5.2 for the applicable performance category for the specific DER type. Figure H.4 of IEEE 1547-2018 is applicable.

5.2 Constant Power Factor Control

Otter Tail requires the settings for constant power factor to be disabled, unless otherwise specified in the Interconnection Agreement.

5.3 Voltage-Reactive Power Control (Volt-Var)

Otter Tail requires the settings for Volt-Var Power Control to be enabled, unless otherwise specified in the Interconnection Agreement.

The Volt-Var Power mode default setting shall be set to the IEEE 1547-2018 default setting as shown below in Table 3, unless otherwise specified by the System Impact Study.

Table 3: Volt-Var Control Mode Default Settings

Volt-Var Power Parameters	Default Settings	
	Synchronous Machine-based DER	Inverter-based DER
V_{Ref}	V_N*	V_N*
V_1	0.9 V_N	.92 V_N
V_2	V_N	.98 V_N
V_3	V_N	1.02 V_N
V_4	1.1 V_N	1.08 V_N
Q_1[a]	25% of nameplate apparent power rating, injection	44% of nameplate apparent power rating, injection
Q_2	0	0
Q_3	0	0
Q4	25% of nameplate apparent power rating, absorption	44% of nameplate apparent power rating, absorption
Open Loop Response Time	10 s	5 s

*V_N is assumed to be set at the nominal operating voltage at the reference point of applicability (e.g., 120, 208, 240, 277, 480 Volts)

[a]The DER reactive power capability may be reduced at lower voltage(s)

5.4 Voltage-Active Power Control (Volt-Watt)

Otter Tail requires the settings for Volt-Watt control to be enabled for IEEE 1547-2018 Category B systems, unless otherwise specified by the Interconnection Agreement. The Volt-Watt function shall be optional for Category A DER and only enabled by mutual agreement between Otter Tail and the DER Operator.

The Volt-Watt control mode default settings shall be set to the IEEE 1547-2018 Category B default settings as shown below in Table 4, unless otherwise specified by the System Impact Study.

Table 4: Volt-Watt Control Mode Default Settings

Voltage-Active Power Parameters	Default Setting
V_1	1.06 V_n
P_1	P_{rated}

V_2	1.1 V_n
P_2 (applicable to DER that can only generate active power)	The lesser of 0.2 P_{rated} or P_{min}[a]
P'_2 (applicable to energy storage)	0[b]
Open Loop Response Times	10 s

[a] P_{min} is the minimum active power output in p.u. of the DER rating
[b] P_{rated} is the maximum amount of active power that can be absorbed by the DER ESS operating in the negative real power half plane, through charging, shall follow this curve as long as available energy storage capacity permits this operation.

Refer to the MN TIIR Section 5 for more information these control functions and for more on how to resolve abnormal voltage concerns.

5.5 Active-Reactive Power Control (Watt-Var)

Otter Tail requires the settings for active-reactive power control to be disabled, unless otherwise specified in the Interconnection Agreement.

5.6 Constant Reactive Power Control

Otter Tail requires the settings for constant reactive power control to be disabled, unless otherwise specified in the Interconnection Agreement.

6 Response to Abnormal Conditions

All DER shall disconnect when the Area EPS experiences abnormal frequency or voltages outside of the applicable ride-through settings to avoid unintentional islanding. All DER shall trip for any abnormal voltages or frequency with clearing times as shown in the most recent MN TIIR. They also align with the default requirements from the national IEEE 1547-2018 standard and its newest amendment, IEEE 1547a-2020.

6.1 Voltage Ride-Through and Tripping

Reference the MN TIIR to determine default clearing time settings.

6.2 Frequency Ride-Through and Tripping

Reference the MN TIIR to determine default clearing time settings.

6.3 Transfer-Trip Systems

Transfer-trip functions may affect the ride-through capabilities of a DER. See Section 7 for more Protection details.

6.4 Dynamic Voltage Support

Otter Tail requires Dynamic Voltage Support be disabled, unless otherwise specified in the Interconnection Agreement.

The volt-var and volt-watt functions of the advanced inverters, as described in Section 5, will actively support the systems defined nominal voltage. However, the DER system shall not enable the use of a variable reference voltage to regulate the

voltage outside of the predefined nominal system voltage setpoint during abnormal system conditions.

7 Protection

7.1 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.

7.1.1 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.

7.2 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).

7.3 Protection Requirements

7.3.1 General Relay Information

7.3.1.1 The majority of Otter Tail's distribution facilities utilize automatic reclosing and therefore the IC should assume this when designing their DER.

7.3.1.2 For DER utilizing a UL 1741 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.

7.3.1.3 For all other DER requesting interconnection in parallel with Otter Tail's 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.

7.3.1.4 For non-inverter based DER, 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.

7.3.1.5 For all DER systems which utilize inverters for the protective functionality, the inverter settings shall be provided to Otter Tail for review and approval prior to final interconnection testing. The inverter settings shall be provided via the EPRI Common File Format for DER Settings Exchange and Storage[1 above]. Please refer to Section 16 for an example of Otter Tail's Specified Settings (URP-SS) and an example of the Applied Settings file (URP-AS) that will be returned to the Utility for review.

7.3.2 Relaying

7.3.2.1 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.

7.3.2.2 Required relays shall have test plugs or test switches installed to permit field testing and maintenance of the relay without unwiring or disassembling the equipment.

7.3.2.3 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.

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

7.3.2.5 All relays shall be equipped with setting limit ranges at least as wide as specified in IEEE 1547-2018, and meet other requirements as specified in the 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 1547-2018.

7.3.2.6 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.

7.3.3 Types of Relaying

7.3.3.1 Over-voltage relay (IEEE Device 59) shall operate to trip the DER per the requirements of IEEE 1547-2018.

7.3.3.2 Under-voltage relay (IEEE Device 27) shall operate to trip the DER per the requirements of IEEE 1547-2018.

7.3.3.3 Over-frequency relay (IEEE Device 81O) shall operate to trip the DER off-line per the requirements of IEEE 1547-2018.

7.3.3.4 Under-frequency relay (IEEE Device 81U) shall operate to trip the DER off-line per the requirements of IEEE 1547-2018.

7.3.3.5 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.

7.3.3.6 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.

7.3.3.7 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.

7.3.3.8 Direct Transfer Trip – All DER shall disconnect from Otter Tail when the Local EPS is disconnected from its source to avoid unintentional islanding. DER that remain in parallel with Otter Tail may require a transfer trip system to sense the loss of the Area EPS source. The size and type of the DER along with the voltage class, capacity, existing system conditions, and/or minimum demand on the feeder will determine the need for transfer trip installation. The System Impact Study will identify any specific requirements outside those outlined in Section 7.4.

Please refer Section 7.4 for more details on Direct Transfer Trip requirements.

7.3.3.9 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.

7.3.3.10 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.

7.3.4 Open Phase Protection

7.3.4.1 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.

7.3.4.2 Typical configurations that require additional relaying include configurations with zigzag or grounded wye-delta grounding banks..

7.3.4.3 There are many methods for achieving open phase conditions. This will be coordinated in the final Engineering Design phase. Please contact Otter Tail for additional information.

7.3.5 Single-phase on Multiphase Services

7.3.5.1 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.

7.3.5.2 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.

7.3.5.3 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.

7.4 Direct Transfer Trip (DTT) Requirements

Unless designed to operate as an island, all DER systems are required to disconnect from Otter Tail's Area EPS within two seconds, per IEEE 1547-2018, when that portion of Otter Tail's Area EPS is disconnected from its source. For many inverter based DER systems, a UL 1741 certification provides assurance that the DER will disconnect from the Area EPS upon loss of the utility source. For non-certified systems, and in situations where the UL certification of the system(s) may be inadequate, disconnection is triggered by a direct transfer trip (DTT) signal from

Otter Tail's Area EPS that will trip off the DER with a breaker or recloser. If sections 7.4.1 and 7.4.2 are insufficient to determine the need for a DTT scheme, then a System Impact Study may be needed to determine the necessity for a transfer trip installation.

7.4.1 DER Interconnections Above 15 kV

7.4.1.1 Direct Transfer Trip (DTT) to Otter Tail owned equipment, customer owned equipment only upon mutual agreement between parties, or a combination of both, may be required under, but not limited to, one or more of the following system conditions:

- Generation has ability to cause reverse power flow at the substation protective device(s) and transmission system; OR
- There exists, within the Area EPS or Local EPS, a mixture of synchronous, asynchronous, and/or inverter-based generation; OR
- Aggregate generation on the Area EPS exceeds two-thirds (67%) of the minimum system demand; OR
- Generation facility nameplate rating greater than 10 MVA

The System Impact Study results may determine needs or requirements for DER interconnections above 15 kV beyond those outlined in this section.

7.4.2 DER Interconnections Below 15 kV

7.4.2.1 Direct Transfer Trip (DTT) to Otter Tail owned equipment, customer owned equipment only upon mutual agreement between parties, or a combination of both, may be required under, but not limited to, one or more of the following system conditions:

- Generation has ability to cause reverse power flow at the substation protective device(s) and transmission system; OR
- Generation exceeds two-thirds (67%) of the minimum system demand **AND** contains synchronous generation, inverter-based generation with grid-forming capability, or a combination of both; OR
- Generation facility nameplate rating greater than 1 MVA

The System Impact Study results may determine needs or requirements for DER interconnections below 15 kV beyond those outlined in this section.

7.5 Types of Interconnections

7.5.1 Open Transition

This type of transition requires a 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.

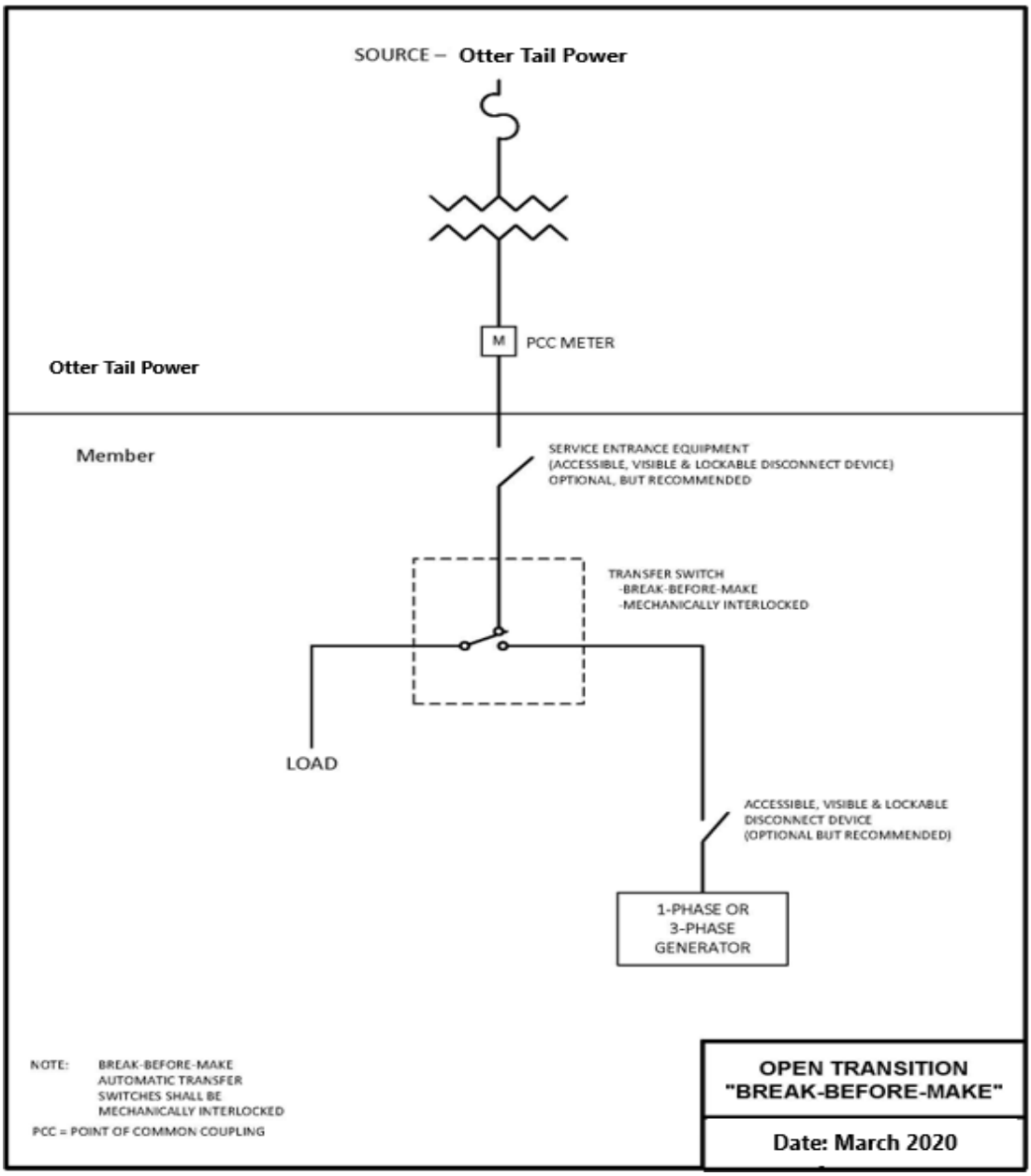

Figure 1 - General Open Transition One-Line Diagram

7.5.2 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.

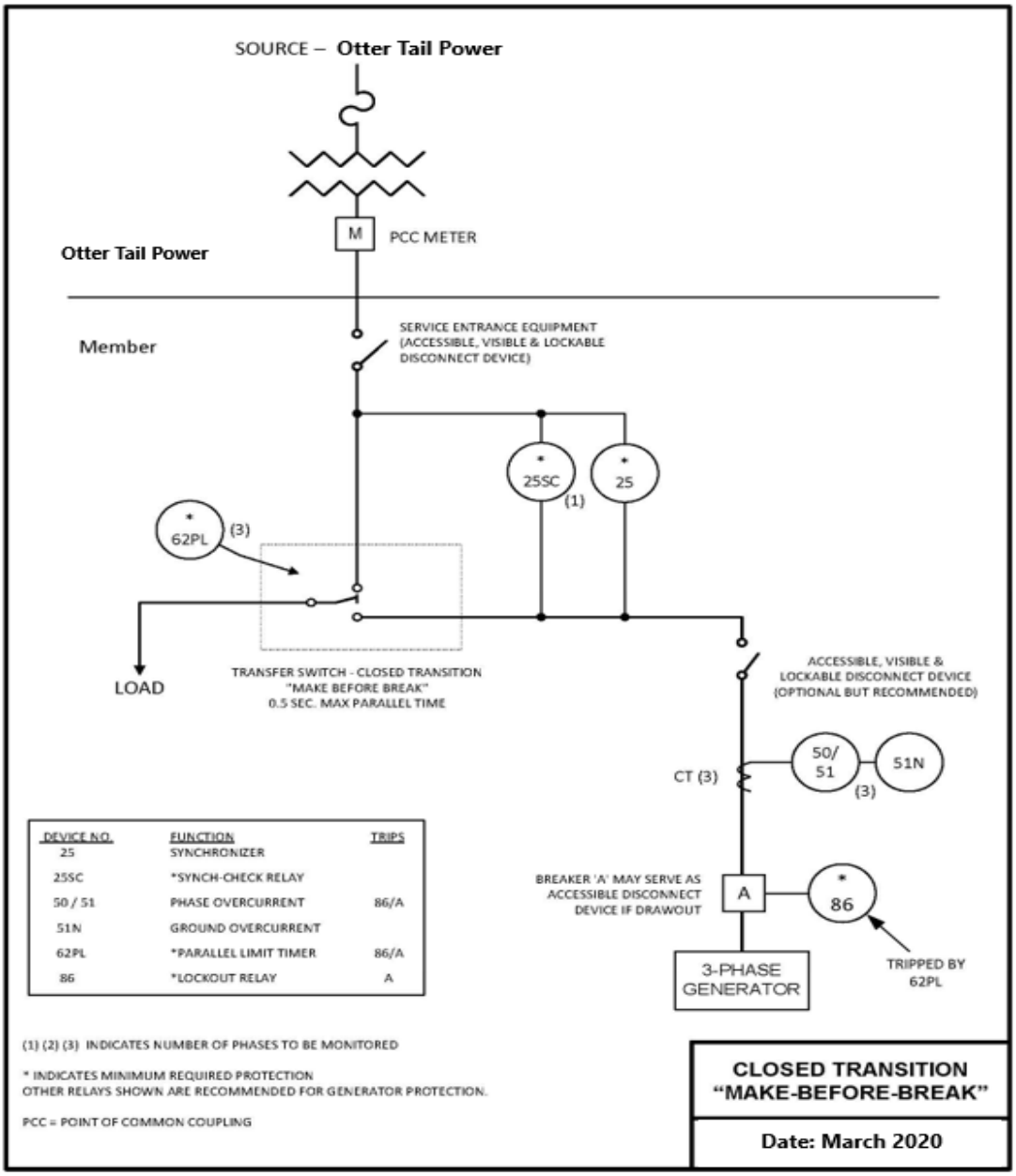

Figure 2 – General Closed Transition One-Line Diagram

7.5.3 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.

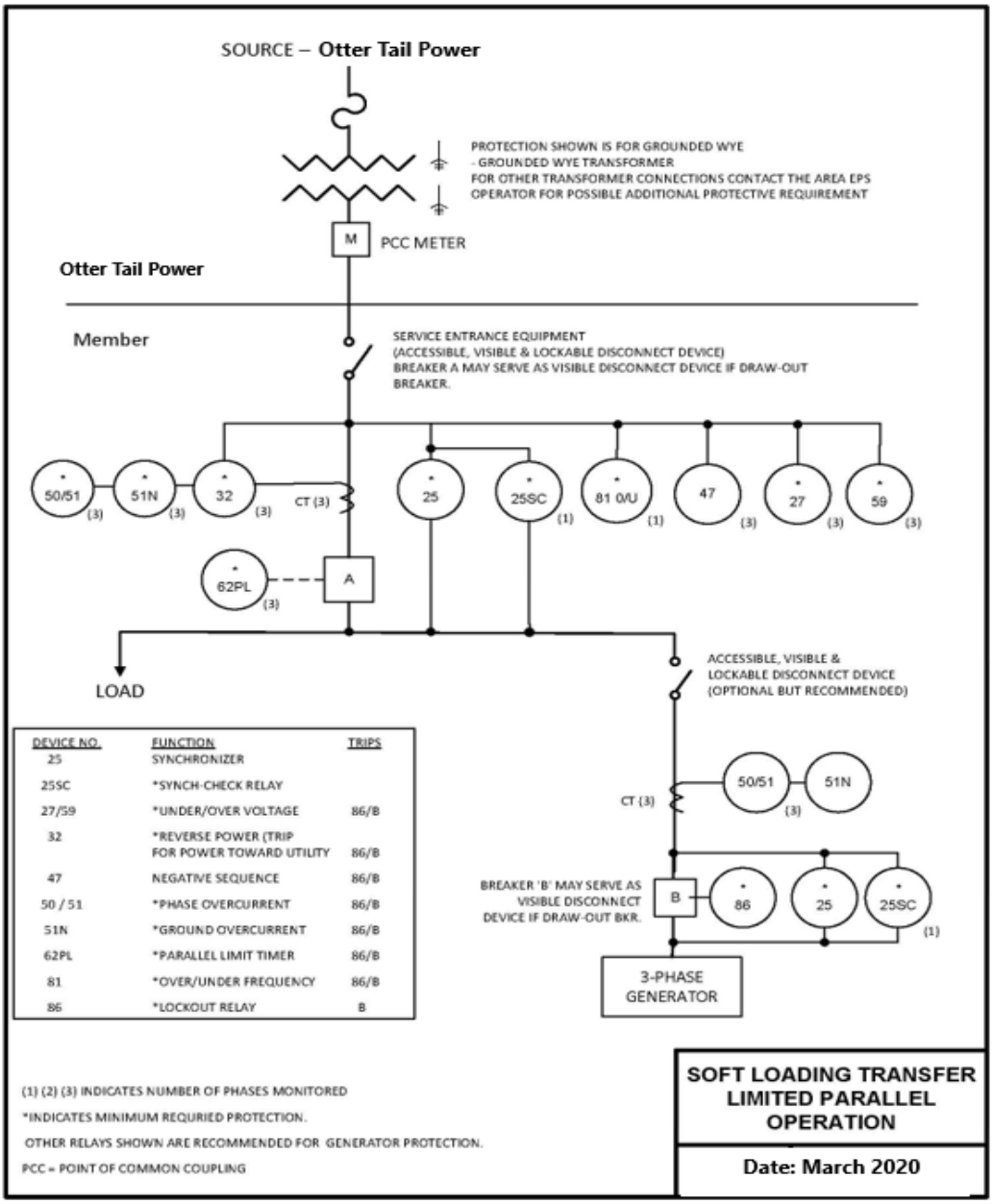

Figure 3 - General Soft Loading Limited Parallel One-Line Diagram

7.5.4 Soft Loading Extended Parallel

Special design, coordination, and agreements are required before any Soft Loading Extended Parallel operation will be permitted. The System Impact Study will identify the issues involved.

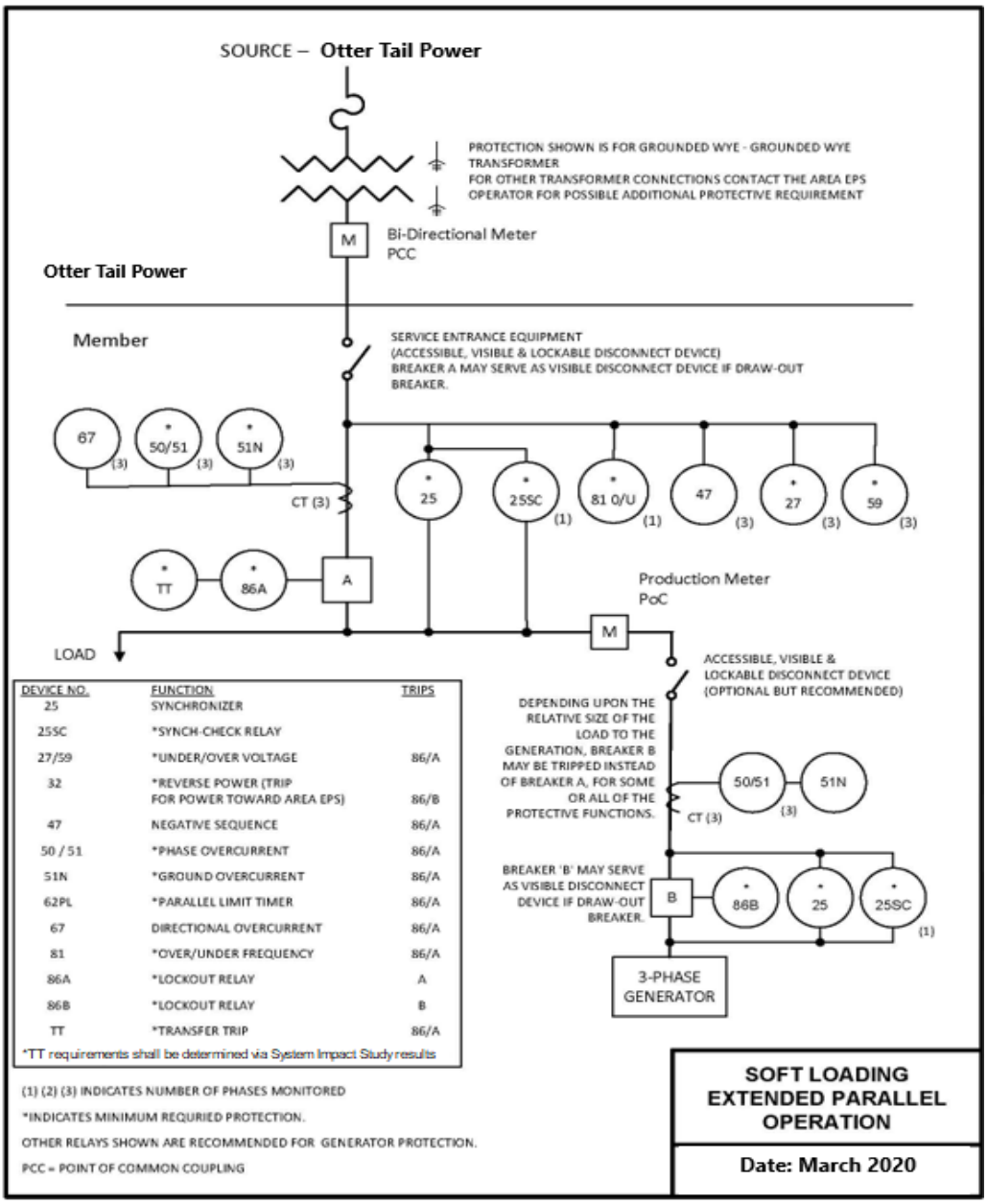

Figure 4 — General Soft Loading Extended Transition One-Line Diagram

7.5.5 Inverter Connected

This is a parallel connection between the DER and the Area EPS. Solar, wind, and energy storage systems are examples of DER which typically use inverters to convert from DC to AC and to interconnect to the Local EPS or Area EPS. See Section 7 for additional Protection requirements.

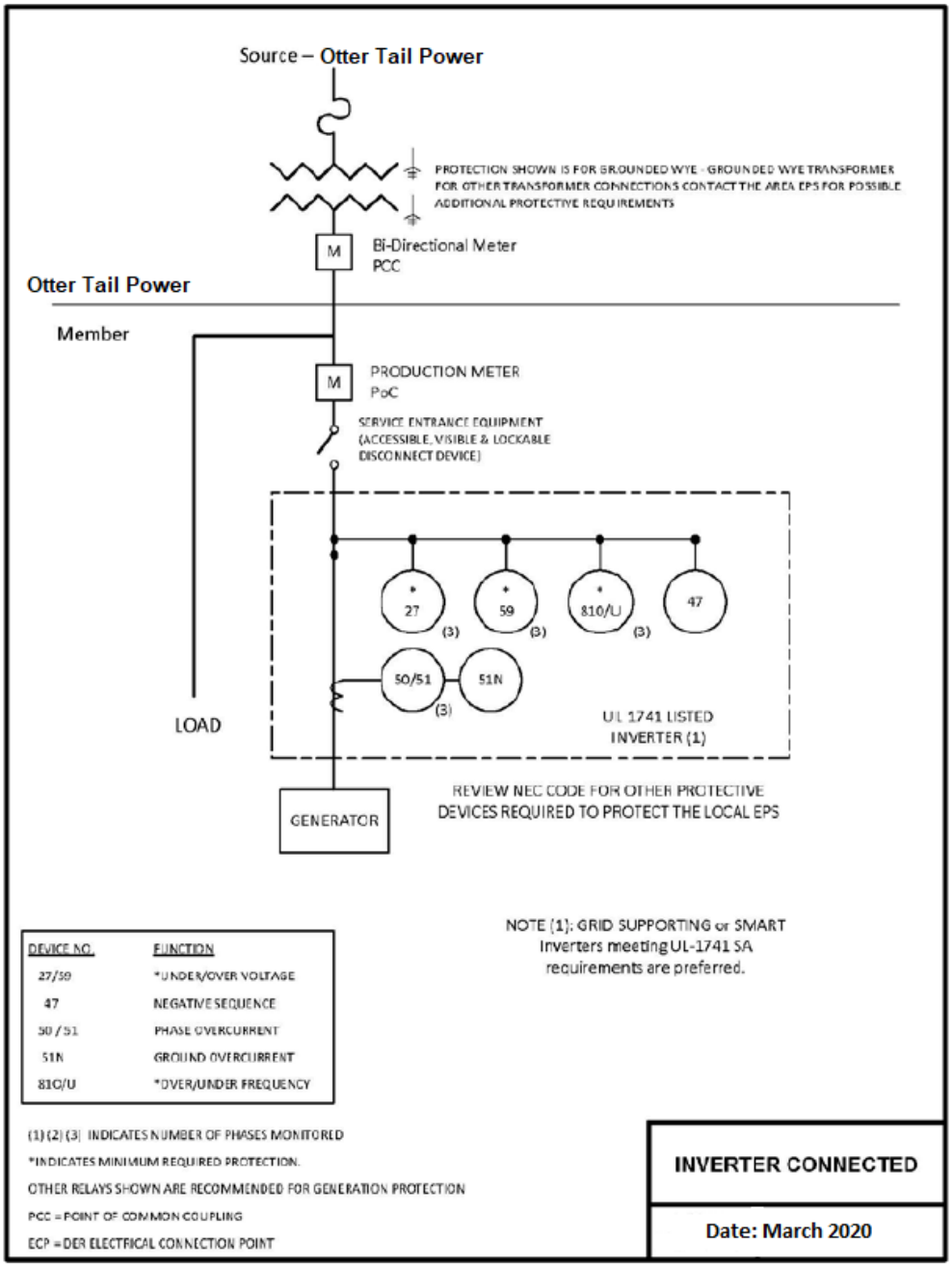

Figure 5– General Inverter Connected DER One-Line Diagram

7.6 DER Interconnection Transformers & 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.

7.6.1 Wye-Wye Transformation

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

7.6.2 Wye-Delta Transformation

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 Otter Tail's Area EPS from the grounded wye winding. All supplemental documentation shall be provided to Otter Tail for review.

7.6.3 Delta-Wye Transformation

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

8 Operations

8.1 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.

8.2 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.

8.3 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 Otter Tail.

8.4 Power Ramp Rates

To mitigate power quality and voltage step change/flicker issues, Otter Tail requires a minimum of a 5 minute (300 second) generation ramp rate to full nameplate output (20% nameplate output/minute rate).

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 Otter Tail's Area EPS voltage to go outside of the ANSI range A voltage levels, mitigation measures will be needed.

8.5 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 MN TIIR and the updated IEEE 1547-2018 standard.

9 Power Control Systems

9.1 General

Power control systems shall be NRTL certified.

9.2 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.

9.3 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.

10 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.

10.1 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.

10.1.1 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.

10.2 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.

10.2.1 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 1547-2018 document. Due to Federal Regulations, specific protocols cannot be called out in this document. Please contact Otter Tail for additional information.

10.2.2 Communications Transfer Rates

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

10.3 Security

10.3.1 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.

10.3.2 Network Security

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

11 Energy Storage

11.1 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.

11.2 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. With mechanical interlocks, it can be designed to operate as a Closed Transition or Open Transition system, per requirements outlined in Section 7.5.

If the Emergency Storage DER System is controlled by an electronic controller that is UL certified and tested, the controller must operate as if it were an open transition break-before-make switch. Mechanical interlocks are required between the two source contacts to ensure one of the contacts always remains open. Thus, the Emergency Storage DER System may never operate in parallel simultaneously with Otter Tail's Area EPS during abnormal system conditions and shall disconnect prior to transitioning between normal and emergency service.

11.3 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 9.2 and follow the security requirements in section 10.3.

11.4 Non-Exporting

Under this control mode, the IC shall provide the necessary documentation per section 9.1 and follow the security requirements in section 10.3.

11.5 Enter Service

After the loss of voltage from the Area EPS, the ESS shall follow IEEE 1547-2018 requirements to recharge and follow Section 8 of this manual to generate.

11.6 Modification of Control Modes & Inverters

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

Should the IC replace existing UL 1741 SB certified inverter(s) due to damage, age, or condition, the inverters shall be replaced "like for like" and configured utilizing the same Utility Specified Settings (URP-SS). If a "like for like" conversion is not possible or if the inverter(s) being replaced are legacy systems not certified to UL 1741 SB, then the IC will inform Otter Tail and request a Material Modification[2 above].

All new inverter(s) shall be UL 1741 SB certified and be tested for and configured to the Utility Specified Settings (URP-SS) outlined below in Section 16.

12 Metering Requirements

12.1 General Requirements

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

12.2 Location and access of metering

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

12.3 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.

12.4 Types of Metering Configurations

See Sample One-Line Diagrams in Section 15 of this TSM.

13 Signage and Labeling

13.1 General

All signage and labeling shall meet all necessary NEC Requirements.

13.2 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.

13.3 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.

14 Test and Verification Requirements

14.1 Procedure

The IC shall provide a testing procedure to Otter Tail per the MN DIP criteria. This criteria can be found below in Section 14.2.

Prior to the witness testing for all DER systems which utilize UL 1741 SB inverter technology, the DER Installer shall provide Otter Tail a -AS (Applied Settings) Utility Required Profile (URP) .CSV file with the Certification of Completion, as outlined in Section 16. This is to confirm how the inverter(s) are configured and document the response of the inverter(s).

Section 16 also contains the Otter Tail "Specified Settings" -SS URP example which details Otter Tail's required inverter configuration, based on the autonomous function settings outlined within this TSM.

An electronic .CSV file with all applicable fields completed and a picture of the inverter nameplate is required to be provided to Otter Tail to confirm and document the inverter configuration. This file is to be provided by the DER Installer to Otter Tail before or with the filing of the Certification of Completion document.

For DER systems utilizing multiple inverters of the same size and type, where all inverters have the same applied settings, the installer shall provide, from one inverter, a .CSV applied settings (-AS) URP file and a picture of its nameplate to represent the configuration and settings of the whole inverter system.

14.2 Testing Criteria for non-Simplified Process DER

14.2.1 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.

14.2.1.1 Grounding

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

14.2.1.2 Fault Current

Fault current characterization information is required in IEEE 1547-2018, 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.

14.2.1.3 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.

14.2.1.4 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.

14.2.1.5 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.

14.2.1.6 Inverters

Otter Tail requires that all inverters shall be programmed and configured per the Otter Tail Specified Settings URP (URP-SS) and any inverter power control system tested to ensure proper operation of the DER system.

The applied settings URP file format (URP-AS) shall be returned to Otter Tail prior to the witness test with the Certification of Completion and reviewed to ensure the inverter(s) configured settings conform with Otter Tail's TSM requirements.

If the DER System utilizes multiple inverters of the same size and type, then the DER Installer only needs to return one URP-AS file to Otter Tail.

Refer to Section 16 for examples of the Utility Required Profiles (URP).

14.2.1.7 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.

14.2.1.8 Phase Tests

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

14.2.1.9 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 1547-2018. 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.

14.2.2 Commissioning Test Criteria

14.2.2.1 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. The DER shall either separate from Otter Tail's Area EPS altogether or stop generating within 2 seconds, per IEEE 1547-2018.
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.

14.2.2.2 Control Modes

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

14.2.2.3 Enter Service

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

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

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

14.2.2.3.4 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.

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

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

14.2.3 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.

14.3 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 MN TIIR.

14.4 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.

15 Sample Documents for Simplified Process

15.1 One-line Diagrams

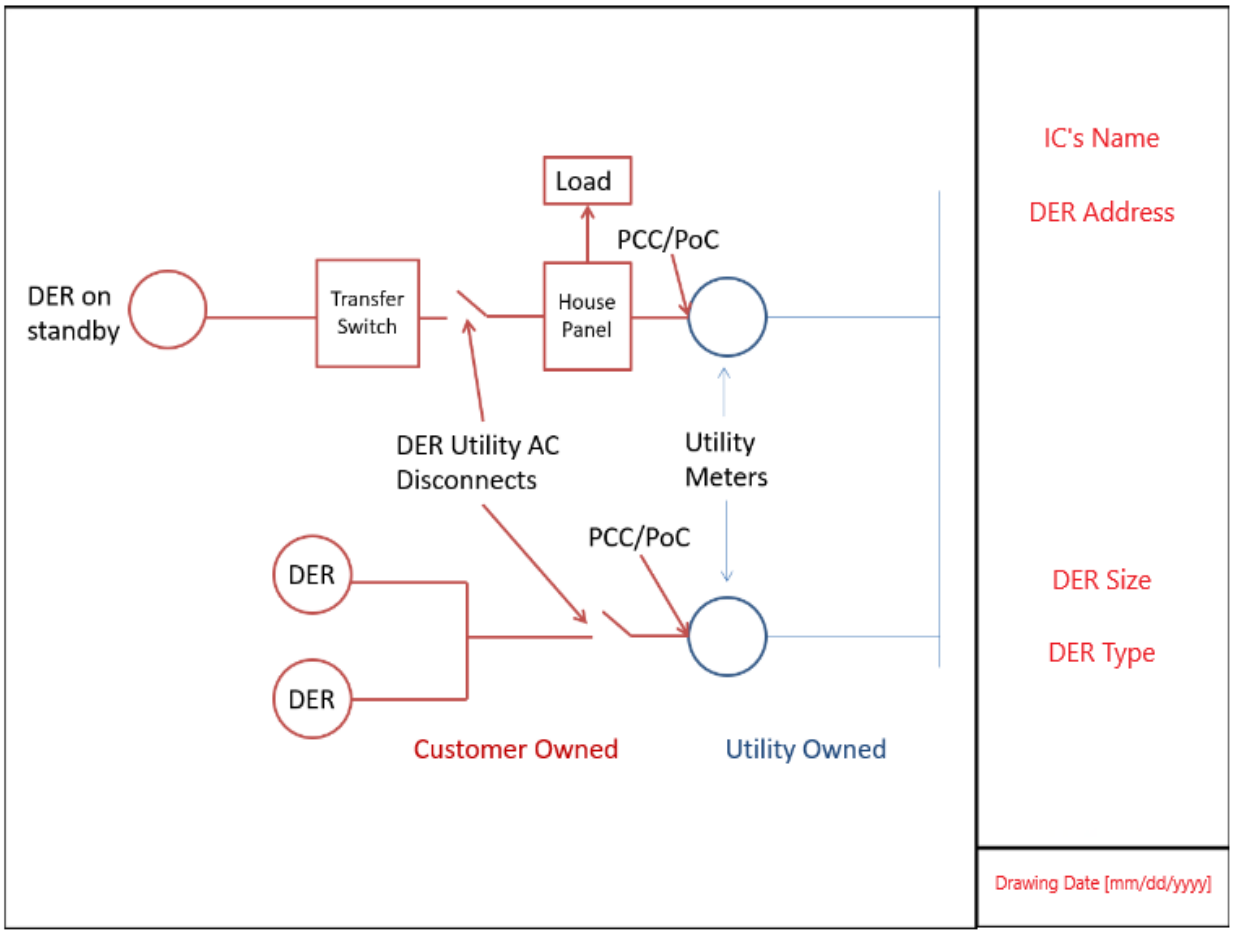

Figure 6- One-line for Load with a Separate Parallel DER Interconnection

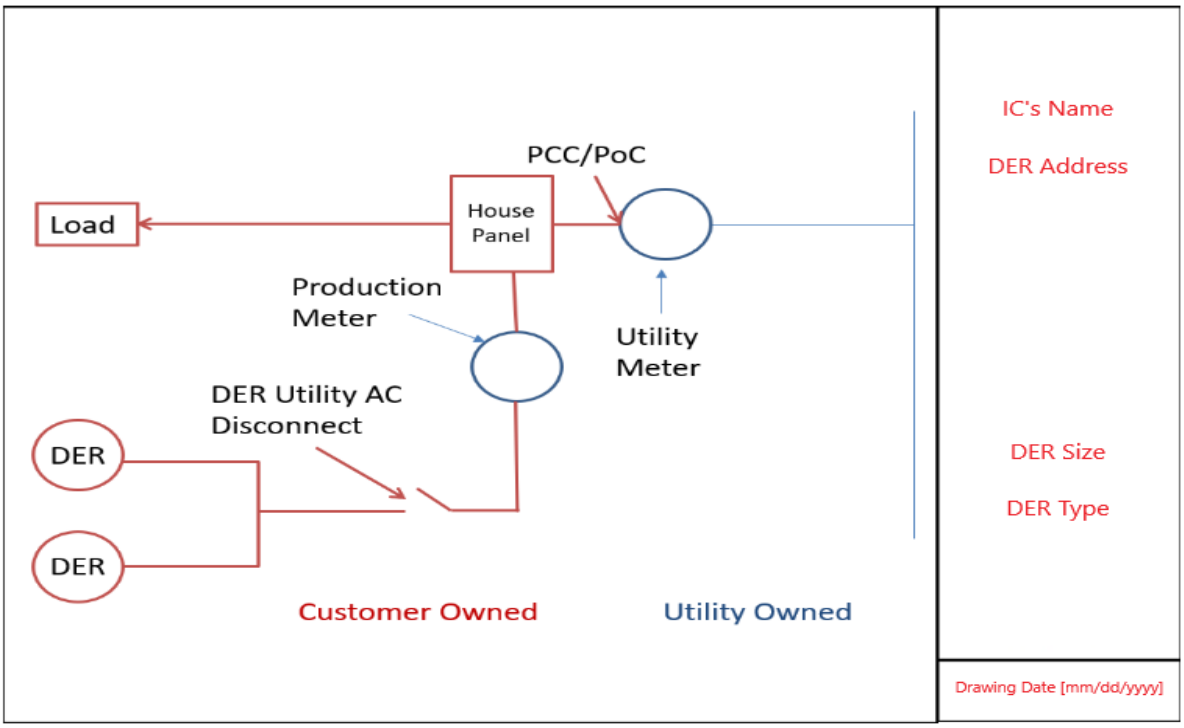

Figure 7 - One-line for Net Meter DER

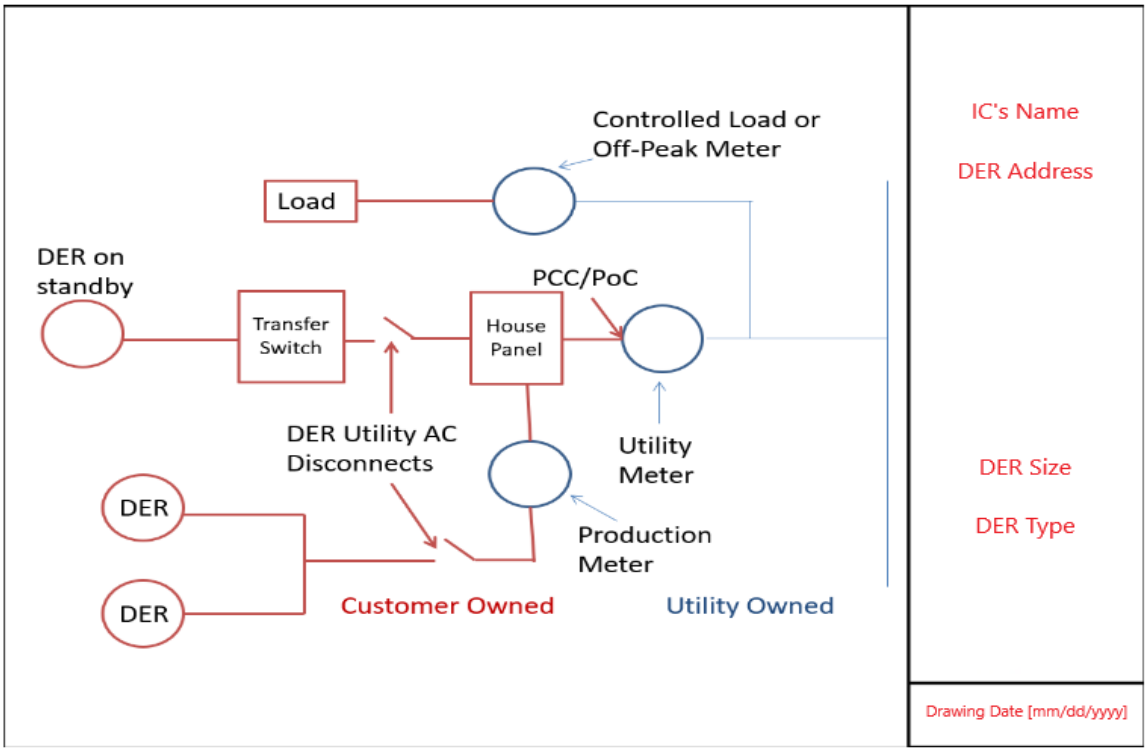

Figure 8 - One-line for DER with Controlled Load or Off-peak Meter Load

15.2 Site diagram

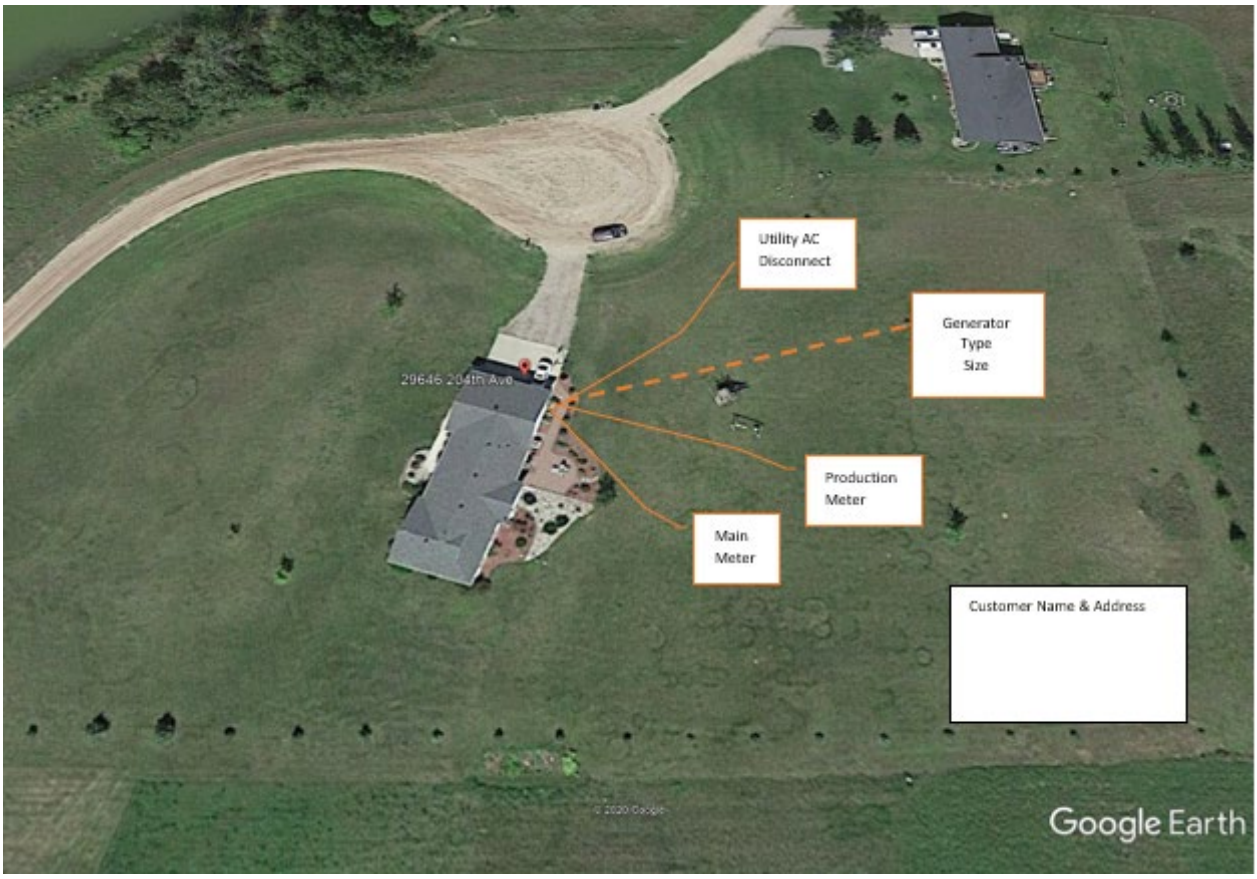

Figure 9 - Site Diagram Example

16 Utility Required Profiles for Inverter Based DER Systems

16.1 Utility Required Profile – Specified Settings (URP-SS)

Otter Tail has posted on its website, a .CSV file with the Specified Settings (-SS) outlined below, for inverter based DER systems that apply for interconnection(s) to Otter Tail's Area EPS following January 1st, 2024.

Also posted on Otter Tail's website is a .CSV file which can be used to provide the Applied Settings (-AS) of the inverter(s) back to Otter Tail prior to witness testing. An example version of the Applied Settings file with notes detailing each required field is shown below in Section 16.2.

PARAMETER	**VALUE**
COMMENT	**THESE ARE THE UTILITY SPECIFIED SETTINGS**
MT_FILE_INFO_TYPE	SS
COMMENT	**THESE SETTING ARE APPLICABLE FOR THE FOLLOWING CONDITIONS**
MT_UTILITY_NAME	OTTER_TAIL_POWER
MT_COUNTRY	United States of America
MT_STATE	Minnesota
MT_APPLICABILITY_DATE	09/01/2023
MT_POWER_CONVERSION_ DEV-APP	INVERTER
MT_NP_NORMAL_OP_ CAT-APP	CAT_B
MT_NP_ABNORMAL_OP_ CAT-APP	CAT_III
MT_NP_P_MAX-MIN-APP	0.0
MT_NP_P_MAX-MAX-APP	1000000
MT_PRIMARY_POWER_ SOURCE	SOLAR-WIND-HYDRO
COMMENT	**ENTER_ SERVICE_PARAMETERS (1547 Defaults)**
ES_PERMIT_SERVICE-SS	ENABLED
ES_V_LOW-SS	0.917
ES_V_HIGH-SS	1.05
ES_F_LOW-SS	59.5
ES_F_HIGH-SS	60.1
ES_DELAY-SS	300
ES_RANDOMIZED_DELAY-SS	0
ES_RAMP_RATE-SS	300
COMMENT	**CONSTANT_POWER_FACTOR_MODE_ PARAMETERS**
CONST_PF_MODE_ENABLE-SS	DISABLED
CONST_PF_EXCITATION-SS	ABS
CONST_PF-SS	0.98

CONST_Q_MODE_ENABLE-SS	DISABLED
CONST_Q-SS	0
COMMENT	**VOLT-VAR_MODE_PARAMETERS (1547 STANDARD VALUES)**
QV_MODE_ENABLE-SS	ENABLED
QV_VREF-SS	1.0
QV_VREF_AUTO_MODE-SS	DISABLED
QV_VREF_TIME-SS	5
QV_CURVE_V1-SS	0.92
QV_CURVE_Q1-SS	0.44
QV_CURVE_V2-SS	0.98
QV_CURVE_Q2-SS	0.0
QV_CURVE_V3-SS	1.02
QV_CURVE_Q3-SS	0.0
QV_CURVE_V4-SS	1.08
QV_CURVE_Q4-SS	-0.44
QV_OLRT-SS	5
COMMENT	**WATT-VAR_CONTROL_PARAMETERS**
QP_MODE_ENABLE-SS	DISABLED
COMMENT	**VOLT-WATT_CONTROL_PARAMETERS (1547 STANDARD VALUES)**
PV_MODE_ENABLE-SS	ENABLED
PV_CURVE_V1-SS	1.06
PV_CURVE_P1-SS	1.0
PV_CURVE_V2-SS	1.10
PV_CURVE_P2-SS	0.0
PV_OLRT-SS	10
COMMENT	**OVER_UNDER_VOLTAGE_MUST_TRIP_PARAMETERS (MISO RECOMMENDED VALUES)**
OV2_TRIP_V-SS	1.20
OV2_TRIP_T-SS	0.16
OV1_TRIP_V-SS	1.10
OV1_TRIP_T-SS	2.0
UV1_TRIP_V-SS	0.70
UV1_TRIP_T-SS	5.0
UV2_TRIP_V-SS	0.45
UV2_TRIP_T-SS	0.32
COMMENT	**OVER_UNDER_FREQUENCY_MUST_TRIP_PARAMETERS (MISO RECOMENDED VALUES)**
OF2_TRIP_F-SS	62.0
OF2_TRIP_T-SS	0.16
OF1_TRIP_F-SS	61.2
OF1_TRIP_T-SS	300.0

UF1_TRIP_F-SS	58.5
UF1_TRIP_T-SS	300.0
UF2_TRIP_F-SS	56.5
UF2_TRIP_T-SS	0.16
PF_DBOF-SS	0.036
PF_DBUF-SS	0.036
PF_KOF-SS	0.05
PF_KUF-SS	0.05
PF_OLRT-SS	5.0

Figure 10 – Example URP-SS Based on MN TIIR Requirements

16.2 Utility Required Profile – Applied Settings (URP-AS)

Below is the Applied Settings (-AS) table. A .CSV file with these fields completed is required to be provided to Otter Tail by the DER Installer prior to witness testing to confirm the inverter(s) configuration and to document the settings.

For string inverters where all inverters have the same Applied Settings, only one URP-AS .CSV file is required to be returned to the utility and will represent the configurations and settings for the whole inverter system.

All parameters are required to be filled in unless the parameter name below is in *ITALICS*.

PARAMETER	**VALUE**	**NOTES**
COMMENT	**THIS FILE IS THE AS-SET OR -AS FILE FOR THE INSTALLATION**	
MT_FILE_INFO_TYPE	AS	Context of the data in the file -SS is the utility specified settings file & -AS is the returned Applied Settings file
COMMENT	**BASIC_INVERTER_INFORMATION**	
NP_P_MAX		Active power rating in watts at unity power factor
NP_P_MAX_OVER_PF		Active power rating in watts at specified over-excited power factor
NP_OVER_PF		Over-excited power factor (VArs injected)
NP_P_MAX_UNDER_PF		Active power rating in watts at specified under-excited power factor
NP_UNDER_PF		Under-excited power factor (VArs absorbed)
NP_VA_MAX		Maximum apparent power rating in volt-amperes
NP_NORMAL_OP_CAT	CAT_B	Normal operating performance category
NP_ABNORMAL_OP_CAT	CAT_III	Abnormal operating performance category
NP_Q_MAX_INJ		Maximum injected reactive power rating in volt-amperes reactive
NP_Q_MAX_ABS		Maximum absorbed reactive power rating in volt-amperes reactive
NP_P_MAX_CHARGE		Maximum active power charge rating in watts

NP_APPARENT_POWER_ CHARGE_MAX		Maximum apparent power charge rating in volt-amperes. May differ from the apparent power maximum rating
NP_AC_V_NOM		Base nominal AC voltage rating in RMS Vac
NP_AC_V_MAX		Maximum output RMS AC voltage (VH) in the continuous operating region
NP_AC_V_MIN		Minimum output RMS AC voltage (VL) in the continuous operating region
NP_SUPPORTED_MODES	QV-QP-PV-CONST_PF-CONST_Q-PF	Indication of support for each control mode function separated by dashes
NP_REACTIVE_SUSCEPTANCE		Reactive susceptance that remains connected to the Area EPS in the cease to energize and trip state
NP_MANUFACTURER		Manufacturer
NP_MODEL		Model
NP_SERIAL_NUM		Serial number
NP_FW_VER		Firmware version
AP_LIMIT_ ENABLE		Limit active power function ENABLED or DISABLED
AP_LIMIT		Active power limit setting. Per unit value based on NP_P_MAX or NP_P_MAX_CHARGE. Negative values indicate active power absorption
COMMENT	**ENTER_ SERVICE_PARAMETERS (1547 Defaults)**	
ES_PERMIT_SERVICE-AS	ENABLED	Permit service function enable. This function is activated by request from the Area EPS Operator
ES_V_LOW-AS	0.917	Enter service voltage - low - setting. Per unit value based on NP_AC_V_NOM (voltage base)
ES_V_HIGH-AS	1.05	Enter service voltage - high - setting. Per unit value based on NP_AC_V_NOM (voltage base)
ES_F_LOW-AS	59.5	Frequency in Hz, and shall be reported to 3 decimal places
ES_F_HIGH-AS	60.1	Frequency in Hz and shall be reported to 3 decimal places.
ES_DELAY-AS	300.0	Minimum intentional enter service delay
ES_RANDOMIZED_DELAY-AS	300.0	Enter service randomized delay (optional feature in IEEE Std 1547-2018)
ES_RAMP_RATE-AS	300.0	Enter service soft-start duration in seconds. Time from zero to 100% of NP_P_MAX.
COMMENT	**CONSTANT_POWER_FACTOR_MODE_ PARAMETERS**	
CONST_PF_MODE_ENABLE-AS	DISABLED	Constant power factor mode enable.
CONST_PF_EXCITATION-AS		Under or over excited
CONST_PF-AS	0.98	Constant power factor setting, no sign should be used
CONST_Q_MODE_ENABLE-AS	DISABLED	Constant reactive power mode select.
CONST_Q-AS		Injecting reactive power setting. Per unit value based on NP_VA_MAX. Negative signs shall be used to indicate absorbing VAr.

COMMENT	VOLT-VAR_MODE_PARAMETERS (1547 STANDARD VALUES)	
QV_MODE_ENABLE-AS	ENABLED	Voltage-Reactive power mode enable.
QV_VREF-AS	1.0	Per unit value based on NP_AC_V_NOM (voltage base)
QV_VREF_AUTO_MODE-AS	DISABLED	Autonomous Vref adjustment enable.
QV_VREF_TIME-AS	5.0	Vref adjustment time constant in seconds as specified by the Area EPS operator
QV_CURVE_V1-AS	0.92	Volt-VAr point V1 setting. Per unit value based on NP_AC_V_NOM.
QV_CURVE_Q1-AS	0.44	VArs at V1 setting. Per unit value based on NP_VA_MAX. Negative signs shall be used to indicate absorbing VAr.
QV_CURVE_V2-AS	0.98	Volt-VAr point V2 setting. Per unit value based on NP_AC_V_NOM.
QV_CURVE_Q2-AS	0.0	VArs at V2 setting. Per unit value based on NP_VA_MAX. Negative signs shall be used to indicate absorbing VAr.
QV_CURVE_V3-AS	1.02	Volt-VAr point V3 setting. Per unit value based on NP_AC_V_NOM.
QV_CURVE_Q3-AS	0.0	VArs at V3 setting. Per unit value based on NP_VA_MAX. Negative signs shall be used to indicate absorbing VAr.
QV_CURVE_V4-AS	1.08	Volt-VAr point V4 setting. Per unit value based on NP_AC_V_NOM.
QV_CURVE_Q4-AS	-0.44	VArs at V4 setting. Per unit value based on NP_VA_MAX. Negative signs shall be used to indicate absorbing VAr.
QV_OLRT-AS	5.0	Volt-VAr open-loop response time
COMMENT	**WATT-VAR_CONTROL_PARAMETERS**	
QP_MODE_ENABLE-AS	DISABLED	Active power-Reactive power mode enable.
COMMENT	**VOLT-WATT_CONTROL_PARAMETERS (1547 STANDARD VALUES)**	
PV_MODE_ENABLE-AS	ENABLED	Voltage-Active power mode enable
PV_CURVE_V1-AS	1.06	Volt-Watt point V1 setting. Per unit value based on NP_AC_V_NOM.
PV_CURVE_P1-AS	100.0	Watts at point V1 setting. Per unit value based on NP_P_MAX.
PV_CURVE_V2-AS	1.10	Volt-Watt point V2 setting. Per unit value based on NP_AC_V_NOM.
PV_CURVE_P2-AS	0.0	Watts at point V2 setting. Per unit value based on NP_P_MAX or NP_P_MAX_CHARGE. Negative values indicate active power absorption.
PV_OLRT-AS	10.0	Volt-Watt - Open loop response time
COMMENT	**OVER_UNDER_VOLTAGE_MUST_TRIP_PARAMETERS (MISO RECOMMENDED VALUES)**	
OV2_TRIP_V-AS	1.20	OV2 must trip over-voltage setting. Per unit value based on NP_AC_V_NOM.
OV2_TRIP_T-AS	0.32	OV2 must trip duration setting

OV1_TRIP_V-AS	1.10	OV1 must trip over-voltage setting. Per unit value based on NP_AC_V_NOM.
OV1_TRIP_T-AS	5.0	OV1 must trip duration setting
UV1_TRIP_V-AS	0.70	UV1 must trip under-voltage setting. Per unit value based on NP_AC_V_NOM.
UV1_TRIP_T-AS	2.0	UV1 must trip duration setting
UV2_TRIP_V-AS	0.45	UV2 must trip under-voltage setting. Per unit value based on NP_AC_V_NOM.
UV2_TRIP_T-AS	0.16	UV2 must trip duration setting
COMMENT	**OVER_UNDER_FREQUENCY_MUST_TRIP_PARAMETERS (MISO RECOMENDED VALUES)**	
OF2_TRIP_F-AS	62.000	OF2 must trip over-frequency magnitude setting. Frequency values shall be reported to 3 decimal places.
OF2_TRIP_T-AS	0.16	OF2 must trip duration setting
OF1_TRIP_F-AS	61.200	OF1 must trip over-frequency magnitude setting. Frequency values shall be reported to 3 decimal places.
OF1_TRIP_T-AS	300.0	OF1 must trip duration setting
UF1_TRIP_F-AS	58.500	UF1 must trip under-frequency magnitude setting. Frequency values shall be reported to 3 decimal places.
UF1_TRIP_T-AS	300.0	UF1 must trip duration setting
UF2_TRIP_F-AS	56.500	UF2 must trip under-frequency magnitude setting. Frequency values shall be reported to 3 decimal places.
UF2_TRIP_T-AS	0.16	UF2 must trip duration setting
PF_DBOF-AS	0.036	Over frequency deadband offset from nominal frequency in Hz. Frequency values shall be reported to 3 decimal places.
PF_DBUF-AS	0.036	Under frequency deadband offset from nominal frequency in Hz. Frequency values shall be reported to 3 decimal places.
PF_KOF-AS	0.05	Over frequency per unit frequency change corresponding to a 1 per unit power change (frequency droop).
PF_KUF-AS	0.05	Under frequency per unit frequency change corresponding to a 1 per unit power change (frequency droop).
PF_OLRT-AS	5.0	Frequency-Active power open-loop response time

Figure 11– Example URP-AS Based on Otter Tail's URP-SS