NETWORK DISTRIBUTION ENERGY RESOURCES (DER) CONNECTION ENGINEERING GUIDELINE

1.0 PURPOSE AND SCOPE

1.1 Purpose

The purpose of this document is to describe the Ameren **Network DER (Distributed Energy Resources) Connection Engineering Guideline** requirements, in terms of the requirements provided to the customer relative to a proposed DER connection to Ameren Missouri's grid or spot network system, and to provide guidelines for engineering review of the proposed DER connection. DER connections to the Ameren Missouri (or Company) network distribution system, if the Company requirements are not met, can result in damage to Company equipment and service disruptions.

1.2 Scope

The scope of this document provides recommended criteria and practices for interconnection of Distributed Energy Resources (DER) to a secondary network area grid or spot network, in accordance with current Company requirements and industry standards and recommendations. This document is written to meet IEEE 1547.6 - Recommended Practice for Interconnecting Distributed Recourses with Electric Power Systems Distributed Secondary Networks (current edition). Company requirements include meeting the requirements of Ameren Missouri Renewables, the Ameren Electric Service Manual, Company tariffs filed with the MOPSC, and this document.

Throughout this specification Ameren and/or Ameren Missouri is also referred to as the "Company." References to the Customer, or the Customer's design professionals, contractors, or representatives, shall be referred to as the "Customer."

1.3 Background

Ameren Missouri has four low voltage grid networks, at 216Y/125V, and multiple 480Y/277V spot networks. Grid networks serve multiple customers over a wide dense urban area while spot networks serve a single customer or a group of customers at a particular location. Network systems are very reliable because service is not interrupted at the loss of one or more primary feeders. Under normal conditions, grid and spot networks operate with all network protectors (NWP) closed, sharing all customer loads between all transformers – in practice, the closest transformers to the load centers see most of the loading impact. NWP electronic relays are set to open on reverse real power current (as little as 1-2 watts), to clear reverse fault current flow to a faulted primary feeder cable. The NWP electronic relay also supervises NWP automatic closing if the voltage magnitude and phase relationship with the grid or spot network

meets the closing criteria. The ability of the NWP to properly clear reverse current power flows into the network grid or spot network can be put into jeopardy with a connected DER to the network distribution system that does not meet the requirements outlined in this document.

In addition to potentially impeding the ability of the NWP to clear faults, DER systems can result in NWP cycling, hampering the ability of NWPs to self-restore (prevent closing), nuisance tripping, and islanding (total service outage to the customer).

2.0 DEFINITIONS AND ABBREVIATIONS

2.1 Abbreviations

2.1.1 **C_{DER}** – Capacity of the DER in kW

2.1.2 **DER** – Distributed Energy Recourses [photovoltaic or "solar," batteries, or motor-generator sets (induction or synchronous)]

2.1.3 **kV** – kilo (1000) Volts

2.1.4 **kVA** – kilo (1000) Volt-Amperes (Apparent Power)

2.1.5 **L_{MIN} –** minimum customer load levels in kW (without DER)

2.1.6 **MLS –** Minimum Load Setting

2.1.7 **MIR –** Minimum Import Relay

2.1.8 **MOPSC –** Missouri Public Service Commission

2.1.9 **NW –** Network

2.1.10 **NWP** – Network Protector

2.1.11 **OCPD** – Over Current Protective Device

2.1.12 **PV** - Photovoltaic or "solar"

2.1.13 **RLS –** Restoration Load Setting

2.1.14 **SWBD** – Switchboard (≤ 600 V installations)

2.1.15 **SWGR** – Switchgear (typically for ≥ 601V installations)

2.1.16 **TCC** – Time Current Curve

2.1.17 **3∅** – Three Phase

2.1.18 **XFMR** – Transformer

2.2 Definitions

2.2.1 **Cycling** – The occurrence where the NWP breaker experiences a significant number of open-close operations during the daily load cycle, prompted by small changes in customer loads or from the primary feeders supplying the spot network. This is typically a spot network phenomenon, but it can occur on a grid network in locations that mimic a spot network because that location is a concentrated load center with multiple NWPs.

2.2.2 **DER Network Interconnect Impact Study (DERNIIS)** – Engineering study to determine feasibility to interconnect proposed customer DER to the network distribution system and to determine the MIR/MLS settings for the protection schemes.

2.2.3 **Minimum DER Load** – Relative to PV installations, this is the minimum 24-hour cycle loading of the customer, assuming maximum PV kW output. The MLS is based on the Minimum DER Load in kW.

2.2.4 **MLS and RLS Settings** – MLS or Minimum Load Setting is the DER set point for customer load - DER (rated output) in kW, supplied from the spot or grid where the DER would be curtailed by remote trip. The RLS is the restoration load setting to return the DER system back to service after an MLS remote trip, once load levels have exceeded the RLS. The Company may require the MLS to be set at a higher kW load level, if necessary, to prevent a spot network protector to open on low loading, even with circle close enabled.

2.2.5 **PV AC Rating** – The LESSER of the customer inverter AC nameplate rating or 95% of the customer PV equipment DC rating. The PV AC rating is used to determine the customer PV equipment VA apparent power rating.

3.0 AMEREN REQUIREMENTS AND CRITERIA FOR INTERCONNECTING DER SYSTEMS TO GRID OR SPOT NETWORKS

3.1 General

The following sections provide DER interconnect requirements and criteria when a customer proposes to interconnect to the Ameren Missouri network distribution system – either for a grid or a spot network system interconnect request. Section 3.2 of this document provides the basic requirements for DER interconnect on a Company network system.

3.2 Customer Network Distribution System DER Connection Requirements

Customer Requirements for Network Distributed Recourses Interconnect Requests - Any customer requesting to connect Distributed Recourses (DER) – i.e. solar voltaic, batteries, or motor generators – for the purposes to of net-metering (not emergency or standby generation) - to either the low voltage grid network (216Y/125V) or a spot network (480Y/277), shall comply with the following requirements as a condition of service, in addition to the standard requirements and procedures for service, as stated the Company tariffs filed with the MOPSC and the Ameren Electric Service Manual:

3.2.1 Submit a Customer DER interconnect request to Ameren Missouri Renewables for initial review. MO Renewables ensures the customer is aware of Ameren Electric Service Manual requirements and the network distribution system requirements as provided within this document. MO Renewables with then provide the customer interconnect request to Underground Engineering for review and approval.

3.2.2 MO Renewables will complete the normal DER documentation with the customer.

3.2.3 Underground Engineering will review the request for determination whether the proposed new DER interconnect is a grid or spot network system connection, if the proposed DER system can be connected to the network distribution system (by meeting the Company requirements within this document), or if the customer will be required to take service (new or conversion) from the radial distribution system.

3.2.4 If a DER network interconnect, the Company will provide MO Renewables customer drawing and equipment review comments, MLS and RLS setting criteria, and approval for customer construction.

3.2.5 If a DER network interconnect, upon completion of customer system construction, the Company will test the system for compliance.

3.2.6 If the customer proposed DER maximum output is greater than the maximum customer load, and the customer desires to sell power back to the Company, then the Customer will be required to be served from the radial distribution system and enter into a Paralleling Operating Agreement with Ameren Missouri.

3.2.7 The proposed DER installation shall comply with the latest versions IEEE 1547.6 Recommended Practice for Interconnecting Distributed Recourses with Electric Power Systems Distributed Secondary Networks, whose requirements are fulfilled by meeting the requirements within the guideline document. Customer equipment compliance shall include protection schemes to:

3.2.7.1. Prevent any real power reverse flow into the network from the customer DER equipment

3.2.7.2. Prevent any fault current flow (real and reactive) into the network from the customer DER equipment

3.2.7.3. Monitor DER kW output and curtail by remote trip of the customer DER systems when reaching Ameren determined minimum customer loading levels, including time for MLS set point to be detected, time for the disconnect command to be communicated, and time for remote tripping by the main disconnect switch.

3.2.8 The customer shall provide submittals, to include protection scheme description to show compliance with the Network Distribution Resources (DER) Connection Engineering Guideline requirements, and other related OEM equipment sheets, for Company review and approval, **or…**

3.2.9 Take service from the radial distribution system where any IEEE 1547.6 related restrictions would not apply – if the proposed DER connection request is for an existing network supplied service, and if the proposed DER equipment is not IEEE 1547.6 compliant, the customer shall incur all costs for the Company to convert the existing network supplied service to the radial system

3.2.10 One year of load data - a minimum of one summer and winter load cycle data – captured from Company revenue metering, for a customer DER connection request where Company metering already exists. If the customer DER interconnect request to Ameren Missouri Renewables is part of a proposed new business customer service connection project (where one year's load data is not available), the default MLS and

RLS settings shall apply. For most network DER service requests, the default MLS and RLS settings will be adequate.

3.3 Customer Submittals

3.3.1 Customer one-lines shall show all existing customer distribution system equipment (main OCPD/disconnect) and any other relevant customer equipment switching points, the Ameren service connection point, the proposed DER connection, and protective control devices. Other technical document submittals include OEM DER equipment sheets (in particular, the PV-AC rating); MIR OEM relay type and settings, wiring diagrams (single and 3-wire diagrams) that show the protection scheme and location of the relaying CTs. The OEM 1-lines shall indicate the DER total kW output.

3.3.2 Customer protection scheme submittals shall include OEM single line and 3-line wiring diagrams and descriptions to clearly show how the DER protection scheme will prevent reverse power flow by monitoring the kW output, and will disconnect the DER system or take it "offline," when customer loading levels reach the MLS load levels, as specified by Ameren.

3.3.3 The Customer shall provide a report to indicate the required settings have been set on the DER MIR.

3.4 DER Protection Scheme MIR Settings/Requirements

3.4.1 MIR shall monitor customer loading and if feasible, DER output; relaying CTs shall be shown on the protection scheme single and 3-wire diagrams to meet this requirement.

3.4.2 The protections scheme shall specify the MIR relay and the OEM's recommended time delay in cycles or seconds.

3.4.3 MIR shall include device 32 reverse power relay (or equivalent) to sense reverse current and provide an immediate command to open a switch (remote trip) to isolate the DER system from the network.

3.4.4 MIR shall curtail or disable DER generation below the MLS default setting at 150% of the DER maximum kW output.

3.4.5 Following a device 32 reverse power operation or rapid loss of load, the MIR shall disable the DER system until customer loading levels achieve default setting 250% of the DER maximum kW output (RLS setting).

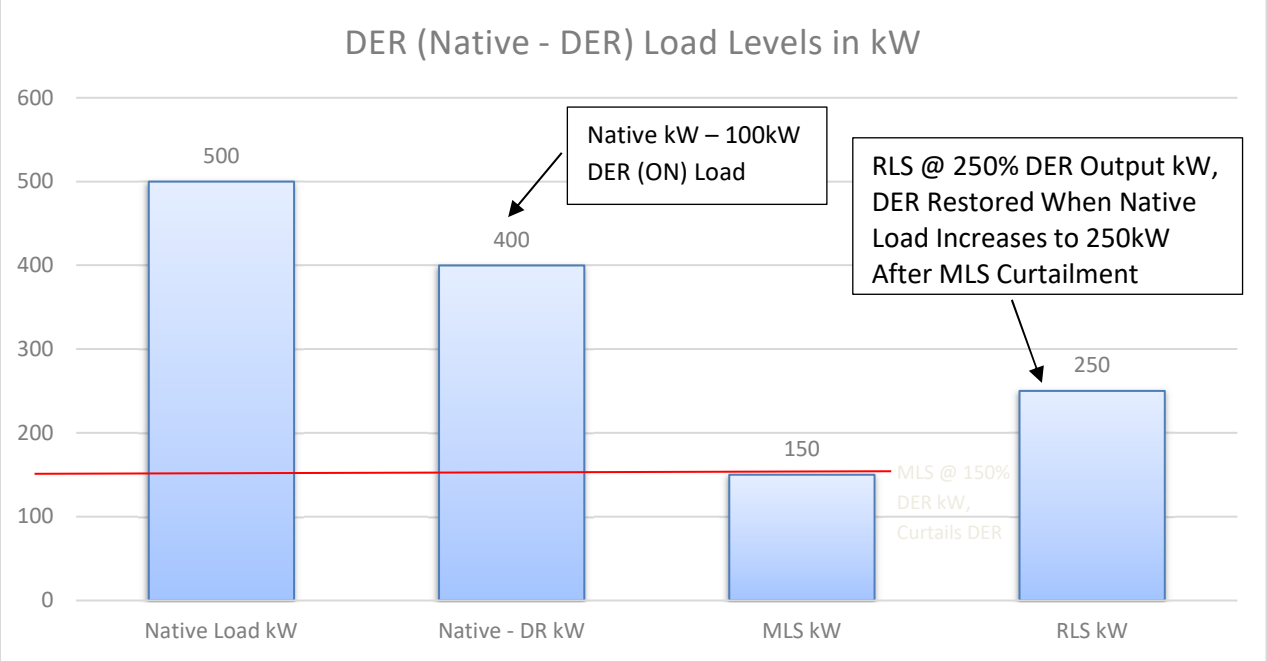

Table 1 – 100kW DER Example of Load Max-Min and Typical MLS and RLS Load Levels

4.0 ENGINEERING STUDY

4.1 DER Network Interconnect Impact Study - General

A load study for the customer contemplating a DER connection to either a Company grid or spot network shall be required for DER installation, called a DER Network Interconnection Impact Study (DERNIIS). The DERNIIS is used to determine if the default MLS and RLS settings need to be amended based on a particular network customer's load profile (summer and winter minimum-peak loading), at the time of the network DER request. If for an existing customer with ≥ one year of load data, the DERNIIS would be completed at the time of the Customer DER interconnect request to Ameren Missouri Renewables. If a new business customer, then the initial DERNIIS would be completed at the Customer DER interconnect request to Ameren Missouri Renewables and then again after a minimum of one year's load data has been captured to establish permanent MLS and RLS settings.

4.2 Engineering Study Elements and Other Recourses

The following is a list of resources and other information required to capture data and to simulate the proposed DER system and its impact on the Company network distribution system.

- The propose new DER customer shall be an MV-90 customer with an interval meter, to capture one year's maximum and minimum kW demand
- Separate – additional metering may be required to capture 1-year maximum and minimum kW demand data at the customer tap box or the network service compartment
- Weather data – NOAA
- ADMS for network protector and network feeder data

Acknowledgments

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