All Distributed Energy Resources (DER) requirements are subject to Company's Minimum Requirements for Interconnection Service and Ohio Administrative Code 4901:1-22 (OAC). These Technical Requirements by the Company shall not be in conflict with any requirements in the OAC. It is acknowledged that IEEE Standard 1547 "Standard for Interconnecting Distributed Resources with Electric Power Systems" (IEEE 1547)[11] is the basis for interconnection Technical Requirements for most jurisdictions. The intent is to utilize IEEE 1547 requirements and to supplement those with a minimal number of additional requirements where appropriate. The purpose of a minimal number of Company requirements not included in IEEE 1547 is to add clarity to some IEEE 1547 sections and to specify requirements for issues not addressed in IEEE 1547. These Technical Requirements apply to all DER technologies including synchronous machines, induction machines, or static power inverters/converters.

The interconnection system hardware and software used by a DER to meet these Technical Requirements do not have to be located at the Point of Common Coupling. However, the Technical Requirements shall be met at the Point of Common Coupling.

A table summarizing the DER Technical Requirements is attached as Appendix 1. The pertinent IEEE 1547 clause number(s) are shown in this table.

Basic Technical Requirements:

The Technical Requirements in IEEE 1547 cover the following areas, Voltage Regulation, Voltage Disturbances, Harmonic Current Injection, Direct Current Injection, Grounding Scheme Compatibility, Inadvertent Energizing, Monitoring Operation, Isolation Device, Withstand Performance, Paralleling Device, Response to Area EPS Faults, Reclosing Coordination, Unintentional Islanding, Voltage and Frequency Detection, Abnormal Voltage or Frequency, Reconnection Following a Disturbance, Secondary Grid and Spot Network Systems, and Testing and Maintenance.

Testing:

A DER proposing to interconnect with the Company's transmission and distribution systems (AEP Ohio System) must be tested as per IEEE 1547 Clause 5 to demonstrate that the interconnection system meets the requirements of IEEE 1547 Clause 4. Documentation of the results of the Design Test and Production Tests shall be provided to AEP Ohio at the time of application unless such tests are to be conducted as part of the Commissioning Tests.

When the interconnection system of the DER uses an assembly of discrete components, documentation of testing must be provided to AEP Ohio at the time of application to confirm the compatibility of the discrete components to properly function together. Otherwise, AEP Ohio may require the Design Test to be conducted as part of the Commissioning Tests.

Written test procedures shall be approved by AEP Ohio for all tests to be performed as Commissioning Tests. To avoid delay, these test procedures should be submitted to AEP Ohio well in advance of the scheduled date of the Commissioning Tests.

Additional Technical Requirements:

Circuit Breaker - If a main circuit breaker (or circuit switcher) between the interconnection transformer and the AEP Ohio System is required, the device must comply with the applicable

[1] IEEE publications are available from the Institute of Electrical and Electronics Engineers, 443 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331 (http://standards.ieee.org/)

current ANSI Standard from the C37 series of standards that specifies the requirements for circuit breakers, reclosers and interrupting switches.

Main Disconnect Switch – A readily accessible, lockable, visible-break isolation device shall be located between the Area EPS and the DER.

- AEP standards require a single isolation device between the Area EPS and all DER Facilities at a customer's premise. This is to allow the company to isolate all DER Facilities with a single operation.
    - Exceptions to the single isolation device standard are at the discretion of the Area EPS Operator and require prior approval. Exceptions will only be considered following a written request from a Professional Engineer stating the necessity for multiple isolation devices.
- The isolation device shall be installed in addition to any other disconnect type devices that may be required by other applicable codes or standards.
- The isolation device may be required to be fused or non-fused by the Area EPS Operator. It may be required to be properly fused for the size (ampacity) of the wires in a "line side tap" connection configuration, or to be non-fused when the disconnect is not intended to provide overcurrent protection.

Note: AEP strongly encourages all customers to ensure that their important loads are not electrically behind the DER isolation switch so that the load can continue to be served by AEP even when the DERs must be isolated by opening this switch.

- AEP standards require that the isolation device should be immediately adjacent to the AEP meter (within 6 feet and between 4 to 6 feet above grade) and be clearly marked with labeling that easily identifies the DER Disconnect Switch which will isolate energized equipment from the utility grid. Figures 3, 4, and 5 below are presented as examples for consideration.
    - Exceptions to the standard location for the isolation device requires prior approval by the Area EPS Operator and will only be considered following a written request stating the necessity for an exception.
    - If the Area EPS Operator approves an exception for the location of the disconnect, a permanent plaque must be placed next to the existing meter clearly stating the location of the isolation device at the premise.

Figure 3: Sample Labeling

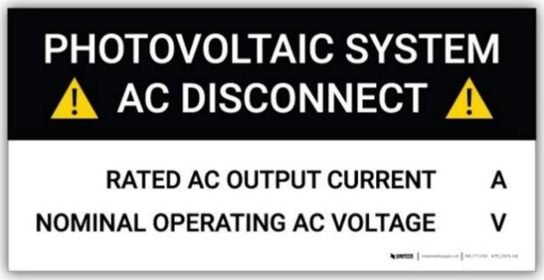

Figure 4: Sample Labeling

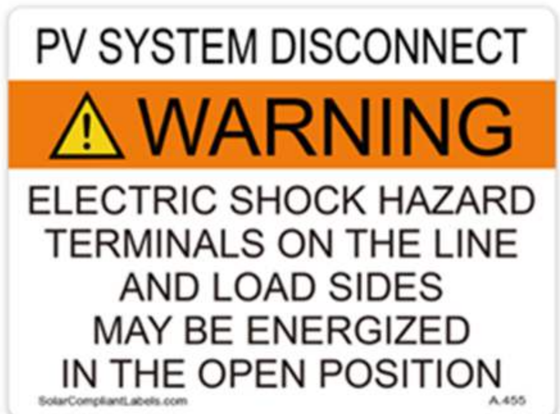

Figure 5: Sample Labeling

- AEP expects this isolation device to be properly maintained in good working condition by the interconnecting DER Customer. Where used for isolation of a DER unit that continues to produce voltage after isolation from the Area EPS, the isolation device shall be capable of withstanding 220% of the DER rated voltage across the device for an indefinite duration.
- A knife-blade switch that conforms with the National Electric Code and has a visible break/open is an example of an appropriate isolation device for overhead installations.
- The disconnect switch itself must be readily accessible, lockable, visible-break isolation device such that AEP Ohio can lock the position of the switch in place using a padlock (a lockable cover on the switch does not meet this requirement), and plainly indicate whether it is in the open (off) or closed (on) position.

Terminating Structure – When a new interconnection line is required, the interconnection customer shall provide a suitable structure to terminate the interconnection line. The customer is responsible for ensuring that terminating structure or substation structural material strengths are adequate for all requirements, incorporating appropriate safety factors. AEP Ohio will provide line tension information for maximum dead-end. The structure must be designed for the maximum line tension along with an adequate margin of safety.

Substation electrical clearances shall meet or exceed the requirements of the National Electrical Safety Code. Installation of disconnect switches, bus support insulators and other equipment shall comply with accepted industry practices.

Surge arresters shall be selected to coordinate with the BIL rating of major equipment components and shall comply with recommendations set forth in the applicable current ANSI Standard C62.2 that specifies the requirements for surge arresters and other surge protection devices.

Momentary Paralleling – For situations where the proposed DER will only be operated in parallel with the AEP Ohio System for a short duration (less than 100 milliseconds), as in a make-before-break automatic transfer scheme, the requirements of IEEE 1547 do not apply except as noted in Clause 4.1.4. All make-before-break automatic transfer switch systems proposed by the interconnection customer must comply with UL 1008 and be listed by a nationally recognized testing laboratory.

Voltage Unbalance – The interconnection customer is responsible for operating the proposed DER such that the voltage unbalance attributable to the DER does not exceed 2.5% at the Point of Common Coupling.

Power Factor - Each DER shall be capable of operating at some point within a power factor range from 0.9 leading to 0.9 lagging. Operation outside this range is acceptable provided the reactive power of the DER is used to meet the reactive power needs of the electrical loads within the interconnection customer's facility or that reactive power is otherwise provided under tariff by AEP Ohio. The interconnection customer shall notify AEP Ohio if it is using the DER for power factor correction.

System Stability – AEP Ohio may require a stability study for DERs if the aggregate generation is greater than 10 MW and in an area where there are known or posted stability limitations to generation located in the general electrical vicinity (e.g., three or four transmission voltage level busses from the transmission voltage bus serving the distribution circuit where the DER proposes to interconnect.

Maintenance and Testing – The interconnection customer is responsible for the periodic scheduled maintenance on the interconnection system of the DER (relays, interrupting devices, control schemes, and batteries that involve the protection of the AEP Ohio System). Unless the equipment manufacturer provides study results that demonstrate the need for less frequency, interconnection systems that depend upon a battery for proper function shall be checked and logged once per month for proper voltage. At least once every four years, the battery must be either replaced or a discharge test performed.

A periodic maintenance program is to be established in accordance with the requirements of IEEE-1547. AEP Ohio may examine copies of the periodic test reports or inspection logs associated with the periodic maintenance program. Upon request, AEP Ohio shall be informed of the next scheduled maintenance and be able to witness the maintenance performed and any associated testing.

Monitoring – AEP Ohio reserves the right, at AEP Ohio's initial expense, to install special test equipment as may be required to perform a disturbance analysis and monitor the operation and control of the DER to evaluate the quality of power produced by the DER.

Evaluation of System Impact:

A DER proposing to interconnect to the AEP Ohio System may have significant impact on the safety and reliability of one or more of the following portions of the electrical power system; the AEP Ohio Distribution System, the AEP Ohio Transmission System, the Distribution or Transmission System of a third party (called an Affected System) and the electrical system where the DER is to be connected. AEP Ohio shall not be responsible for the evaluation of the safety and reliability impacts on the electrical system where the DER is to be connected. AEP Ohio approval of a DER interconnection should not be construed as an endorsement, confirmation, warranty, guarantee, or representation concerning the safety, operating characteristics, durability, or reliability of the DER facility and the electrical system where it is connected.

AEP Ohio Distribution System Impact —

AEP Ohio is responsible for evaluating the system impact of a proposed DER interconnection based upon the information provided in the interconnection application once the application is considered complete.

A study to determine system impact will be performed based upon the interconnection request's position in the Queue and the applicable time limits established by the regulatory authority having jurisdiction. The study time limits and study scope vary depending upon the regulatory authority and the type, size and proposed use of the DER..

AEP Ohio supports limited study and the use of a screening process to expeditiously identify and approve DERs that can be interconnected without significant system impact AEP Ohio screening criteria is based on the OAC.

Additional study time is generally required to evaluate DERs that are not pre• certified. The exception may be for DERs that have been evaluated previously by AEP Ohio and were found to meet the Technical Requirements including the necessary testing.

The possible outcomes of the system impact study could include the following:

1) The proposed DER interconnection meets the Technical Requirements and there are no system impacts that would require modification or upgrade to either AEP Ohio facilities or the DER installation;

2) The proposed DER interconnection does not meet the Technical Requirements and modifications or changes are required to either AEP Ohio facilities or the DER installation;

3) The proposed DER interconnection would result in negative system impact and modifications or changes are required to either AEP Ohio facilities or the DER installation;

4) The proposed DER interconnection requires new AEP Ohio facilities.

The potential distribution system impacts listed in Appendix 2 may need to be examined as part of the system impact study.

AEP Ohio Transmission System Impact –

AEP Transmission will determine if there may be an impact to the AEP Ohio transmission system (including any transmission system stability impact) or an impact to a third party's system when the interconnection occurs on the AEP Ohio distribution system.

AEP Ohio will coordinate processing the interconnection request to assure the proper process is followed and all required milestones are met.

Affected System Impact –

AEP Ohio will review each request for interconnection to the AEP Ohio distribution system to determine if the potential exists for impact to a third party's system. For example, the distribution systems of several Rural Electric Cooperatives are interconnected to AEP Ohio distribution feeders.

If the potential exists for an impact to their system, AEP Ohio will notify the third party of the proposed interconnection request and coordinate processing the interconnection request to assure that the proper process is followed and all required milestones are met.

Appendix 1

Distributed Energy Resource Technical Requirements

Attribute	Requirement
Voltage Regulation	IEEE 1547 - Clause 4.1.1
Voltage Disturbances	IEEE 1547 - Clause 4.3.2
Harmonic Current Injection	IEEE 1547 - Clause 4.3.3
Direct Current Injection	IEEE 1547 - Clause 4.3.1
Grounding Scheme Compatibility	IEEE 1547 - Clause 4.1.2
Inadvertent Energization	IEEE 1547 - Clause 4.1.5
Monitoring Provisions	IEEE 1547 - Clause 4.1.6
Isolation Device	IEEE 1547 - Clause 4.1.7
Withstand Performance	IEEE 1547 - Clause 4.1.8.1 and Clause 4.1.8.2
Paralleling Device	IEEE 1547 - Clause 4.1.8.3
Response to Area EPS Faults	IEEE 1547 - Clause 4.2.1
Reclosing Coordination	IEEE 1547 - Clause 4.2.2
Unintentional Islanding	IEEE 1547 - Clause 4.4.1
Abnormal Voltage	IEEE 1547 - Clause 4.2.3
Abnormal Frequency	IEEE 1547 - Clause 4.2.4
Reconnection Following a Disturbance	IEEE 1547 - Clause 4.2.6
Secondary Grid and Spot Network Systems	IEEE 1547 - Clause 4.1.4
Testing	IEEE 1547 - Clause 5
Periodic Interconnection Tests	IEEE 1547 - Clause 5.5
Circuit Breaker	Meet appropriate ANSI C37 standard
Disconnect Switch	Single isolation device between the Area EPS and all DER connecting to the Area EPS at a customer's premise
Terminating Structure	Adequate structural material strength suitable to terminate line
Surge Arresters	Meet applicable ANSI C62.2 standard
Momentary Paralleling	Comply with Underwriter's Laboratories Standard 1008 and IEEE 1547 – Clause 1.3
Voltage Unbalance	Unbalance attributable to DER 2.5% or less
System Stability	Study required for units greater than 10 MW when limitations exist

Appendix 2

Potential Distribution System Impacts

Voltage Regulation - With the addition of the DER, the voltage level on both the primary and secondary must be maintained within acceptable limits for both on peak and off peak conditions.

1) Reverse power flow through voltage regulators or load tap changers may cause the regulator or load tap changer to regulate the voltage incorrectly.

2) Improper settings of the DER controls may result in the steady state voltage straying outside the + or - 5% limits at the point of common coupling on a 120 volt basis.

3) Low voltage may be experienced after a temporary fault or when restoring service after a permanent fault if the presence of the DER is essential to the maintenance of adequate voltage.

4) The loss of DER synchronous machine exciters may cause excessive reactive power losses and low voltages on a circuit.

5) The presence of DERs with varying output (e.g. wind turbines, photovoltaic cells, etc.) may cause excessive switching of capacitor banks and/or an excessive number of regulator or load tap changer operations.

6) When line drop compensators are used on a circuit, the presence of DERs may significantly alter the intended regulation scheme.

7) The presence of DERs on a secondary system may cause the off peak voltage level to exceed its upper limit.

8) The DER owner could experience periods when his unit(s) trips off line from overvoltage due to system voltage excursions.

Voltage Flicker - Several DER technologies have the potential for creating objectionable voltage flicker. In extreme cases the size of the DERmay need to be limited to prevent objectionable flicker or system improvements may be necessary to limit the voltage flicker. Possible flicker sources include:

1) Wind turbines may produce rapidly varying output due to changes in wind speed, wind turbulence, intensity, tower shadowing effects and blade pitching.

2) Photovoltaic (PV) installations may produce rapidly varying output due to intermittent cloud cover over the cells.

3) Reciprocating engine DERs may produce rapid output fluctuations caused by engine misfiring due to low quality fuel.

4) Induction machine DERs may produce voltage flicker due to current inrush when they are connected.

5) Synchronous machine DERs may produce voltage flicker due to poor voltage matching and phase angle synchronization at contact closure.

6) Power inverter based DERs may not have soft start technology to limit the rate of change of power output at starting.

7) Interaction of DERs with other devices such as voltage regulators, load tap changers and switched capacitor banks may produce objectionable voltage flicker.

Overcurrent Protection and Protective Device Coordination - With the addition of a DER on a circuit, another source of fault current is introduced. The available fault current at any location on the feeder will depend upon the type of fault (e.g. line-to-ground, three phase, double-line-to-ground, etc.), the fault impedance, and the status of the DER on the feeder (i.e. on or off line). Each DER technology has its own unique fault current characteristics.

The presence of DERs may create several problems with overcurrent protection and the coordination of protective devices. Some of the problems include:

1) The "reach" of overcurrent protective devices may be reduced due to a reduction in the fault current contribution from the station source with DERs on a feeder. For faults located downstream from a DER,, the fault current contribution from the station source will be reduced when the DER unit is on line.

2) Recloser to fuse coordination may no longer exist with the introduction of a DER on the feeder so fuses may blow for temporary faults.

3) Sectionalizers may misoperate if the DER maintains voltage when the sectionalizer should be "counting" an operation.

4) Nuisance tripping of a circuit recloser or station breaker may occur from a fault located on an adjacent feeder due to the fault current contribution from the DER.

5) The presence of an interconnection transformer with a primary voltage wye grounded winding connection and a secondary voltage delta connection at the DER can desensitize ground fault relays and the ground fault settings on recloser controls.

6) The introduction of DER to a secondary spot or grid network system can cause nuisance trips of protectors and protector cycling and may lead to out of phase protector closing resulting in equipment damage.

7) The presence of a DER may exacerbate cold load pickup problems following a feeder outage.

8) The addition of a DER may increase the available fault current to the point where utility system or customer owned protective device fault interrupting ratings are exceeded.

9) If the DER remains on the feeder after a protective device opens for any reason, then the protective device may reclose with the system voltage and the DER voltage out of synchronism.

10) Distribution automation schemes may be adversely affected by the introduction of DERs.

11) System under frequency conditions may result in feeder or transformer overload conditions.

Harmonic Current Injection - Several DER technologies have the potential for introducing harmonic distortion. Possible harmonic issues include:

1) Rotating machines produce 3rd harmonic distortion. Machines having a pitch of either 5/6 and 11/16 introduce the most distortion with 2/3 pitch being the preferred pitch to minimize distortion.

2) Inverter based DER may inject harmonic voltages and currents into the utility grid or may serve as a system sink for harmonics.

3) Wye-wye transformer connected DER and single phase DERs have the potential for being the worst harmonic sources.

Other Issues - Several other issues relating to the interconnection of DERs need to be considered. Potential problems to look for include:

1) Voltage on unfaulted phases may approach 1.73 times nominal during single line to ground faults when delta-wye or delta-delta connected transformer banks are used for the DER transformation.

2) Resonant overvoltages can occur if a synchronous or induction generator DER is isolated with capacitors during line to ground faults.

3) Single phase switching of a delta connected DER transformer bank may create ferroresonant overvoltage conditions.

4) DER may present utility worker and public safety concerns by inadvertently re-energizing the electric power system during abnormal system conditions.

5) The addition of DER may overload conductors or equipment.

6) The presence of a DER may defeat attempts to clear fault conditions by continuing to energize the feeder during fault events.

7) Induction and synchronous machine DER may be over excited by the presence of a capacitor bank in an unintentional islanding situation and produce high voltages in the island.

8) Inverter based DER may inject direct current onto the feeder causing transformer saturation.

9) When a grounded-wye high-side/delta low-side connected transformer bank is used to connect a DER, circulating current in the delta winding may result in transformer overloading. This transformer connection allows zero sequence current to circulate in the delta winding.

10) When feeders are switched from their normal configuration to affect load transfers or to restore power to customers during outage situations, the presence of a DER may create voltage regulation problems, objectionable voltage flicker, improper protective device operation and coordination or other problems.