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Purpose

This guide defines the Requirements for Transmission Connected Facilities, hereafter referred to as Requirements, that constitute the facility connection requirements for all affiliates of FirstEnergy (FE) that own and operate transmission, transmission <100 kV, and/or distribution systems and facilities. The Requirements have three primary objectives:

- Facilitate the safe, efficient, and reliable integration of any electrical transmission, generation, or load connection facility into the FE Transmission System.
- Are intended to ensure a compatibility of electrical designs and equipment and, thereby, contribute to the uniformity of service to all parties connected to the FE Transmission System.
- Describe the FE plans to achieve the required system performance throughout the planning horizon by establishing connection requirements for new and materially changed transmission, generation, and load connection facilities connected to the FE Transmission System.

Applicability

This procedure applies to any Connecting Party seeking to modify or establish a new connection to the FE Transmission System, unless otherwise noted.

Background

A Connecting Party seeking to modify or establish a new connection to the FE Transmission System must use these Requirements when planning an installation, but should be aware that these Requirements may not address all details in specific cases. These Requirements provide a general reference for typical situations that can be utilized when evaluating any potential new or modified connection to the FE Transmission System. As such, these Requirements constitute the minimum acceptable requirements.

Transmission Planning Studies

The planning study and analysis of new or modified transmission, generation, and load connection facilities connected to the FE Transmission System are coordinated with the interconnected transmission system through the PJM Regional Transmission Expansion Plan (RTEP), and the updated Multi-Regional Modeling Working Group Process (MMWG) base cases. The RTEP process is documented on the PJM website (www.pjm.com).

All changes to FE's Transmission System, including new interconnections and material changes, require thorough studies to assess their impact on system performance and reliability. Connecting Parties must provide a series of models at various project milestones: a steady-state power flow model, a generic positive sequence dynamic and short-circuit model, and both a user-defined positive sequence and an electromagnetic transient (EMT) model. For any material changes to existing interconnections, updated models reflecting those changes are required throughout the project lifecycle including after commercial operation. EMT models are essential for evaluating system response to transients, including inverter-based resource (IBR) behavior during system events, as well as power quality impacts to the transmission system related to the IBR or a large load interconnection. FE's studies are ongoing, and Connecting Party submitted models must accurately represent as-built site conditions and meet benchmarking requirements, including dynamic response comparisons as outlined in ***PJM Dynamic Model Development Guidelines for Interconnection Analysis*** and in *Appendix H, Dynamic Modeling Requirements for Inverter-based Resources*.

After construction, project owners are responsible for supplying up-to-date, validated models for commissioning and ongoing compliance, ensuring both positive sequence and EMT models match field data. During commercial operation, a Connecting Party must provide updated models after any material change or upon FE's request, accompanied by an attestation of accuracy and compliance. All communications and submissions should be made through the designated FE point of contact.

Additional provisions may be necessary as a result of the specific connection proposal and the findings of FE and/or PJM studies performed, or other North America Electric Reliability Corporation (NERC), ReliabilityFirst (RF), or PJM requirements that may be more restrictive. As an example, requirements for connection of a High Voltage Direct Current (HVDC) line will be considered on a case-by-case basis.

FE notifies adjacent transmission owners, transmission customers, Regional Transmission Organizations (RTOs) or others, including governmental authorities, that may be impacted by the proposed new or modified transmission, generation, or load connection facilities as required by any existing tariff, interconnection agreement, and/or PJM process. FE shares its study results and data with the impacted parties, as appropriate, in accordance with applicable Standards and Codes of Conduct. At its discretion, any impacted party may perform an independent evaluation of the impact of the proposed connection or modified connection to the FE Transmission System. As a prerequisite to construction, the Connecting Party must resolve all disputed issues with any impacted party and acquire all permits prior to the initiation of any work to install the facilities required to support the proposed connection.

Compliance

All facilities proposed for connection to the FE Transmission System are evaluated to ensure compliance with all NERC, RF, FE planning criteria, and PJM requirements, if applicable.

By submitting a request to connect transmission, generation, and/or load connection facilities to the FE Transmission System or a request to modify an existing connection of such facilities to the FE Transmission System, the Connecting Party agrees to comply with these Requirements, applicable NERC and RF standards, the PJM Open Access Transmission Tariff, the PJM Amended and Restated Operating Agreement, and other applicable PJM agreements, manuals, and documents.

Standards

In all cases, the FE standards are consistent with the requirements for facility connections as specified by the applicable NERC Reliability Standards, RF reliability principles and standards, guides, procedures, and reference documents, and applicable PJM tariffs, agreements, manuals, and other requirements. RF is the successor organization to three former NERC Regional Reliability Councils: Mid-Atlantic Area Council (MAAC), East Central Area Reliability Coordination Agreement (ECAR), and Mid-American Interconnected (MAIN) organizations. ECAR and MAAC documents referenced in these Requirements remain applicable for FE operating companies in these former reliability regions until RF develops new replacement standards and documents for the combined areas.

FE Transmission System

The system includes transmission and transmission <100 kV systems, lines, substations, and other facilities owned and operated by FE for the purpose of transmitting electricity regardless of voltage, unless specifically stated otherwise. The following table lists the facilities as covered by this document:

Operating Company	765	500	345	230	138	115	69	46	36	34.5	25	23
Cleveland Illuminating Company			B*		B*				T			
Jersey Central Power & Light		B		B		B				T		
Metropolitan Edison		B***		B***	B***	B***	T***					
Monongahela Power	B	B	B		B		T	T		T	T	T
Ohio Edison			B*		B*		T*			T		T
Penelec		B***	B***	B***	B***	B**		T***				
Penn Power		B*	B*		B*		T*					
Potomac Edison		B		B	B	B	T			T		
Toledo Edison			B*		B*		T*			T		
West Penn Power		B**	B**	B**	B**	B**	T	T		T	T	
ATSI		B	B		B		T					
KATCo		B	B	B	B	B						
MAIT		B	B	B	B	B	T	T				

B – Bulk Electric Systems (BES) (>100kV)
T – Transmission (<100 kV)
* Owned and Operated by ATSI
** Owned and Operated by KATCo
*** Owned and Operated by MAIT

1. Load Connection (Retail or Wholesale – with or without Generation)

A Load Connection is an electrical connection between the FE Transmission System and connecting party's facilities where the connecting party receives power from the electric system. The connecting party's facilities are not a networked transmission system (i.e., the facilities are radial in nature) and might include behind-the-meter generation. These connections are typically referred to as Retail or Wholesale Load Connections.

1.1. Load Connections – Application for Service

1.1.1. When information on the location and size of any new or modified connection proposal has been determined, the Connecting Party must complete the appropriate application and submit it with any required deposit to the specified FE agent.

- Retail Customers of FE who are Connecting Parties should contact their regional FE Operating Company.
- Wholesale Connecting Parties should contact the Manager, FERC and Wholesale Connection Support, FirstEnergy, 341 White Pond Drive, Akron, Ohio 44320.

1.1.2. The application for a new or modified retail or wholesale transmission connection/service can be found on the FE website at:
https:/www.firstenergycorp.com/feconnect/wholesale-interconnections.html

- Any large emerging load (i.e., data center, cryptocurrency mining facilities, hydrogen electrolyzers, manufacturing facilities, and arc furnaces) are required to complete and submit the NERC Data Center Information Collection Questionnaire with the FE load application. These large emerging loads are also required to provide a composite load model or other user-defined model representing the load facility dynamics in PSS®E format.
- Applications for Wholesale Generation Connection service are available electronically from the PJM website (www.pjm.com).

1.1.3. Applications with Generation[1]

- To qualify as a load connection, it is required that the generation controls be designed to not export power to the FE Transmission System under any conditions. Generation systems intended to export power must follow the requirements identified in *Section 2, Generation Connection*.
- Any load connection with generation intending to export or operate in parallel with the FE Transmission System must be studied and approved by FE to ensure the safety and reliability of the transmission system and compliance with any regulatory requirements. The connecting party must submit an interconnection application clearly indicating intent to export and submit all required information to FE. FE then performs a system impact study to determine:
  - If Connecting Party's proposed generation meets FE's technical requirements. If not, a written report is provided that identifies any required changes to the Connecting Party's facilities in order to comply with FE's technical requirements.
  - Any required revenue metering equipment upgrades and costs. The costs may be the responsibility of the Connecting Party.
  - Any transmission system modifications or upgrades necessary. All transmission system modifications or upgrades required due to the generation addition may be the responsibility of the Connecting Party.

[1] Per FERC Order 2003-A, a participant in a state jurisdictional retail net metering program and interconnecting to the transmission system must be a net consumer of electricity on a monthly basis.

- Connecting Parties with IBRs generator interconnections (including solar, wind, Battery Energy Storage Systems (BESS), and hybrids) seeking to connect to the FE transmission and transmission <100 kV system must provide the necessary modeling information specified in *Appendix H, Dynamic Modeling Requirements for Inverter-based Resources*.

- Any new Generation Connection, or any change in amount of existing generation on a load serving entity's distribution system that is 2 MVA or larger, requires review by FE to determine any resulting impact on the FE Transmission System.
- Wholesale connections to FE Operating Company-owned distribution system requires conformance with the latest version of ***IEEE Standard 1547***. For additional information, refer to the specific operating company website.
- Any load connection that includes generation, whether behind-the-meter or intended for parallel operation, must ensure that all generation equipment, especially IBRs, complies with the relevant IEEE standards for interconnection and power quality, including the most recent and adopted versions of ***IEEE Standards 519, 1453, 2800***. Compliance is required regardless of whether the generation is intended to export power or operate in parallel with the FE Transmission System.

1.2. Load Connections – Evaluation of Application

1.2.1. The processing of load connection requests includes a Transmission Planning Study to determine the impact of the proposed load connection facilities on the FE Transmission System. This may include a Conceptual Load Study (CLS) and/or a Detailed Load Study (DLS).

1.3. Load Connections – Construction and Interconnection Service Agreements

1.3.1. Agreements must be signed before FE begins any supporting detailed design and construction work. Refer to *Appendix A, Procedure for Connecting New Substation or Lines to FE Facilities* for additional details about these steps.

1.4. Load Connections – Site Construction Completion and Inspection by FE

1.4.1. A review of the connected facility must be performed by FE prior to energization of a Connecting Party owned facility. Refer to *Appendix A, Procedure for Connecting New Substation or Lines to FE Facilities* of this document for additional details and *Appendix B, Substation Checkout Guide* for an example checkout guide for this review step.

1.5. Load Connections – Configuration and Detailed Requirements – This section describes the configurations and requirements for load connections to the FE Transmission System. FE reserves the right to specify the final acceptable configuration and requirements.

1.5.1. Transmission Line Tap Connection

Connecting parties interested in pursuing a tap connection to the FE Transmission System must consider that FE will periodically require a temporary outage to perform maintenance work on the facilities supporting the Connecting Party's service. This outage will not exceed five (5) consecutive days and will not occur more than once annually. Connecting parties concerned about the impact of this outage should consider a Looped Connection.

Refer to *Section 8, Revenue Metering Requirements* for further information.

- Transmission Line Tap Connection – Above 230 kV
  - **Configuration:** Tap connections are not permitted on the FE 345 kV and 500 kV transmission systems and for FE 230 kV lines that are deemed critical to the BES.

- Transmission Line Tap Connection – At 230 kV
  - **Configuration:** *Figure 1C* illustrates the acceptable tap supply configuration for the FE 230 kV transmission supply voltage and some of the basic connection requirements.
  - **In-Line Transmission Switches:** Motor operated mechanisms and SCADA control is installed by FE on the in-line transmission switches to reduce the time required for restoration in the event of permanent line faults on the FE Transmission System. As shown in *Figure 1C* and the referenced note (3) on the figure, the in-line switches are required at the tap point to allow for sectionalizing the line without supply interruption to the Connecting Party at FE's expense. Due to concerns with the practical ability to reliably operate 230 kV line switches, FE requires these switches to be located in a substation. Therefore, it is required that the FE transmission line be extended in a parallel manner, as indicated, to the substation switches.
  - **Interrupting Device:** For all tap connections, any interrupting or switching device which is in the through path of FE power flow shall be under operational authority and control of FE or PJM as defined in the applicable interconnection or operating agreement entered into by FE and the Connecting Party (i.e., Interconnection Agreement).
  - **Transformer:** The high side transformer winding configuration for connecting substation transformers must be either delta or ungrounded wye.
- Transmission Line Tap Connection – At 200 kV and Below
  - **Configuration:** *Figure 1A* and *Figure 1B* illustrate acceptable tap supply configurations for FE transmission supply voltages at 200 kV and below and some of the basic connection requirements.
  - **In-Line Transmission Switches:** Motor operated mechanisms and SCADA control are installed by FE on the in-line transmission switches in order to reduce the time required for restoration in the event of permanent line faults on the FE transmission system. As shown in *Figure 1A* and *Figure 1B*, and the referenced note (2) on the figures, the in-line switches are required at the tap point to allow for sectionalizing the line without supply interruption to the Connecting Party at FE's expense.
  - **Transformer:** The high side transformer winding configuration for connecting transformers must be either delta or ungrounded wye.
- Transmission Line Tap Connection – Protection Requirements
  - The specific recommendations and requirements for protection are made by FE based on the individual substation location, voltage, and configuration.
  - Additional protection details specific to transmission line tap connections for Load Connection facilities can be found in *Appendix G, Distribution Power Transformer Protection*, and specifically *Figure 10A* and *Figure 10B* as minimum requirements; however, the guidance shown in *Figure 11A* and *Figure 11B* is preferred. Connecting Parties installing transformers larger than 15 MVA are required to install relaying as described in *Figure 11A* and *Figure 11B*.
  - In order to provide adequate protection to the FE Transmission System in a Transmission Line Tap Connection, FE may require that the Connecting Party furnish and install, at its expense, transfer trip transmitters at its facility to send tripping signals from the Connecting Party's facility to (an) FE location(s). This additional protection will also necessitate, at the Connecting Party's expense, the purchase and installation of transfer trip equipment at the FE location(s) and a dedicated communication channel(s) between the FE location(s) and the Connecting Party's facility, including any lease fees for the communications channel.

- Transmission Line Tap Connection – Remote Relay Access and Disturbance Monitoring.
  - Although not normally required at tap connected facilities, FE may require remote relay access at a specific facility.

1.5.2. Transmission Line Looped Connection

- Transmission Line Looped Connection – All Voltages
  - **Configuration:** Loop connected facilities have the potential to significantly affect the reliability and loadability of the FE Transmission System and therefore must be designed and built in either a breaker-and-a-half or a ring bus configuration. *Figure 2* illustrates a typical loop supply configuration and some of the basic connection requirements.
  - **Interrupting Device:** Any interrupting or switching device which is in the through path of FE power flow shall be owned by and under operational authority and control of FE as defined in the Interconnection Agreement or Operating Agreements.
  - **Transformer:** A delta or ungrounded wye high side winding configuration for connecting substation transformers is acceptable. Other transformer winding configurations may be acceptable subject to completion of system studies by FE.
- Transmission Line Looped Connection – Protection Requirements
  - The specific recommendations and requirements for protection are made by FE based on the individual substation location, voltage, and configuration. Refer to *Appendix G, Distribution Power Transformer Protection*.
  - Pilot (relay communication) channels are required for all new BES connections.
- Dual pilot channels over fiber must be used for short lines which are lines up to five miles long or the SIR at any terminal is greater than four. Refer to ***PJM Manual 07, PJM Protection Standards*** regarding Dual Pilot Channels for Protective Relaying. Additionally, if the primary line impedance is less than four ohms the application must be reviewed to determine whether the use of fiber is required under a short line determination after consideration of the CT/VT ratios and relay accuracy limitations.
- If the line is not determined to be short, other forms of communication channels such as Power Line Carrier (PLC) can be considered.
- Transmission Line Looped Connection – Remote Relay Access & Disturbance Monitoring
  - All Connecting Parties are required to install and maintain Disturbance Monitoring Equipment per the current version of ***NERC Standard PRC-002-2***. All requirements of this standard shall be met by the Connecting Party as if it is a Transmission Owner, regardless of its registry status with NERC.
  - All digital relays which have the capability of recording system disturbance information and that are used for protection of the FE Transmission System shall be provided with the equipment necessary to allow FE to remotely retrieve this data. This shall be done via either Connecting Party supplied access to the public phone system or through Connecting Party supplied digital communications circuits, at the option of FE.

1.6. Load Connections – Power Factor

1.6.1. Power Factor Requirements

- Load connections directly connected to the FE Transmission System shall be planned and designed to operate as close to unity power factor as practical, in order to minimize the reactive power burden on the FE Transmission System. The FE requirement specifies that the power factor at the Point of Interconnection (POI) must be maintained within the range of 0.97 lagging to 0.99 leading.

1.6.2. Power Factor Correction

- Shunt capacitors are frequently used to control the power factor of a Connecting Party's facility and shall be installed on the customer side of the POI. However, there are several areas that should be addressed in applying capacitors to avoid potential problems. These problems can include, but are not limited to, transient voltages due to capacitor switching and voltage amplification due to resonance conditions. The services of a qualified consultant should be obtained to review the specific application and provide recommendations regarding control of these phenomena.

1.7. Load Connections - Load Shed

FE is obligated to have an automatic Underfrequency Load Shedding (UFLS) plan to comply with NERC standards. Connecting Parties greater than or equal to 25 MW of load without an automatic UFLS plan for meeting these NERC requirements shall either install underfrequency relaying or request that FE install UFLS relaying at the Connecting Party's expense. Refer to *Section 10.2 Maintenance of Device and Control Schemes* for additional requirements. The FE Transmission Planning and Protection (TPP) team specifies the amount of load to be shed and frequency set points in accordance with the UFLS compliance requirements of NERC and the applicable Planning Coordinator. The Connecting Party must comply with FE's instructions in a timely manner and take appropriate measures to mitigate the impact of such Connecting Party's facilities on the UFLS plan.

FE applies automatic UFLS relaying in compliance with the applicable NERC and PJM requirements and agreements.

- Underfrequency Load Shed in PJM West Zone

  For the FE OpCos within the former ECAR region (Cleveland Electric Illuminating Company, Mon Power, Ohio Edison, Penn Power, Potomac Edison, Toledo Edison, West Penn Power), ***PJM Manual 36, System Restoration, Section 2.3.2*** requires the PJM West Control Zone to shed at least 25% of their system load in five nominal steps of 5% according to the following schedule:

Step	Frequency	Minimum Load Dropped (%)
1	59.5 Hz	5
2	59.3 Hz	5
3	59.1 Hz	5
4	58.9 Hz	5
5	58.7 Hz	5

All Load Connection Wholesale Connecting Parties within the former ECAR region of the FE Transmission System shall have an automatic UFLS plan in effect that meets NERC and ***PJM Manual 36, System Restoration, Section 2.3*** requirements.

- Underfrequency Load Shed in PJM Mid-Atlantic Zone

  For the FE OpCos within the former MAAC region (Jersey Central Power and Light, Met-Ed and Penelec), ***PJM Manual 36, System Restoration, Section 2.3*** requires the PJM Mid-Atlantic Control Zone to shed at least 30% of their system load in three nominal steps of 10% according to the following schedule:

Step	Frequency	Minimum Load Dropped (%)
1	59.3 Hz	10
2	58.9 Hz	10
3	58.5 Hz	10

  All Load Connection Wholesale Connecting Parties within the former MAAC region of the FE Transmission System shall have an automatic underfrequency load shedding plan in effect that meets NERC and ***PJM Manual 36, System Restoration, Section 2.3*** *requirements*.

- Undervoltage Load Shed:

  FE may apply automatic undervoltage load shedding relaying to prevent cascading transmission system outages. The specific locations where undervoltage load shedding relaying must be installed and the amounts of load to be shed are determined by special system studies. Load Connection Wholesale and Retail Connecting Parties may be required to install undervoltage load shedding schemes as identified by FE through these special studies.

1.8. Load Connections – Real Estate

As required by the applicable tariffs, the Interconnection Customer, at its sole cost and expense, will provide to the Company all real property rights over such lands at such times and in such a manner as the Company reasonably requires in order to perform its obligations for the construction, operation, and maintenance of its electric facilities.

2. Generation Connections

Generation facilities directly or indirectly connected to and operated in synchronism with the FE Transmission System have additional requirements beyond the specification of the other sections in this document. The additional requirements are described in this section.

2.1. Generation Connections – Configuration

2.1.1. New Generation Connections or upgrades to existing Generation Connections at transmission voltage levels will require detailed system studies per ***PJM Manual 14G, Generation Interconnection Requests*** to determine the feasibility of the proposed connection point and the specific connection requirements.

- *Figures 3, 4, 5, and 6* show typical connections for the Connecting Party's substations and associated generation.
- Refer to *Appendix C, Breaker Ring Bus Decision Process – Generation Connections* for additional information about the configuration of the connected facilities.
- Any new Generation Connection, or any change in amount of existing generation on a load serving entity's distribution system that is 2 MVA or larger, requires review by FE to determine any resulting impact on the FE Transmission System.

> **NOTE**
> This restriction only applies to generators not selling into PJM and all increases to wholesale connections must be studied through the PJM generation interconnection process.

- Wholesale connections to FE OpCo-owned distribution systems require conformance with the latest version of ***IEEE-1547***. For additional information, refer to the specific operating company website via https://www.firstenergycorp.com/feconnect.html.
- For a high-level overview of the Generation Interconnection process, refer to ***PJM Manual 14A, New Services Request Process***.

2.2. Generation Connections – Design Requirements

2.2.1. The Connecting Party is responsible for specifying appropriate equipment and facilities such that the parallel generation is compatible with the FE Transmission System.

2.2.2. The Connecting Party is also responsible for meeting any applicable federal, state, and local codes.

2.2.3. The minimum FE Transmission System connection design requirements for parallel generation are as follows:

- Reactive Power
  - The Connecting Party must meet the power factor requirements outlined by ***PJM Manual 14G, Generation Interconnection Requests***, which can be accessed via PJM's website at www.pjm.com.
  - For all generation facilities, other than wind-powered and other non-synchronous generating facilities, the minimum requirement shall be the provision of a reactive power capability sufficient to maintain a composite power delivery at continuous rated power output at a power factor as defined in ***PJM Manual 14G, Generation Interconnection Requests***. This requirement is measured at either the POI or generator terminals as specified in ***PJM Manual 14G, Generation Interconnection Requests***. These reactive requirements apply to both the initial installation as well as to any incremental change in unit MW capability. FE will coordinate with the Connecting Party to identify the optimal generator step-up transformer tap to make such a capability available when demanded.

- For all wind-powered or other non-synchronous generating facilities, the minimum requirement shall be the provision of a reactive power capability sufficient to maintain a composite power delivery at a power factor as defined in ***PJM Manual 14G, Generation Interconnection Requests*** This requirement is measured at either the POI or generator's terminals as specified in ***PJM Manual 14G, Generation Interconnection Requests***. These reactive requirements apply to both the initial installation as well as to any incremental change in unit MW capability. FE coordinates with the Connecting Party to identify the optimal generator step-up transformer tap to make such a capability available, when needed.
- Any different reactive power requirements that FE and/or PJM determines to be appropriate for wind-powered or other non-synchronous generation facilities will be stated in the applicable interconnection agreement(s).
- Induction generators and other generators with no inherent VAR (i.e., reactive power) control capability, or those that have a restricted VAR capability less than the defined requirements, must provide dynamic supplementary reactive support located at the generation facility with electrical characteristics equivalent to that provided by a similar-sized synchronous generator.
- It is the responsibility of the Connecting Party to set the unit auxiliary transformer taps so that all plant auxiliaries operate satisfactorily within the full power factor range set forth in ***PJM Manual 14G, Generation Interconnection Requests***.

- Generator Frequency
  - Connected generation is to be designed to produce balanced, three-phase, 60 Hz voltages and currents.
- System Grounding
  - Where momentary isolation of the generation on a portion of the FE Transmission System does not result in an effectively grounded system (X0/X1 positive and less than 3, and R0/X1 positive and less than 1 for an effectively grounded system), then the FE Transmission System is subject to overvoltages on unfaulted phases during system faults involving ground. Prior to the synchronization of the generation to the FE Transmission System, the Connecting Party is responsible for the replacement of any silicon carbide gapped arresters on the affected FE circuit(s) that would experience overvoltages exceeding the arrester duty cycle rating due to the generation source during the clearing of ground faults. Metal Oxide Varistor (MOV) arresters on the affected FE circuit(s) are evaluated against their temporary overvoltage (TOV) capability characteristic. The Connecting Party is responsible for the replacement of any MOV arresters should their TOV capability be exceeded due to the generation source during the clearing of ground faults.
- Disconnecting Devices
  - An FE approved, gang-operated switch shall be installed on each transmission line supply exit from the FE-owned facility towards the Connecting Party's facility to provide for the visibly assured electrical isolation of the facility.
  - Generating facilities with looped line connections shall also be equipped with an FE approved disconnecting device installed to provide the visibly assured electrical isolation of the generation. The disconnecting device shall be located in the high side leads of the generator step-up transformer or at a mutually agreed upon location.
  - The disconnecting device(s) shall be accessible to FE personnel 24 hours a day and designed to the standards and requirements such that the switch is lockable in the open position with an FE padlock. They shall be identified with a FE designated equipment number(s).

- The disconnecting device(s) shall be installed near the POI.
- Refer to *Section 6.2.4 and 6.4.6* for additional details and requirements.
- All Generation Connections regardless of connection voltage are required to have fully rated circuit breakers. Refer to *Section 6.2.6* for additional details and requirements.

- Transient Stability Performance

  All generation facilities must comply with all NERC and FE transient stability performance standards. During system studies, FE or PJM performs a transient stability analysis to verify compliance with these standards. All Connecting Parties must perform validation testing to confirm dynamic modeling characteristics in a manner that is consistent with NERC Reliability Standard requirements.

- Connecting Transformer Requirements
  - All new generator only and new generator plus load facilities must be isolated from the FE Transmission System by a power transformer. The transformer connecting to an effectively grounded portion of the FE Transmission System shall be a two winding transformer (i.e. no tertiary winding) and have a wye grounded winding on the high (transmission system) side and have a delta connected winding on the low side. The winding configurations of the transformer connecting to a non-effectively grounded portion of the FE Transmission System shall be determined by FE on a case-by-case basis.
    - A wye grounded winding on the high (transmission system) side establishes an effective ground on the transmission system and mitigates overvoltage conditions during ground faults.
    - A delta connected winding on the low side provides isolation of zero-sequence currents such that the FE Transmission System will not be exposed to ground faults on the generator system. This eliminates the need for relay coordination and risk of transmission overtripping.

NOTE

This configuration provides isolation of triplen harmonics on the generator system from impacting the transmission system.

NOTE

If a ground reference is required on the generator's system, a separate grounding transformer may be installed.

  - Inverter-based generation that is UL1741 certified for anti-islanding protection connected to the transmission <100 kV system shall have a delta or ungrounded wye winding on the transmission side.
  - Inverter-based generation that is not UL1741 certified for anti-islanding protection connected to the transmission <100 kV system shall have a transmission-side winding determined by FE on a case-by case basis.
  - Wholesale connections to FE Operating Company owned distribution systems require conformance with the latest version of ***IEEE Standard 1547***. For additional information, refer to the specific operating company website via https://www.firstenergycorp.com/feconnect.html.
  - All new generator additions to existing load facilities must be isolated from the FE Transmission System by a power transformer. Transformer winding configurations shall be determined by FE on a case-by-case basis.
  - Inverter-based generation connected to the transmission > 100 kV system shall comply with IEEE Standard 2800-2022.

- Communication Channel to FE Substation
  - Redundant fiber optic-based communications channels must be installed and maintained between the Connecting Party's generating facility and the interconnecting FE substation. These channels are used for all control, relay, and direct transfer trip (DTT) signals and other communication as agreed by FE and the Connecting Party. FE requires the two redundant direct fiber paths to meet ***PJM Manual 07, PJM Protection Standards*** regarding Dual Pilot Channels for Protective Relaying.

2.3. Generation Connections – Generation Controls

2.3.1. Automatic Voltage Regulator (AVR)

- All generators connected to the FE Transmission System shall be equipped with an AVR and shall be operated with the AVR activated and controlling voltage to the Voltage Schedule provided by FE.

2.3.2. Reactive Compensation

- A circuit shall be provided in the AVR to permit the control of voltage beyond the generator terminals. This is known as reactive line drop compensation. The point of control is to be adjustable over a range covering 0% to 15% reactance on the generator base beyond the generator terminals.

2.3.3. Overcurrent Limiter

- The excitation system is to be provided with a current limiting device, which supersedes or acts in conjunction with the AVR to automatically reduce excitation so that generator field current is maintained at the allowable limit in the event of sustained under-voltages on the FE Transmission System. The AVR shall be capable of field forcing in the event of a close-in fault, up to the generator field's emergency thermal limit for up to a half second in duration.

2.3.4. Underexcitation Limiter

- A limiter to prevent instability resulting from generator underexcitation is required.

2.3.5. Power System Stabilizer (PSS)

- PSS shall be installed on all generating units of 70 MW or larger when required by PJM or FE. No PSS shall be in service unless required by PJM or FE.

2.3.6. Speed Governing

- All synchronous generators shall be equipped with speed governing capability. This governing capability shall be unhindered in its operation consistent with overall economic operation of the generation facility. Overspeed protection in the event of load rejection is the responsibility of the Generation Owner.

2.3.7. Automatic Generation Control (AGC)

- Depending upon various control area factors applicable to tie line and frequency regulation, provision for dispatch control of the generation facility by the System Control Center (SCC) AGC system may be required. This determination is made on a case-by-case basis.

2.4. Generation Connections – Operating Requirements

2.4.1. The Connecting Party is responsible for operating its parallel generation with full regard for the safe practices of, and with full cooperation under the supervision of, the SCCs. A Connecting Party's parallel generation shall not supply power into the FE Transmission System unless a specific written agreement has been entered into to supply power into the FE Transmission System. Under no circumstances shall a Connecting Party energize FE Transmission System facilities that have been de-energized without authorization from the SCC. FE Transmission System circuits which are electrically disconnected from the FE Transmission System and are energized by the Connecting Party's generation facilities constitute a potential safety hazard for both FE personnel and the general public. Also, the energizing of such circuits at abnormal voltage or frequency could cause damage to connected electrical equipment of both FE and other entities.

2.4.2. BESS and other IBRs participating in frequency regulation or ancillary service markets must be operated in accordance with the most recent and adopted versions of ***IEEE Standards 519, 1453, 1547, 2800***, including limits on rapid voltage changes, dynamic performance, and provision of validated dynamic models to the Transmission Owner. Operation must not result in excessive voltage swings, voltage imbalance, or abnormal operation of voltage regulation equipment (including distribution transformer load tap changers (LTCs)) on the FE Transmission System. If FE studies or monitoring identify adverse impacts, FE reserves the right to require the Connecting Party to implement operational adjustments, additional controls, mitigation measures, or to fund and facilitate necessary system upgrades to address these impacts and maintain system reliability.

2.4.3. FE reserves the right to disconnect service to any parallel generation facility for any reason if FE deems the parallel generation to have become, or may become, a detriment to the safe operation of the FE Transmission System.

2.4.4. The minimum requirements for operation of parallel generation on the FE Transmission System are contained herein:

- Synchronization
  - The Connecting Party assumes all responsibility for properly synchronizing its generation for parallel operation with the FE Transmission System. Upon loss of the FE supply, the Connecting Party shall immediately and positively cause the parallel generation to be separated from the FE Transmission System. Synchronizing of generation to the FE Transmission System may be required to be performed under the direction of the SCC.
- Voltage Schedule/Power Factor
  - Specification of the generator voltage schedule is determined under the direction of the SCC. A steady-state deviation from this schedule between +1.5% to –1.5% of the nominal voltage will be permissible. Generator output voltage may be required to be under the control of the SCC.
  - In situations where use of a voltage schedule is determined by FE to be inappropriate, FE may substitute adherence to a specified power factor for adherence to a specified voltage schedule. A steady state deviation from this power factor within +2% to –2% will be permissible.
  - Failure of the Connecting Party to maintain voltage or power factor within the scheduled range may result in rate penalties to the generation owner and/or discontinuation of parallel operation with the generation owner's facility.

- Voltage Range
  - The generation facility must be capable of continuous non-interrupted operation within a steady-state voltage range during system normal and single facility outage conditions as specified in *Section 4, Transmission System Characteristics*. During emergency and/or transient system conditions, voltages may temporarily be outside of these ranges.
- Frequency Range
  - The generation facility must be capable of continuous, non-interrupted operation in the frequency range of 59.5 to 60.5 Hz. For a limited time, non-interrupted operation is also expected outside of this frequency range in accordance with RF requirements or the turbine/generator manufacturer's recommendation, whichever is greater.
  - The generation facility operating within the former ECAR region of the FE Transmission System is required to remain interconnected to the FE Transmission System during frequency disturbances as prescribed by ***PJM Manual 36, System Restoration, Section 2.3***.
- Voltage Balance
  - All three-phase generation connected to the FE Transmission System shall produce 60 Hz balanced voltages. Voltage unbalance attributable to the generation facility's combined parallel generation and load shall not exceed 1.0% measured at the point-of-service.
    - Voltage unbalance is defined as the maximum phase deviation from average as specified in ***ANSI C84.1, American National Standard for Electric Power Systems and Equipment – Voltage Ratings, 60 Hertz.***
- Net Demonstrated Real and Reactive Capabilities
  - Connecting Parties will be required to comply with the appropriate NERC and RF requirements for both real and reactive capacity verification testing. Such tests must be performed in coordination with the SCCs, with sufficient notice provided for FE approval, to ensure that the FE transmission system can be operated reliably during their completion.
  - For units located within PJM, the Net Demonstrated real capacity will be determined annually by the SCC in compliance with the ***PJM Manual M21, Rules and Procedures for Determination of Generating Capability***.
  - Individual generators in the generation facility must make available the full steady-state over- and under-excited reactive capability given by the manufacturer's generator capability curve at any MW dispatch level. Such documentation shall be provided to FE.
  - FE retains the right to request a reactive capability test of any generation facility if, by its demonstrated operation, it is found to be non-compliant with the FE standards.
  - The failure of the Connecting Party to show a compliance with the generator reactive power requirements, as identified by test or from monitored operation, is subject to the terms of *Section 2.2.3, Reactive Power* of these Requirements. The Connecting Party will be required to install supplemental reactive resources to resolve such deficiencies and meet its system obligations.

- Other Applicable Operating Requirements
  - In order to assure the continued reliability of the FE Transmission System, the Connecting Party may be required to adhere to other operating requirements and/or operating practices. These include the coordination of maintenance scheduling, observance of a specified forced outage rate, operations procedures during system emergencies, participation in control area operating reserves, provisions for backup fuel supply or storage, and provisions for emergency availability. Such requirements shall be addressed in the Interconnection or Operating Agreement.
  - Conformance with applicable requirements in the following NERC/RF documents is required:
    - ***MOD-024 – Verification of Generator Gross and Net Real Power Capability***
    - ***MOD-025 – Verification of Generator Gross and Net Reactive Power Capability***
    - ***RF_Criteria_PRC-002 – Disturbance Monitoring and Reporting Criteria***
    - ***VAR-002 – Generator Operation for Maintaining Network Voltage Schedules***
  - All data reportable to RF and/or NERC shall also be made available to FE upon request.
- Operating Restrictions
  - Situations necessitating generation curtailments or forced outages as the result of unavailability of facilities owned and/or operated by FE are to be addressed in the Interconnection Agreement.

2.5. Generation Connections – Protection Requirements

2.5.1. The Connecting Party is to design their protective system to clear any faults within their zones of protection with one or no more than two local circuit breakers.

- Generators connecting at 100 kV or greater shall have two independent relay schemes that are redundant and provide high speed fault clearing for all zones of protection covering the 100 kV and above portion of the generator's system. The terminal breaker at the Generator end of any direct connection line is to be included in one of these protection zones.
  - Redundant protection practices include independent instrument transformer CT and PT connections for primary and backup schemes, independent DC control circuits with no common wiring or cabling, isolating switches or auxiliary tripping relays, separate circuit breaker trip coils to be used for primary and backup schemes, and independently protected DC supply circuits for primary, backup and breaker failure relay schemes at a minimum, when a separate primary and backup battery system are not available.
- Generators connecting at less than 100 kV shall have two independent relay schemes that are redundant providing fault clearing for all zones of protection covering the high side portion of the generator's system, including the Generator Step Up (GSU) transformer. The schemes are not required to be high speed in all cases. The terminal breaker at the Generator end of any direct connection line is to be included in one of these protection zones.

2.5.2. The transmission tie line between the Connecting Party facility and the FE system requires protective relaying installed at the Connecting Party's terminal.

- Protection of this line shall include independent primary and backup schemes that must coordinate with schemes on the FE system. Line current differential is preferred in most cases, but other approaches may be acceptable if coordination can be achieved. Dual line differential schemes using fiber are required for all new BES generator tie lines. FE will provide specific settings guidance for the following required elements:
  - Ground Fault protection that detects faults involving ground faults on the FE Transmission System from the Connecting Party's terminal.
  - Phase Fault protection that detects phase-to-phase or three-phase faults on the FE Transmission System from the Connecting Party's terminal.

2.5.3. The Connecting Party shall provide utility-grade relays for protection of the FE Transmission System. FE shall approve all relays specified for the protection of the FE Transmission System, including time delay and auxiliary relays. Relay operation for any of the listed functions that are required shall initiate immediate separation of the parallel generation from the FE Transmission System.

Additional relays may be required by FE to provide the following adequate protection for the FE Transmission System:

- Underfrequency and Overfrequency protection
- Undervoltage and Overvoltage protection
- Directional Power that is specifically to detect, under all system conditions, a loss of FE Transmission System primary source. The relay shall be sensitive enough to detect transformer magnetizing current supplied by the generator.
- Breaker Failure protection that is to specifically detect a stuck breaker condition at the generation substation and send a trip signal to the remote ends of the connected line via direct transfer trip.
- Transfer Trip Transmitter that is to provide adequate protection to the FE Transmission System. The Connecting Party shall furnish and install, at its expense, transfer trip transmitters at its facility to send tripping signals from the Connecting Party's facility to FE location(s). This additional protection also necessitates, at the Connecting Party's expense, the purchase and installation of transfer trip equipment at the FE location(s) and a dedicated communication channel(s) between the FE location(s) and the Connecting Party's facility, including any lease fees for the communications channel. FE will determine if a high-speed ground switch is an acceptable alternative to a transfer trip transmitter for this purpose, but the decision to allow this is fully at FE's discretion.
- An Anti-Islanding scheme that provides tripping logic to the Generation Owner for isolation of the generation upon opening of the FE supply circuits.

2.5.4. Frequency Disturbance Response

- Connecting Parties proposing a Generation Connection are required to remain interconnected to the FE Transmission System during frequency disturbances as prescribed by ***PJM Manual 36, System Restoration, Section 2.3***.

2.5.5. Remedial Action Schemes

- Remedial Action Schemes or Special Protection Schemes shall not be used to either eliminate or minimize the need for otherwise required transmission system upgrades.

2.5.6. Inverter-based Generation Special Requirements:

- Connecting Parties shall provide acceptable detailed models and supporting documentation for short circuit, dynamic, and EMT studies.
- Connecting Parties with IBR generator interconnections, including solar, wind, BESS, and hybrids, seeking to connect to the FE Transmission System, must provide the necessary modeling information specified in *Appendix H, Dynamic Modeling Requirements for Inverter-based Resources*.
- Inverter-based generation connected to the transmission system shall comply with ***IEEE Standard 2800-2022***.
- Inverter Based Generation Connections above 100 kV
  - For inverter-based Generation Connections at 100 kV and above, FE may require fiber optic communications to remote terminals to be installed at the Connecting Party's cost to facilitate anti-islanding transfer trip and appropriate fault clearing in various contingencies to ensure coordination if the connection results in short transmission lines being created. Fiber for anti-islanding transfer trip may also be required if there are challenges using PLC for this purpose.
- Inverter Based Generation Connections below 100 kV
  - Generation facilities that comply with ***IEEE-1547*** and are UL1741 certified or that provide documentation by a third party testing organization of successful testing of the proposed inverter equipment in accordance with ***IEEE-1547.1*** that are connected to the FE Transmission System below 100 kV are required to have intertie relays installed, but may be exempt from other protection requirements, such as anti-islanding transfer trip. This determination shall be made solely by FE. Such facilities shall be required to meet all other, non-protection related requirements of this document.

2.6. Generation Connections – Underfrequency Load Shedding

The Connecting Party of a generator connecting to a transmission or sub-transmission circuit that is part of an existing automatic UFLS scheme to meet NERC standards is financially responsible for relocating that UFLS scheme to another part of the power system.

2.7. Generation Connections – Distribution System Connection

Wholesale connections to FE operating company owned distribution systems require conformance with the latest version IEEE-1547. For additional information, refer to the specific operating company website via https://www.firstenergycorp.com/feconnect.html. Intertie protection systems and anti-islanding and DTT may be required to mitigate issues caused by back feed into the transmission system. This protection performance will need to comply with at least one of the following:

- UL1741 if an IBR, or
- ***PJM Guideline for Ride Through Performance of Distribution-Connected Generators***, dated Q4 2019, or
- ***IEEE Standard 1547-2018*** or
- ***IEEE Standard 1547.1*** testing compliant

The determination of the location and type of intertie protection including anti-islanding protection are divided into three levels of generation compared to local load.

1) If the maximum generation is substantially less (50%) than the distribution transformer minimum load. At this level, the distribution company would define the interconnecting customer's intertie requirements.
2) If maximum generation is at or above 50% and below 100% of minimum load of the distribution transformer, then the intertie relaying is on the low (or, if desired, on the high) side of the transformer. The relaying would include 32/27/59/81 functions. DTT from the transmission source substations may be required to prevent unintentional islanding.
3) If maximum generation is at or above 100% of the minimum load of the transformer, then the intertie relaying is on the high side of the transformer. For certain specific applications, one set of CTs may be required for transmission connections below 100 kV and two sets for connections above 100 kV. DTT from the transmission source substations may be required to prevent unintentional islanding.

2.8. Generation Connections – Real Estate

2.8.1. As required by the applicable tariffs, the Interconnection Customer, at its sole cost and expense, must provide to FE all real property rights over such lands at such times and in such a manner as FE reasonably requires in order to perform its obligations for the construction, operation, and maintenance of its electric facilities.

3. Transmission Interconnection (Independent Networked or Transmission < 100 kV Systems)

3.1. Transmission Interconnections – Tap Interconnection

3.1.1. A transmission line tap connection is not allowed for Transmission Interconnections.

3.2. Transmission Interconnections – Loop Interconnection

3.2.1. This type of interconnection is found where a foreign utility has a transmission line terminating at an FE company's substation. For example, a new interconnection with a foreign utility at an existing or new FE substation.

3.2.2. A FE Transmission System connection to an independent networked transmission or transmission < 100 kV system requires a loop connection – either a FE-owned ring bus, a breaker-and-a-half, or a double breaker double bus configuration for the interconnection point.

3.2.3. Refer to *Figure 2*, which illustrates a typical loop connection with the FE Transmission System.

- The transformers shown in *Figure 2* could be connected to the independent transmission system or those transformer positions might be occupied by transmission line terminations originating from the connecting independent transmission system.

3.3. Transmission Line Interconnections – Protection Requirements

3.3.1. The Connecting Party is to design their protective system to clear any faults within their zones of protection with one or more local circuit breakers.

- A Connecting Party facility at 100 kV or greater shall have two independent relay schemes that are redundant, providing high speed fault clearing for all zones of protection covering the 100 kV and above portion of the system. The terminal breaker at the Connecting Party end of any direct connection line is to be included in one of these protection zones.
  - Redundant protection practices include independent instrument transformer CT and PT connections for primary and backup schemes, independent DC control circuits with no common wiring or cabling, isolating switches or auxiliary tripping relays, separate circuit breaker trip coils to be used for primary and backup schemes, and independently protected DC supply circuits for primary, backup and breaker failure relay schemes at a minimum when a separate primary and backup battery system are not available.
  - Pilot (relay communication) channels are required for all new BES connections.
    - Dual pilot channels over fiber must be used for short lines which are lines up to five miles long or the SIR at any terminal is greater than four. Refer to ***PJM Manual 07, PJM Protection Standards*** regarding Dual Pilot Channels for Protective Relaying. Additionally, if the primary line impedance is less than four ohms, the application must be reviewed to determine whether the use of fiber is required under a short line determination after consideration of the CT/VT ratios and relay accuracy limitations.
    - If the line is not determined to be short, other forms of communication channels such as PLC can be considered.
- A Connecting Party facility at less than 100 kV shall have two independent relay schemes that are redundant providing fault clearing for all zones of protection covering the system below 100 kV. The schemes are not required to be high speed in all cases. The terminal breaker at the Connecting Party end of any direct connection line is to be included in one of these protection zones.

3.3.2. The transmission tie line between the Connecting Party facility and the FE system requires protective relaying installed at the Connecting Party's terminal.

- Protection of this line shall include independent primary and backup schemes that must coordinate with schemes on the FE system. Line current differential is preferred in most cases, but other approaches may be acceptable if coordination can be achieved. FE will provide specific settings guidance for the following required elements:
  - Ground Fault protection that detects faults involving ground on the FE Transmission System from the Connecting Party's terminal.
  - Phase Fault protection that detects phase-to-phase or three-phase faults on the FE Transmission System from the Connecting Party's terminal.

3.4. Transmission Interconnections – Direct Foreign Utility Interconnection

3.4.1. This type of interconnection is found where FE has a transmission line terminating at another company's substation. For example, a new interconnection with a foreign utility at the foreign utility's substation.

3.4.2. For Direct Foreign Utility Interconnections, refer to *Figures 7 and 8*.

3.5. Transmission Connection – Real Estate

3.5.1. As required by the applicable tariffs, the Interconnection Customer, at its sole cost and expense, will provide to FE all real property rights over such lands at such times and in such a manner as FE reasonably requires in order to perform its obligations for the construction, operation, and maintenance of its electric facilities.

4. Transmission System Characteristics

4.1. Transmission System Voltage

4.1.1. Nominal Voltage

Transmission Nominal System Voltage Definitions		
500 kV	115 kV	34.5 kV
345 kV	69 kV	25 kV
230 kV	46 kV	23 kV
138 kV		

4.1.2. Operating Voltage Range

- FE's Transmission System is designed to operate between the following percentages of nominal voltage under normal and single transmission element outage conditions.

Nominal Voltage	Operating Range of Nominal Voltage	Notes
500 kV	97% - 110%	
345 kV	92% - 105%	
230 kV	92% - 105%	
138 kV 115 kV	92% - 105%	If Networked
138 kV 115 kV	90% - 105%	If Non-Networked
69 kV 46 kV 34.5 kV	90% - 105%	
25 kV 23 kV	90% - 107.5%	

4.2. Operating Voltage - Emergency Operating Conditions

Under certain emergency conditions involving multiple system contingencies, the FE Transmission System may operate for a period of time outside of ranges listed in *Section 4.1.2*.

- The Connecting Party is responsible for providing any voltage sensing relaying required to protect its facility during abnormal voltage operation.
- In addition, immediate action may be required to disconnect load from the FE Transmission System should voltage fall below the minimum percentage of nominal value listed above.
- The Connecting Party will be given advance notice of such action, to the extent possible, and will be expected to disconnect from the FE Transmission System upon FE request until the initiating condition has been corrected.
  - Reference the PJM Manuals posted on the PJM website at www.pjm.com.

4.2.1. Connecting Party's Voltage Requirements

- If the Connecting Party's supply voltage requirements are more restrictive than the voltage ranges listed above, FE recommends that the Connecting Party consider the addition of voltage regulation equipment in its facility.

4.3. Transmission System Power (MW and MVAR)

4.3.1. The MW and MVAR capacity or demand at the point of connection is limited by the capabilities of the FE Transmission System. Analysis and documentation of these capabilities are provided through the connection processes referenced throughout the entirety of this document.

4.4. Transmission System Operations

4.4.1. Operational issues associated with the proposed facilities will be analyzed and documented through the connection processes referenced throughout the entirety of this document.

4.5. Transmission System Frequency

4.5.1. **Frequency Range:** The FE Transmission System typically operates at a nominal 60 Hz with a variation of +/-0.05 Hz.

4.5.2. **Emergency Operating Condition:** Under certain emergency conditions, the FE Transmission System may operate for a period of time outside of this range.

4.5.3. **Connecting Party Requirements:** The Connecting Party is responsible for providing any frequency sensing relaying required to protect its facilities during abnormal frequency operation.

4.6. Transmission Power Quality

4.6.1. Harmonics and Flicker

Certain electrical equipment located at a Connecting Party facility (e.g., arc furnaces, cycloconverters, etc.) may generate flicker and harmonics that can negatively impact the FE Transmission System and other facilities connected to such system.

- The Connecting Party shall cause its connected facility comply with harmonic voltage and current limits specified in the most recent and adopted ***IEEE Standard 519, IEEE Standard for Harmonic Control in Electrical Power Systems.***
- Flicker is measured as described in the most recent and adopted ***IEEE Standard 1453, IEEE Standard for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems***. P_{st} is a measure of short-term perception of flicker obtained for a ten-minute interval. P_{lt} is a measure of long-term perception of flicker obtained for a two-hour period calculated from 12 consecutive P_{st} values. The connected facility shall be designed and operated such that P_{st} does not exceed 0.8 and P_{lt} does not exceed 0.6 for more than 1% of the time (99% probability level), using a minimum assessment period of one week.
- These flicker and harmonics limits must be met during normal (N-0) system configurations including a generating unit outage. The Interconnection or Operating Agreement for the connected facility must recognize that for scheduled outages of transmission or generation facilities, a flicker (or harmonics) producing connected facility must curtail operation as necessary so that these flicker and harmonics levels do not result in PQ complaints. It is recognized that excursions of flicker and harmonics levels beyond these required limits might occur during unscheduled forced outages resulting in PQ complaints.
- Voltage flicker for infrequent events such as large motor starting will be evaluated based upon the resulting percent voltage dip per event. Refer to ***IEEE Standard 1453, Annex A***. In no case shall the resulting percent voltage dip per motor starting event exceed 3% on the FE Transmission System.

- FE may initially, or in the future, require the installation of a harmonic and/or flicker monitoring system in order to permit ongoing assessment of compliance. Should a Power Quality meter be deemed necessary to be installed in the customer's facility, it would be by the customer and at the customer's expense. FE must have unfettered access to the measured data upon request.

4.7. Sensitive Electrical Equipment

Certain electrical equipment may be sensitive to normally occurring electric interference from nearby connected loads in the Connecting Party's facility or from other entities connected to the FE Transmission System or adjacent systems. If sensitive electrical equipment is to be supplied directly from the FE Transmission System, then it is recommended that the equipment grounding requirements and power supply requirements be examined by the Connecting Party prior to installation.

- Attention should be given to equipment tolerance to various forms of electric interference, including voltage sags and surges, momentary outages, transients, harmonics, or other electrical noise.
- When electrical disturbances to sensitive electrical equipment such as computer, electronics, controls, and communication equipment cannot be tolerated, the Connecting Party shall furnish additional equipment as may be necessary to prevent equipment malfunctions.
- The supplier of such sensitive electrical equipment should be consulted regarding the power supply requirements or the remedial measures to be taken to alleviate potential misoperation of the equipment.
- A power quality consultant can also perform a site survey of the electric power supply environment and furnish recommendations to provide the acceptable level of reliability.

4.8. IBR Power Quality Requirements

IBRs, including BESS, solar, and wind facilities, present unique power quality challenges due to their fast-acting controls and participation in grid services such as frequency regulation.

- All IBRs connected to the FE Transmission System must comply with the most recent and adopted ***IEEE Standard 2800***, in addition to ***IEEE Standards 519 and 1453***, for interconnection and power quality.
- IBRs must operate within defined rapid voltage change (RVC) limits, as specified in ***IEEE 2800***, to prevent excessive voltage excursions and abnormal operation of voltage regulation equipment, including distribution transformer LTCs.
- IBRs are required to provide dynamic reactive power support and maintain voltage and frequency ride-through capability during grid disturbances, as outlined in ***IEEE 2800***.
- The Connecting Party must provide validated dynamic models of their IBR facilities to FE for use in system studies and reliability assessments.
- FE may monitor the operation of IBRs for impacts on system voltage, voltage regulation equipment, and overall power quality. If studies or monitoring identify excessive voltage excursions, abnormal LTC operations (including LTCs of distribution transformers), or other adverse effects, FE may require the Connecting Party to implement corrective actions, including operational changes, control modifications, installation of mitigation equipment, or funding and facilitation of additional system upgrades as determined necessary by FE.

4.9. Phasor Measurement Units (PMUs) and PQ Metering Requirements for Large Load Studies

- PMUs and PQ meters shall be required at any data center connection of 50 MVA or greater. PQ metering must be installed at strategic locations within the new FE station. This includes all feeds to the Connecting Party as well as network lines inside the station. These placements allow for comprehensive monitoring of power quality impacts on both the Connecting Party connection and the transmission network.

5. Line Design Requirements

5.1. Transmission Line/Ground Wire Conductors

5.1.1. Conductor Size and Tension

The sizes and approximate pull-off or dead-end tension for each phase conductor and ground wire shall be coordinated with FE for design of the takeoff structure (i.e., substation termination structure). The exact pull-off tensions are determined after the substation plans are finalized. If the incoming high voltage lines will cross railroad tracks, such as a siding or main line, to reach the substation, it may be necessary to increase the tensions or provide additional height on the substation structure to meet railroad crossing requirements.

- Required to complete the final design of the transmission line, the Connecting Party is to provide to FE the following:
  - GIS Coordinates for the substation termination structure(s) in latitude/longitude with decimal degree being preferred.
  - Final elevation of the graded and stoned substation yard at the substation termination structure location(s).
  - Heights of the conductor and ground wire attachment points on the substation termination structure(s) or final elevation of the attachment points on the substation termination structure(s).
  - Orientation of the substation termination structure(s). The attachment face of substation termination structures is typically oriented to be parallel to the substation fence. Orientation of attachment fence is required to determine placement of the transmission line structure that will support the span into the substation.

5.1.2. Terminal Connections

- The line terminal connectors furnished by the Connecting Party shall be compression type. The ground wire shall be grounded to the steel structure and the station ground grid by the Connecting Party.

5.1.3. Line Conductor Clearance

- The point of attachment of the line entrance conductors shall be of sufficient height to provide the vertical clearance requirements for lines crossing over public streets, alleys, or roads in urban or rural districts, as outlined in the National Electrical Safety Code (NESC).

6. Substation Design Requirements

6.1. Existing Transmission Substations

6.1.1. All new switchyards must meet the current connection requirements.

6.1.2. Due to the evolution of the FE Transmission System, some existing transmission substation switchyards are of a lesser design configuration than those specified in these Requirements. These substation designs are considered grandfathered for purposes of compliance with these Requirements.

6.1.3. When changes are made to a transmission switchyard involving the addition of a new element (e.g., transformer or line exit), an assessment will be made of the practicality of upgrading to the current connection requirements. If not practical at the existing site, but the grandfathered design philosophy could be continued, then no upgrade to the new requirements will be required providing all current reliability criteria are met.

6.2. Short Circuit Data and Interrupting Devices

6.2.1. Short Circuit Data

FE will provide the following anticipated near-term short circuit data for a specific point of connection:

3 Phase Fault:	Amps or MVA
Single Line-Ground Fault:	Amps*
System Impedance on 100 MVA Base:	Z1% and Z0%

* Fault currents are calculated assuming the fault contribution from the connecting facility is zero.

6.2.2. Substation Equipment

- Equipment shall have interrupting and momentary ratings adequate for the short circuit conditions provided. Fault interrupting devices shall have the open-close duty cycle ratings necessary to accommodate their required open-close sequences.

6.2.3. Short Circuit Data Changes

- While FE endeavors, where possible, to anticipate future system changes that may affect the provided values, FE does not assume responsibility or liability with respect to such protective devices, nor guarantee their continuing adequacy against increased interrupting capacity requirements resulting from system changes. The Connecting Party is responsible for periodic review of existing and future fault conditions and for any future equipment upgrades/replacements that are required.

6.2.4. Interrupting Device >100 kV and All Generation Connections

- All load connections to the FE Transmission System above 100 kV and all Generation Connections regardless of connection voltage are required to have fully rated circuit breakers. Circuit breakers shall be capable of interrupting the maximum available fault current at its applied location. The breaker shall interrupt all three phases simultaneously. The tripping control of the interrupting device shall be powered independently of the FE Transmission System AC source to permit operation upon loss of the FE supply. Circuit breaker tripping and closing power is to be supplied by a pneumatic, hydraulic, or spring charge mechanism.

6.2.5. Interrupting Device <100 kV

- For load connections below 100 kV, engineering studies shall be performed to identify the acceptable type of fault interrupting device. If circuit breakers are required below 100 kV, these breakers shall meet the same requirements as above for BES connected breakers.

6.2.6. Interrupting Device Connecting Party Owned

- All gas insulated interrupting devices within the Connecting Party's facility having a direct connection to a FE transmission line shall be equipped with a low gas pressure alarming/tripping/lockout scheme (as appropriate for the particular device) in order to minimize the possibility of a transmission fault resulting from a loss of insulating gas.

6.3. Remote Relay Access and Disturbance Monitoring

6.3.1. Tap Connected Substations

- Although not normally required at tap connected facilities, FE may, at its option, require remote relay access at a specific facility.

6.3.2. Looped Network Connected Substations

- All digital relays which have the capability of recording system disturbance information and that are used for protection of the FE Transmission System shall be provided with the equipment necessary to allow FE to remotely retrieve this data. This shall be done via either Connecting Party supplied access to the public phone system or through Connecting Party supplied digital communications circuits, at the option of FE.

6.4. Other Substation Design Criteria

6.4.1. Equipment Basic Insulation Levels (BIL):

- The minimum required BIL are listed in *Table 1*. Substations in areas with significant airborne pollution may require a higher insulation level.

6.4.2. Transformer Surge Protection (Lightning Arresters)

- Metal oxide arresters are preferred for transformer protection. Minimum arrester ratings are listed in *Table 2*.
- Arresters protecting transformers are generally mounted on the transformer. When the arresters will not be mounted next to the terminals of the equipment to be protected, the voltage at the protected insulation will usually be higher than at the arrester terminals. MOV arrester application guide, ***IEEE Standard C62.22***, should be consulted to determine the maximum acceptable separation distance between the arresters and the protected equipment.
- The Connecting Party should consult the manufacturer's catalog for details concerning arrester protective characteristics, ratings, and application.

6.4.3. Ratings for Current Carrying Equipment:

- For tap connections, the Connecting Party's high voltage bus and associated equipment, such as switches, connectors, and other conductors shall have a minimum continuous current carrying rating and a momentary asymmetrical current rating as listed in *Table 2*.
- For loop connections or network supply configurations, the minimum current ratings for the Connecting Party's high voltage bus and associated equipment, such as switches, connectors, and other conductors, are provided by FE.

6.4.4. Electrical Clearances (Outdoor)

- Electrical substation design clearances are listed in the attached *Table 1*. These design clearances shall be used for electrical facilities up to and including any interrupting device connected directly to a FE transmission line and for all facilities that are part of the FE transmission current path.
- The safety clearances from live parts to all permanent support surfaces for workers shall be no less than the minimum listed in *Table 1* and shall be applied throughout the entire substation.

- The minimum vertical clearance of the conductors above ground and the vertical and horizontal clearance of conductors passing by but not attached to a building or wall shall be in accordance with the NESC or applicable state and local codes, whichever provides the greater clearances.

6.4.5. Insulators for Station

- The required station post insulator types are listed in *Table 3*. Substations in areas with significant airborne pollution may require a higher insulation level. Higher strength insulators are available and shall be used as needed to meet bus momentary short circuit withstand values.

6.4.6. Horn Gap Switches and Disconnect Switches

- A gang operated horn gap switch shall be installed on each transmission line termination at the Connecting Party's facility at a location which is accessible by FE personnel 24 hours a day. The switch shall be lockable in the open position with a FE padlock in order to provide for a visible electric isolation of the Connecting Party's facility and shall be identified with a FE designated equipment number. A motor operator may be required on a case-by-case basis as determined by FE.
- A ground mat of 4' x 6' dimension shall be provided beneath the air switch operating handle and located so that the switchman will remain on the mat while operating the switch. The mat shall have a direct electrical connection to the grounding point of the switch handle and from there to the station ground grid.
- These horn gap switches shall be three pole, single throw, gang operated. Disconnect switches may be single pole, single throw, hook-stick operated or three pole, single throw, gang operated. Characteristics for all horn gap switches and disconnect switches including voltage and BIL ratings, clearances and pole spacing shall be as given in *Table 1*. Substations in areas with significant airborne pollution may require a higher BIL level. There shall be no braids in the current carrying parts of the switch. Gang operated switches shall be complete with a horizontal, rotating-type operating handle. A grounding device is to be furnished for the operating shaft and shall consist of a tin coated, flexible copper braid, located as close as possible to the operating handle. The braid shall have a cross-sectional area equivalent to 4/0 copper cable, or greater. The braid shall be secured to the shaft by means of a galvanized steel U-bolt clamp and associated cradle-type galvanized steel hardware. The opposite end of the braid shall have two (2) 9/16-inch holes at 1-3/4 inch spacing. Both ends of the braid shall be stiffened and protected by a ferrule or additional tinning.
- All switches are to be manufactured and tested in accordance with the latest revision of ***IEEE Standard C37.30, ANSI C37.32,*** and ***IEEE Standard C37.34***.

6.4.7. Substation Fence Safety Clearances

- The fence safety clearances in the Connecting Party's substation shall comply with the most recent and adopted in ***NESC, Section 11***.
- Additional fencing requirements for Non-FE-owned interconnection facilities:
  - There will need to be two (2) separate substations; one for the interconnection and one for the Connecting Party's substation. In addition, there should be separate fencing for both with a minimum of fifteen feet of separation. There should be no common fencing between the two substations.
  - The substation fence should be a minimum of ten feet outside the edge of the right of way.

6.4.8. Grounding System Design and Test

- The grounding system shall be designed in accordance with the latest version of ***IEEE Standard 80, IEEE Guide for Safety in AC Substation Grounding***. The grounding system design and construction shall be verified by tests in accordance with ***IEEE Standard 81, EEE Guide for Measuring Earth Resistivity, Ground Impedance, and Surface Potentials of a Ground System***.
- Ground fault currents from FE sources are listed in *Section 6.2, Short Circuit Data and Interrupting Device Ratings.* Connecting Party equipment ground sources can contribute significant fault current independent of the ground fault values in *Section 6.2, Short Circuit Data and Interrupting Device Ratings*. These ground sources shall be considered in the design of the grounding system.
- If the substation structure is to be wood-pole type construction, the transmission line overhead ground wire, all switch bases, fuse bases, insulator bases, and other non-current carrying metal parts shall be grounded.

7. Communication Design Requirements

7.1. Normal Voice Communications

7.1.1. When required by FE, the Connecting Party shall provide a dedicated voice communication circuit to the SCC. Such a dedicated voice communication circuit must originate from the Connecting Party's 24-hour manned operations office and is typically required for:

- Generation Facilities
  - Synchronization and operation of significant capacity within FE's Control Area.
- Transmission Substations
  - Connected transmission facilities that significantly affect the FE's transmission network capacity and operations.

7.1.2. All other normal voice communication concerning facility operations shall be conducted through the public telephone network to the SCC phone number(s) issued by FE.

7.2. Emergency Voice Communications

7.2.1. Voice communications in the event of a transmission facility emergency shall use the dedicated voice circuits, if available, or public telephone network and phone number(s) designated for emergency use.

7.2.2. It is the Connecting Party's responsibility to take prudent steps when an area or system wide capacity emergency is declared. Load reductions shall be implemented by reducing non-essential loads. This type of reduction is usually conveyed through the local media. Contractual load reductions should already be in effect.

7.2.3. The Connecting Party is responsible for providing the assigned FE SCC a "Connecting Party Contact List" that contains the names of two or more representatives of the Connecting Party, their titles and business, cell, and home phone numbers. Any special information such as police and fire department phone numbers as well as substation phone numbers should be included in the list.

7.2.4. Connecting Parties will be provided an unlisted FE phone number to be used for emergency or routine operations. Operational emergencies (i.e., equipment) warrant a direct call either way. The SCC dispatcher will advise the designated FE representative of problems that need to be handled directly with the Connecting Party.

7.2.5. System capacity emergencies are communicated through the local media except for Connecting Parties with special agreements. These parties are notified electronically in the event of an emergency interruption.

8. Revenue Metering Requirements

Revenue metering equipment shall be installed for Load Connections, Generation Connections, and Transmission Interconnections. Revenue metering is used primarily for energy accounting and billing purposes.

8.1. Load Connection Revenue Metering

8.1.1. Revenue metering is required for retail and wholesale Load Connection facilities with a direct electrical connection to FE.

8.1.2. FE provides, owns, operates, and maintains the revenue metering equipment at the Connecting Party's facility as specified in the applicable tariff or Interconnection Agreement. Refer to *Appendix D, FirstEnergy Revenue Metering Installation Requirements for Transmission Connected Retail and Wholesale Load Customer Facilities* for details including installation requirements.

8.1.3. The FE revenue metering at the Connecting Party's facility shall be installed on the primary side of the step-down transformer, on the load side of the fault-interrupting device, and within the local zone of fault protection for the facility unless otherwise specified by FE. The Connecting Party's proposed design for the revenue metering installation at the facility must be reviewed and accepted by FE. For Federal Energy Regulatory Commission (FERC) tariffed facilities, the revenue metering at the Connecting Party's facility shall be installed on the primary side of the Connecting Party's step-down transformer, on the load side of the fault-interrupting device, and within the local zone of fault protection for the facility. For non-FERC tariffed facilities less than 69 kV, the revenue metering may be located on the line side of the fault interrupting device, at the option of FE. The Connecting Party's proposed metering installation design must be reviewed and accepted by FE.

8.1.4. The revenue metering will be compensated for electrical losses if it is not located at or near the point of service.

8.1.5. FE will determine, on a case-by-case basis, any additional revenue metering requirements for Load Connection facilities with behind-the-meter generation.

8.2. Generation Connection Revenue Metering

8.2.1. Direct Generation Connection to FE Substation

- FE shall, at the Connecting Party's expense, provide, install, own, operate, test, and maintain the revenue metering equipment at the FE substation unless otherwise agreed upon by FE. Refer to *Figures 5 and 6*.
- FE will be responsible for revenue meter data submittals to PJM's Power Meter system unless otherwise agreed upon by FE.
- The Connecting Party shall consult with FE regarding access to energy data from the FE revenue meter.

8.2.2. Tapped Generation Connection to FE Line

- FE shall, at the Connecting Party's expense, provide, own, operate, test, and maintain the revenue metering equipment at the generation facility's step-up substation unless otherwise agreed upon by FE. Refer to *Figure 3*.
- The FE revenue metering equipment shall be located on the high voltage side of the Connecting Party's step-up transformer, on the generation side of the fault-interrupting device, and within the local zone of fault protection for the facility as shown on *Figure 3*, unless otherwise agreed upon by FE.
- The Connecting Party shall, at its own expense, install the FE-owned revenue metering equipment at the step-up substation as specified in *Appendix E, Requirements for FirstEnergy-Owned Revenue Metering at Generation Facilities*.

- The revenue metering shall be compensated for electrical losses in any significant length of customer-owned line between the generation facility and the Point of Interconnection with FE.
- FE will be responsible for revenue meter data submittals to PJM's Power Meter system unless otherwise agreed upon by FE.
- The Connecting Party shall consult with FE regarding access to energy data from the FE revenue meter.

8.2.3. Indirect Generation Connection to FE

FE determines, on a case-by-case basis, the revenue metering requirements for generation facilities connecting indirectly to FE through an existing Connecting Party's POI with FE.

8.2.4. Direct Transmission Connected Generation Facilities with Customer-Owned Revenue Metering.

Refer to the requirements in *Appendix F, FirstEnergy Requirements for Customer-Owned Revenue Metering at Generation Facilities* if, under special circumstances, FE agrees to allow the Connecting Party at their expense to provide, install, own, operate, test, and maintain the revenue metering equipment at a direct transmission connected generation facility's step-up substation.

8.3. Transmission Interconnection Revenue Metering

8.3.1. The Connecting Party shall provide, install, own, operate, test, and maintain the revenue metering equipment at the Connecting Party's facility unless otherwise agreed to by FE and the Connecting Party.

8.3.2. The revenue metering equipment shall be installed at the Point of Interconnection between the Connecting Party's facility and the FE Transmission System unless otherwise agreed to by FE and the Connecting Party.

8.3.3. The revenue metering shall be compensated for electrical losses in any significant length of transmission line between the metering point and the Point of Interconnection.

8.3.4. The Connecting Party, at its own expense, shall provide, install, own, operate, test, and maintain the equipment required for revenue meter data communications at the Connecting Party's facility unless otherwise agreed to by FE and the Connecting Party.

8.4. Revenue Metering Equipment

Revenue metering equipment includes, but is not limited to, current transformers, voltage transformers, mounting structures, wiring, revenue meters, meter sockets, test switches, communication circuits, and associated devices.

8.4.1. General Requirements

- The revenue metering equipment shall meet or exceed all applicable industry standards (e.g., ANSI, IEEE, and National Electrical Manufacturers Association [NEMA]).
- At least (N-1) metering elements shall be used for the revenue metering, where N is the number of wires in the electrical system associated with the revenue metering. Three metering elements shall be the standard for revenue metering located on the transmission side of facilities connecting to FE Transmission System voltages 115 kV and higher unless otherwise agreed to by PJM, FE, and the Connecting Party.
- The responsibility for the revenue metering equipment will vary depending on the type of Connecting Party facility, the supply voltage, and the applicable tariffs or Interconnection Agreements.

- The revenue metering installation shall meet all applicable industry standards for phase-to-phase and phase-to-ground electrical clearances. Connections to primary terminals on the current transformers and voltage transformers shall be designed so that the associated mechanical stresses will not exceed the limits specified by the manufacturers. FE will provide the Connecting Party with manufacturer's information for the current and voltage transformers when these devices will be furnished by FE and installed by the Connecting Party.

8.4.2. Revenue Meters

- The revenue meters shall be capable of recording, storing, and transmitting bi-directional MWh data and MVARh data (or kWh and kVARh data). The revenue meters shall record this data in fifteen-minute intervals unless otherwise agreed to by FE and the Connecting Party.

8.4.3. Revenue Metering Current Transformers

- The revenue meters shall be connected to CTs having a minimum metering accuracy class of 0.3% (as defined in ***IEEE C57.13***) at a minimum burden designation of B-1.8. CTs with lower burden designations may be allowed by FE in special cases, but the secondary burden on the CTs must not exceed the nameplate burden rating.
- The continuous current on the CTs shall not exceed the primary nameplate rating with the thermal current rating factor (RF) applied. The available fault current must not exceed the withstand rating of the CTs.
- The revenue meters shall be connected to dedicated metering CT secondary circuits and should not share the same circuits with relays or other devices.
- Extended range metering CTs are required for connections with significant differences between the magnitudes of the normal continuous high and low power flow levels (e.g., connections to solar or wind generation facilities).

8.4.4. Revenue Metering Voltage Transformers

- The revenue meters shall be connected to voltage transformers (VTs) or coupling capacitor voltage transformers (CCVTs) having a minimum metering accuracy class of 0.3% (as defined in ***IEEE C57.13***) at a minimum burden designation of Y. The secondary burden on the VTs or CCVTs must not exceed the nameplate burden rating.
- The revenue meters shall generally be connected to dedicated metering VT or CCVT secondary circuits and should not share the same circuits with relays or other devices. The revenue meters may be connected to dedicated secondary windings on VTs or CCVTs that have separate secondary windings used for relays or other devices.
- VTs are preferred for revenue metering. The use of CCVTs for revenue metering shall generally be limited to facilities connecting to FE Transmission System voltages 115 kV and higher or where it is impractical to use VTs for technical reasons. A Connecting Party responsible for any CCVTs used for revenue metering may be required to utilize a VT against which the CCVTs can be periodically tested and calibrated.

8.4.5. Operational Metering Data from Revenue Meters

- Operational metering data (e.g., real-time MW and MVAR) is not available from FE-owned revenue meters at Connecting Party facilities. The Connecting Party shall, at its own expense, install, operate, test, and maintain any metering and communications equipment necessary to provide operational metering data that may be required by PJM and/or FE.

8.5. Revenue Metering Access, Security, and Testing

8.5.1. At Connecting Party facilities where FE provides revenue metering equipment, the Connecting Party shall grant FE employees and authorized agents access to the equipment at all hours and for any reasonable purpose.

8.5.2. The Connecting Party shall not permit unauthorized persons to have access to the revenue metering equipment.

8.5.3. The meters, test switches, and any other secondary devices that could have an impact on the performance of the revenue metering shall be sealed at all times and the seals shall be broken by the party responsible for the equipment only when tests, adjustments, and/or repairs are required and after the other party has been informed.

8.5.4. The revenue metering shall be tested for accuracy by the party responsible for the equipment as specified by the applicable tariffs, Interconnection Agreement, PJM requirements, or state commission regulations.

9. Inspection Requirements

9.1. Final Inspection before energization

9.1.1. Before a Connecting Party owned substation can be energized, it must pass a final inspection by FE personnel.

- Inspection concentrates on all substation equipment up to and including the first protective fault interrupting device and the ground system.
- Inspection may include circuit breakers, circuit switchers, power fuses, instrument transformers, switches, surge arresters, bushings, and relays and associated equipment (including battery and battery chargers).
- Inspection will consist of a visual inspection of all major equipment as well as review of required test results.
- The ground system must be checked by using the resistance measurement procedures in accordance with ***IEEE Standard 81, IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System***.

9.2. Inspectors and Documentation

9.2.1. The inspection will be performed by FE personnel who will document the inspection by completing a site-specific form supplied by FE. Refer to *Appendices A and B* for the required procedure and a typical inspection check-off list.

10. Maintenance Requirements

10.1. Maintenance Program Overview

10.1.1. All Connecting Party owned substation equipment up to and including the first protective fault-interrupting device shall be maintained in accordance with “Good Utility Practice” as that term is defined in the ***PJM Open Access Transmission Tariff***. This may include circuit breakers, circuit switchers, power fuses, instrument transformers, switches, surge arresters, bushings, data acquisition equipment, and relays and associated equipment (including battery and battery charger). The Connecting Party is referred to the latest version of ***NERC PRC-005, Protection System, Automatic Reclosing, and Sudden Pressure Relaying Maintenance.*** Depending on the type of connection and equipment installed, the Connecting Party may own applicable equipment and be responsible for PRC-005 compliance.

10.2. Maintenance of Device and Control Schemes

10.2.1. The Connecting Party shall have an FE approved organization test and maintain all devices and control schemes provided by the Connecting Party for the protection of the FE Transmission System. Included in the testing and maintenance will be any initial set up, calibration, and check out of the required protective devices, periodic routine testing and maintenance, and any testing and maintenance caused by a Connecting Party or FE change to the protective devices.

10.3. Maintenance Program Costs

10.3.1. All costs associated with the testing and maintenance of devices provided by the Connecting Party for the protection of the FE Transmission System, including costs incurred by FE in performing any necessary tests or inspections, shall be the responsibility of the Connecting Party.

10.4. Maintenance Program Review and Approval

10.4.1. FE reserves the right to approve the testing and maintenance practices of a Connecting Party when the Connecting Party’s system is operated as a network with the FE Transmission System.

10.4.2. If the Connecting Party’s testing and maintenance program is not performed to the satisfaction of FE or at the required maintenance interval, FE reserves the right to inspect, test, or maintain the protective devices required for the protection of the FE Transmission System.

11. SCADA Requirements (Transmission, Generation, and Load Connection)

11.1. Transmission Interconnection Substations

11.1.1. Loop and Network Connected Transmission Substations

Loop and network connected facilities shall be equipped with a SCADA Remote Terminal Unit (RTU) and shall be connected via an appropriate, Connecting Party supplied, dedicated digital communications channel to the respective FE Transmission SCC Front End Processor (FEP) diversified locations. The RTU shall provide FE with at least the information and control capabilities listed below and must communicate via DNP 3.0 protocol. Facilities with unusual or non-conforming load characteristics may be required to provide additional information and control capabilities beyond those listed.

- Control
  - The RTU shall provide FE with control of all circuit interrupting devices that are directly in the FE transmission power path.
- Position Indication
  - The RTU shall provide FE position indication of all transmission voltage circuit interrupting devices and motor operated disconnect devices.
- Alarms
  - The RTU shall provide FE equipment alarm information for each circuit interrupting device and associated protective relaying in the transmission path. Indication of protective relay operation alarms for relaying other than the transmission line relaying that operates a circuit interrupting device in the transmission path will also be provided. These may include breaker failure or bus differential relaying.
- Operational Metering
  - The RTU shall provide FE instantaneous bi-directional real and reactive power metering (MW and MVAR) and voltage for all FE transmission lines connected to the facility, as well as ampere metering of each circuit breaker in the transmission path. Current transformers (CTs) having a minimum metering accuracy class of 0.3% (as defined in IEEE C57.13) at a minimum burden designation of B-1.8, voltage transformers having a minimum accuracy rating of 0.3%, and meters/transducers having a minimum accuracy rating of 0.25% must be used where these quantities are required to meet the accuracy requirements of ***PJM Manual 01, Control Center and Data Exchange Requirements***. The operational metering equipment shall be provided, installed, and maintained by the Connecting Party.

11.1.2. Non-Loop or Non-Network Connected Transmission Substations

This type of interconnection is found where FE has a transmission line terminating at another company's substation. For example, a new interconnection with a foreign utility at the foreign utility's substation. The Connecting Party shall install and maintain metering equipment and data acquisition system (DAS) equipment at each Interconnection Point for measuring electric energy for the purposes of determining load, effecting settlements, and monitoring and telemetering power flows under this Agreement. The Parties are responsible for providing all SCADA data, as required by their RTO, via their respective Inter-Control Center Communications Protocol (ICCP) data links. The Parties may receive operational data regarding the interconnection between the Parties via the ICCP data links to their Regional Transmission Organization.

11.1.3. Tap Connected Substations

FE may require tap-connected facilities with unusual or non-conforming load characteristics to install a SCADA RTU. Tap connected transmission load facilities do not normally require a SCADA RTU. If an RTU is required, FE will specify the information and control capabilities to be provided.

11.2. SCADA (Operational Metering) Requirements for Generation Facilities (Generation and Load Connection)

For Generation facilities with a direct electrical connection to an FE substation (See *Figures 5 and 6*), the generator is responsible for providing all SCADA data as required by the PJM Tariff via their respective ICCP data links to PJM. FE receives operational data regarding the generator interconnection via its ICCP data link to PJM. FE will also receive operational data regarding the generator interconnection via a direct data link owned installed and maintained by FE at the Connecting Party's expense.

For a tapped line generation facility (See *Figures 3, 7, and 8),* the generator shall be equipped with a SCADA RTU and shall be connected via an appropriate Connecting Party supplied, dedicated digital communications channel to the respective FE FEP diversified locations. The RTU shall provide FE with at least the information and control capabilities listed below and must communicate via DNP 3.0 protocol. Facilities with unusual or non-conforming load characteristics may be required to provide additional information and control capabilities beyond those listed.

11.2.1. Generation Connected Directly to the Transmission System

- Control
  - There is no FE SCADA control of breakers contained within the Connecting Party's generation facility.
- Positive Indication
  - The Connecting Party's RTU shall provide FE position indication of all transmission circuit interrupting devices and motor operated disconnect devices, and if this position indication is not available, position indication will be provided for low side circuit interrupting devices or generator output breakers.
- Alarms
  - The RTU shall provide FE indication of protective relay operation alarms for relaying that impacts the associated FE transmission substation. These might include breaker failure or bus differential relaying.
- Operational Metering
  - The RTU shall provide FE instantaneous bi-directional real and reactive power metering (MW and MVAR) and voltage for all FE transmission lines connected to the Connecting Party's facility. This metering may be on the generator transformer, or circuit breakers owned by the Connecting Party at transmission voltages. Ampere metering of each circuit breaker in the transmission path shall also be provided. If there is additional metering available on an individual generator basis, this information (i.e., instantaneous megawatts, instantaneous megavars, and b phase amps) will be provided to FE. CTs having a minimum metering accuracy class of 0.3% (as defined in ***IEEE C57.13***) at a minimum burden designation of B-1.8, voltage transformers having a minimum accuracy rating of 0.3%, and meters/transducers having a minimum accuracy rating of 0.25% must be used where these quantities are required to meet the accuracy requirements of ***PJM Manual 01, Control Center and Data Exchange Requirements***. The operational metering equipment shall be provided, installed, and maintained by the Connecting Party.

12. Reference Tables and Figures

Table 1 – Substation Electrical Clearances and Insultation Levels

Substation Electrical Clearances and Insulation Levels										
Rated Maximum Voltage Between Phases (kV rms)	Rated Basic Impulse Insulation Level (BIL) kV Crest	Electrical Clearances (inches)[1,2]				Centerline-to-Centerline Phase Spacing (inches)[2]			Vertical Clearance of Unguarded Live Parts[3]	Horizontal Clerance of Unguarded Live Parts[3]
		Ground		Live Part		Disconnect Switches		Horn Gap Switches (Vertical and Side Break)		
		Minimum	Design	Minimum – Metal to Metal	Design Phase Spacing	Vert Break	Side[5] Break			
25.8	150	10	12	15	30	30	36	48	9’-3”	3’-9”
38	200	13	15	18	36	36	48	60	9’-6”	4’-0”
48.3	250	17	18	21	48	48	60	72	9’-10”	4’-4”
72.5	350	25	29	31	60	60	72	84	10’-5”	4’-11”
121	550	42	45	53	84	84	108	120[5]	11’-7”	6’-1“
145	550	42	45	53	84	84	108	120[5]	11’-7”	6’-1”
	650	50	52 ½	63	96	96	132	144[5]	12’-2”	6’-8”
242	900	71	80	89	132	132	192	192[5]	13’-9”	8’-3”
362[4]	1300	104	106	119	174	174	Note[7]	240[5]	17’-2”	11’-8”
550[8]	1800	144	152	222[9]	300	300	Note[7]	324[5]	20’-6”	15’-0”

Notes:

1. Clearances are given for rigid conductors and live parts. Non-rigid conductors (e.g., strain bus) must be located such that any possible movement will not create conditions which cause the clearances to be less than the minimum values shown.

2. These values are based on ANSI C37.32-1996 (except 550, 900 & 1800 BIL design ground clearances are based on the height of a station post insulator).

3. These values are based on the National Electrical Safety Code, Accredited Standards Committee C2-2002. These clearances are to any permanent supporting surface for workers. The vertical clearance to the unguarded bottom of any part of indeterminate potential (e.g., insulator or surge arrester) shall be not less than 8’-6".

4. Clearances for 362 kV voltage are based on a per unit switching surge factor of 2.5.

5. Horn gap switches applied as disconnect switches should use the disconnect phase spacing.

6. FirstEnergy's standard is to use these values for center break switches.

7. Value not yet established.

8. Clearances for 550kV voltage are based on a per unit switching surge factor of 2.0.

9. Based on GPU accepted practice prior to merger.

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Table 2 – Equipment Ratings

Equipment Ratings							
System	Current Carrying Equipment			Surge Arresters			
Nominal System Voltage (kV)	Continuous Amps[1]	Momentary Asymmetrical Withstand	Switch Rated Maximum Voltage	MCOV[3]	Duty Cycle[3]	Class	P. Relief kA Sym.
500	N/A	N/A	550 kV	318 kV	396 kV	Station	65
345	N/A	61 kA	362 kV	209 kV	258 kV	Station	65
230	1200	61 kA	245 kV	140 kV	172 kV	Station	65
138	600	40 kA	145 kV	84 kV	108 kV	Station	65
115	600	40 kA	123 kV	70 kV	90 kV	Station	65
69	600	40 kA	72.5 kV	48 kV	60 kV	(2)	(2)
46	600	40 kA	48.3 kV	31.5 kV	39 kV	(2)	(2)
34.5	600	40 kA	38 kV	24.4 kV	30 kV	(2)	(2)
25	600	40 kA	27 kV	19.5 kV	24 kV	(2)	(2)
23	600	40 kA	27 kV	17 kV	21 kV	(2)	(2)

Notes:

1. For tap supplied connection only. Looped supplied connection must not limit through line rating.
2. Station or Intermediate Class may be used but pressure relief rating must be greater than maximum future Isc.
3. Minimum sized arresters for effectively grounded systems only.

FE will specify the ratings for arresters that will be applied on non-effectively grounded systems.

Table 3 – FirstEnergy Standard Insulators

Table 3 **FirstEnergy Standard Insulators** **Basic Impulse Insulation Levels, Insulator Technical Reference Numbers & Cantilever Strengths**					
Reference Class kV	Standard BIL Level kV	Standard Strength		High Strength	
		Technical Reference No.	Cantilever Strength	Technical Reference No.	Cantilever Strength
23	150	208	2000	227	4000
25	200	210	2000	231	4000
34.5	200	210	2000	231	4000
46	250	214	2000	267	4000
69	350	216	1500	278	3000
115 & 138	550	286	1700	287	2600
230	900	304	950	308	1450
345	1300	324	1000	367	1450
500	1800	391	1450	392	1750

Guide to Figures Mentioned in Requirements for Transmission Connected Facilities

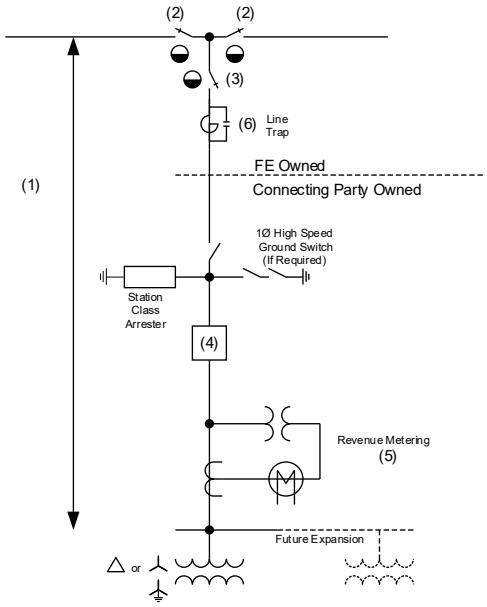
	Voltage				
	69 kV & below	**115 kV & 138 kV**	**230 kV**	**345 kV**	**500 kV**
Connection Type					
Tapped load	Figure 1A	Figure 1B	If deemed non-critical refer to Figure 1C	N/A	N/A
Looped load	Figure 2				
Generator ≤ 20 MW*					
tapped line generation	Figure 3	N/A	N/A	N/A	N/A
Generator > 20 MW					
looped line w/ energy export	Figure 5				
bus connected gen w/ energy export	Figure 6				

** May require a ring bus or equivalent connection type (Figure 5 and 6) based on process referenced in Appendix C.*

The following table provides additional clarifying descriptions for additional SCADA and metering requirements for a connecting party with a transmission system and connected generation.

	Voltage				
	69 kV & below	**115 kV & 138 kV**	**230 kV**	**345 kV**	**500 kV**
Metering/SCADA Requirements					
Transmission system w/ gen on tapped connection	Figure 7		If deemed non-critical refer to Figure 7	N/A	N/A
Transmission system w/ gen on looped connection	Figure 8		If deemed non-critical refer to Figure 8	N/A	N/A

Figure 1A – Load Connection: FE Line Tap Less Than 100 kV

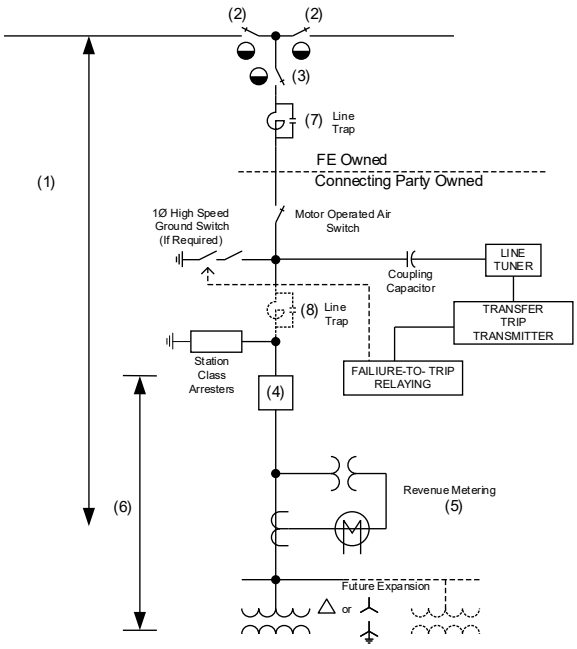


Notes

1. Must meet standards set in FE Transmission Connected Facilities document.
2. Line switches in network path by FE. Supplemental interrupting device (i.e. vacuum interrupters) may be required.◒SCADA control required.
3. Tap switch to be installed at connecting party's expense unless noted by FE. ◒ SCADA control required.
4 . Fully rated interrupting device (i.e., breaker, circuit switcher, or fuses). Utilization of fuses is subject to review from FE.
5. Revenue metering device per section 9.
6. Line trap may be required at tap locations if source stations utilize power line carrier scheme
7. Additional requirements must be followed if behind the meter generation is installed.

BY: CLA APP: DATE: 3/25/2020 ISSUE:	FirstEnergy Transmission Planning & Protection	DIST. CODE: SCALE: NS SIZE: 8.5x11	PARENT DOCUMENT: FIRSTENERGY REQUIREMENTS FOR TRANSMISSION CONNECTED FACILITIES TITLE: FE LINE TAP LESS THAN 100 KV LOAD
REVISION NOTES: REV I: 10/17/2022 - GHM			DWG NO.: FIGURE 1A FILE NAME: Standards (2022-10-17).vsdx REV.: I

Figure 1B – Load Connection: FE Line Tap Between 100 kV and 200 kV



Notes

1. Must meet standards set in FE Transmission Connected Facilities document.
2. Line switches in network path by FE. Supplemental interrupting device (i.e. vacuum interrupters) may be required. ◒ SCADA control required.
3. Tap switch to be installed at connecting party's expense unless noted by FE. ◒ SCADA control required.
4. For connection to circuit of 100 kV or higher, a circuit breaker and breaker failure relaying is required. Breaker failure relaying must send transfer trip to FE source substations via communication system or via high speed ground switch operation.
5. Revenue metering device per section 9.
6. Connecting party substation must be protected by two independent high speed protection schemes.
7. Line trap required at tap location only when a high speed ground switch option is used in place of communication assisted transfer trip and source stations utilize power line carrier scheme.
8. Line trap required at connecting party sub only if communication assisted transfer trip is used. Only one line trap location is require.
9. Additional requirements will be identified by FE and must be followed if behind the meter generation is installed.

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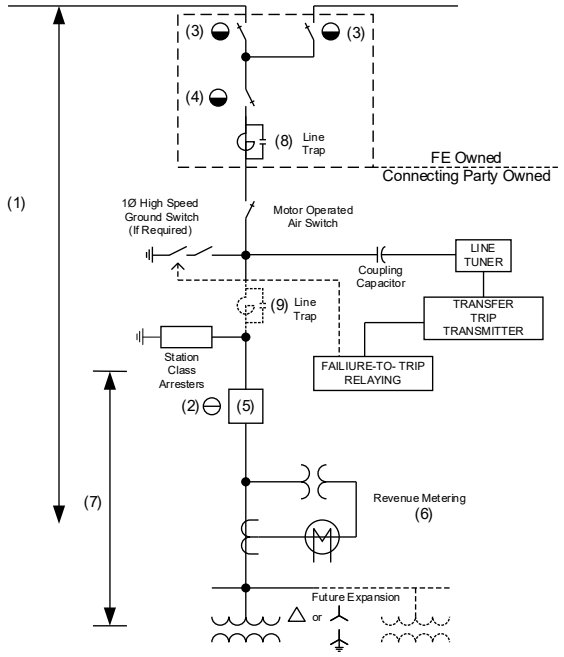
REVISION NOTES: REV I: 10/17/2022 - GHM			TITLE: FE LINE TAP 100 KV TO 200 KV LOAD
			DWG NO.: FIGURE 1B FILE NAME: Standards (2022-10-17).vsdx REV.: I

Figure 1C – Load Connection: FE Line Tap at 230 kV

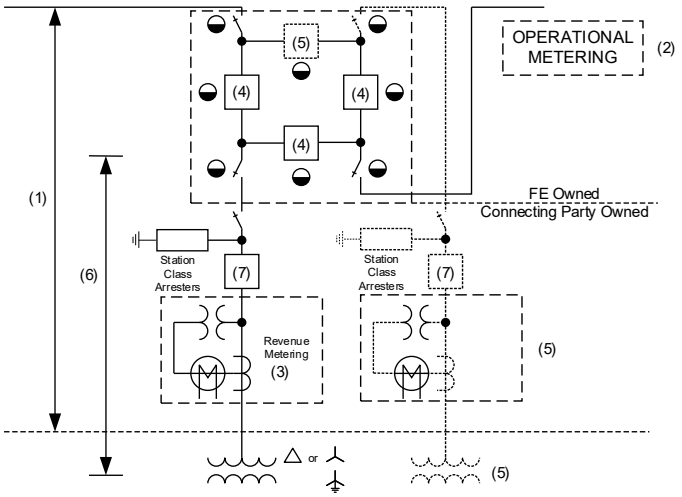


Notes

1. Must meet standards set in FE Transmission Connected Facilities document.
2. Where devices are operated by the connecting party, position indication sent to FE via SCADA.
3. Switches under FE control and required to be located in a substation environment. Supplemental interrupting device(i.e. vacuum interrupter) may be required. Transmission current path must be maintained to FE standards. ◒ SCADA control required.
4. Tap switch to be installed at Connecting Party's expense unless noted by FE. ◒ SCADA control required.
5. For connection at 230 kV, a circuit breaker and breaker failure relaying is required.
6. Revenue metering device per section 9.
7. Connecting party substation must be protected by two independent high speed protection schemes.
8. Line trap required at tap location only when a high speed ground switch option is used in place of communication assisted transfer trip and source stations utilize power line carrier scheme.
9. Line trap required at connecting party sub only if communication assisted transfer trip is used. Only one line trap location is require.
10. Additional requirements will be identified by FE and must be followed if behind the meter generation is installed.

BY: CLA APP: DATE: 3/25/2020 ISSUE:	FirstEnergy® Transmission Planning & Protection	DIST. CODE: SCALE: NS SIZE: 8.5x11	PARENT DOCUMENT: FIRSTENERGY REQUIREMENTS FOR TRANSMISSION CONNECTED FACILITIES TITLE: FE LINE TAP 230 KV LOAD
REVISION NOTES: REV B: 10/17/2022 - GHM			DWG NO.: FIGURE 1C FILE NAME: Standards (2022-10-17).vsdx REV.: B

Figure 2 – Load Connection: FE Loop Line Connection



Notes

1. Must meet standards set in FE Transmission Connected Facilities document.
2. SCADA (operational metering) per section 12
3. Revenue metering per Section 9.
4. Breaker under FE SCADA control. Breaker failure relaying is required,
5. Second transformer and fourth breaker an option with expanded revenue metering. Fourth breaker (if applicable) also requires FE SCADA control.
6. Must be protected by two independent high speed protection schemes
7. Fully rated interrupting device (i.e. breaker, circuit switchers or fuses) for clearing customer equipment faults. Utilization of fuses and circuit switchers is only acceptable in certain conditions below 100 kV and is subject to FE review.
8. Additional requirements will be identified by FE and must be followed if behind the meter generation is installed.

BY: CLA APP: DATE: 3/25/2020 ISSUE:	FirstEnergy® Transmission Planning & Protection	DIST. CODE: SCALE: NS SIZE: 8.5x11	PARENT DOCUMENT: FIRSTENERGY REQUIREMENTS FOR TRANSMISSION CONNECTED FACILITIES
REVISION NOTES: REV I: 10/17/2022 - GHM			TITLE: FE LOOP LINE CONNECTION LOAD
			DWG NO.: FIGURE 2 / FILE NAME: Standards (2022-10-17).vsdx / REV.: I

Figure 3 – Generation Connection: FE Line Tap Less than 100 kV

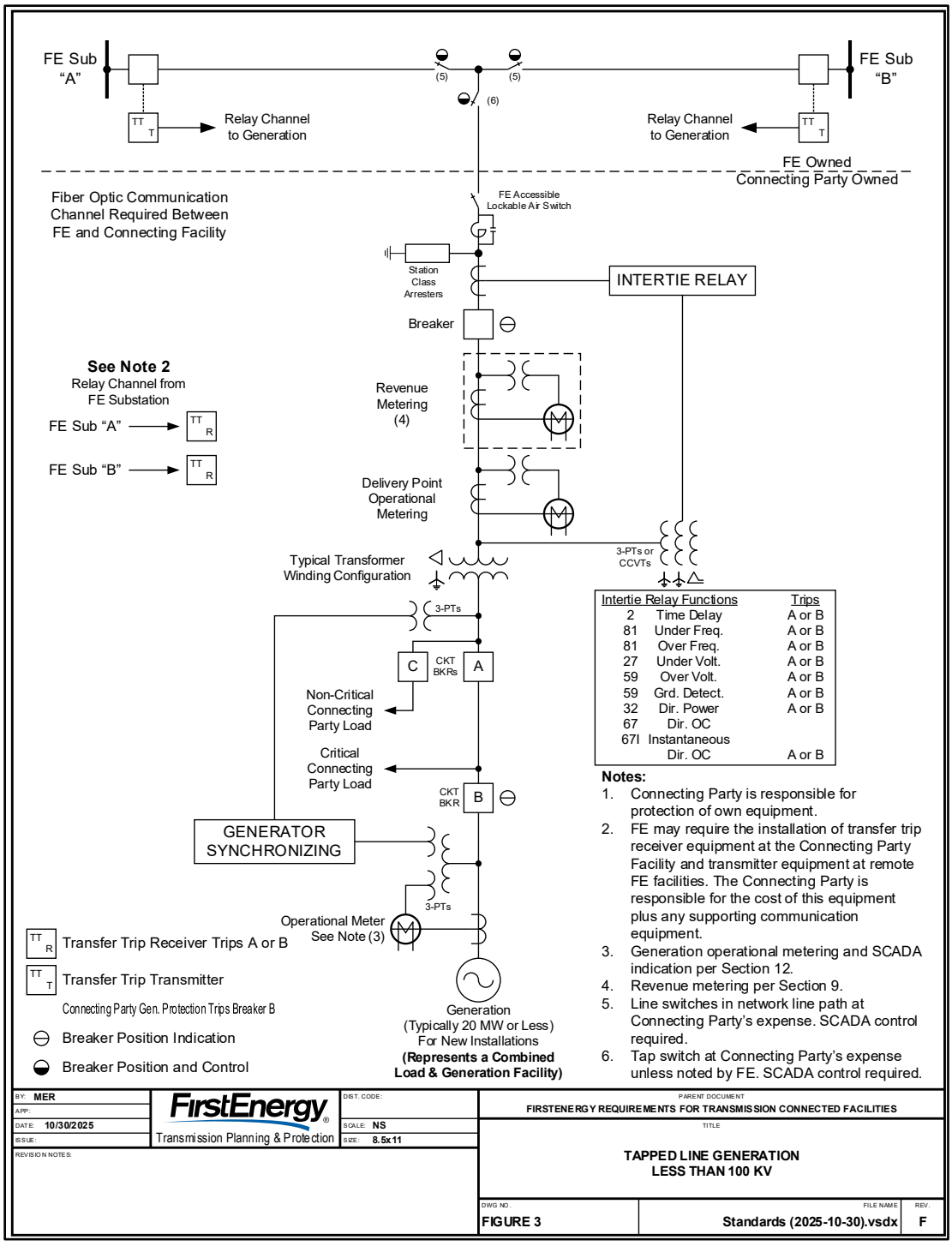


Figure 4 – Generation Connection (Load Shaving Only): FE Line Tap Less than 100 kV

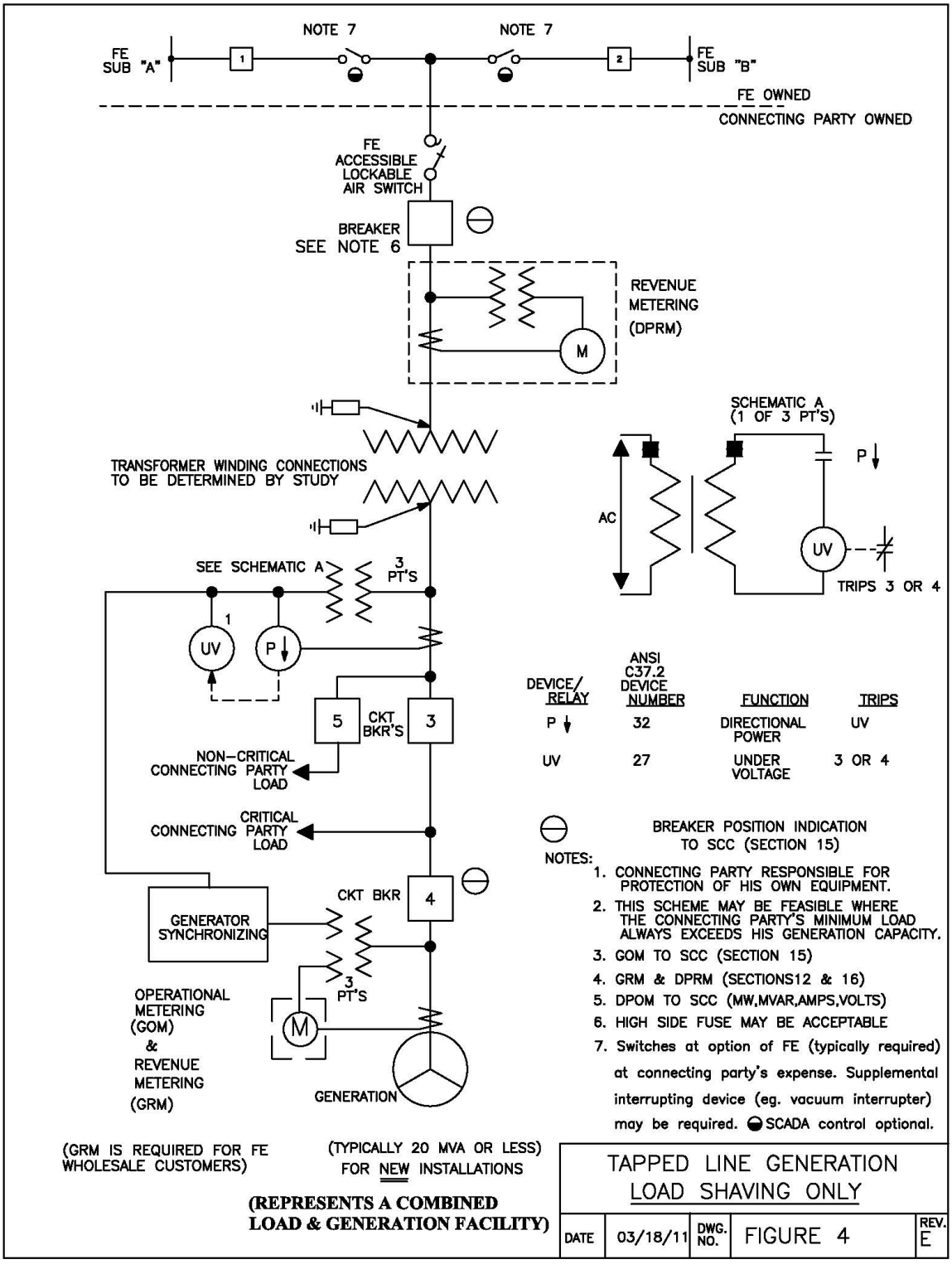
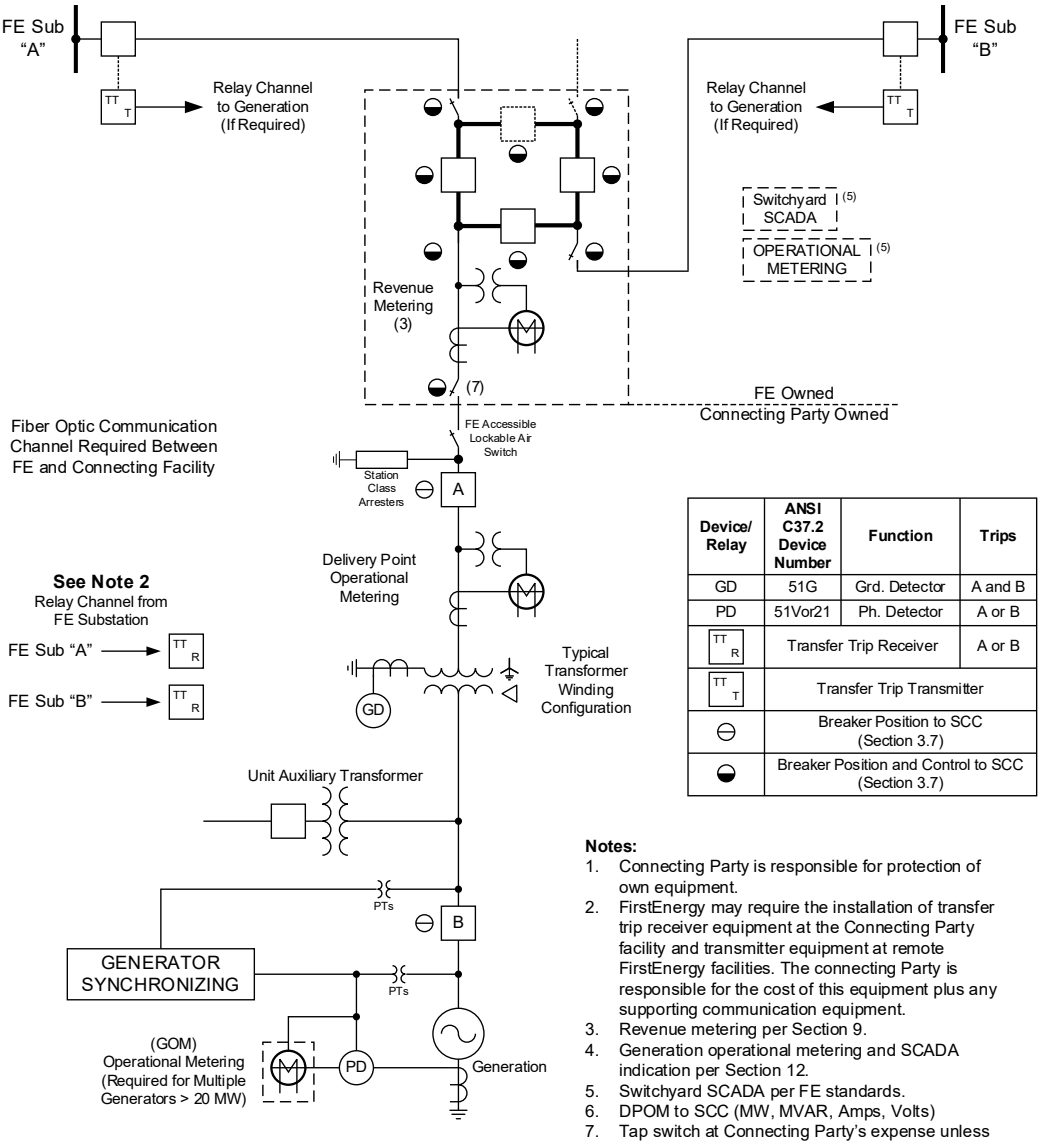


Figure 5 – Generation Connection: FE Looped Line Interconnection



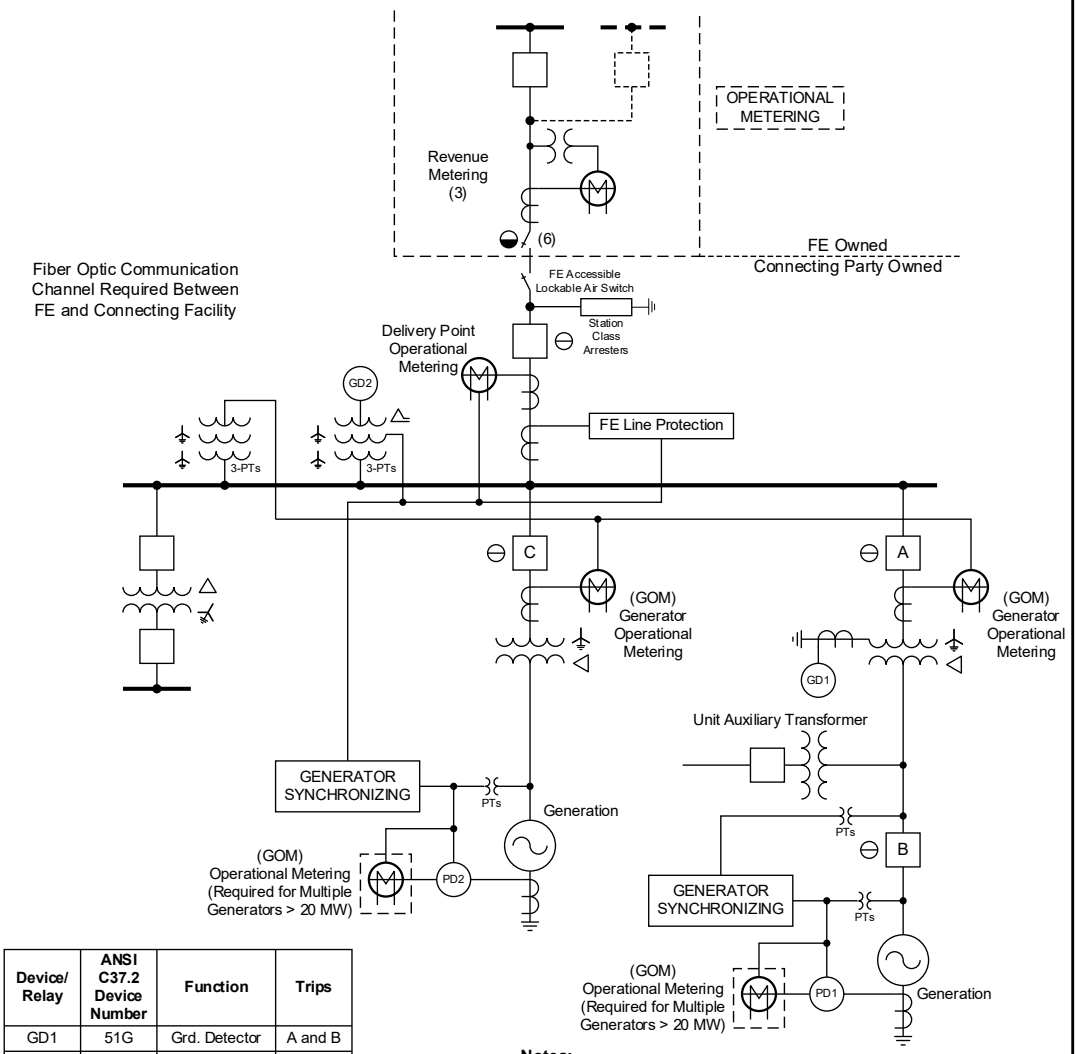
Device/ Relay	ANSI C37.2 Device Number	Function	Trips
GD	51G	Grd. Detector	A and B
PD	51Vor21	Ph. Detector	A or B
TT R	Transfer Trip Receiver		A or B
TT T	Transfer Trip Transmitter		
⊖	Breaker Position to SCC (Section 3.7)		
◒	Breaker Position and Control to SCC (Section 3.7)		

Notes:

1. Connecting Party is responsible for protection of own equipment.
2. FirstEnergy may require the installation of transfer trip receiver equipment at the Connecting Party facility and transmitter equipment at remote FirstEnergy facilities. The connecting Party is responsible for the cost of this equipment plus any supporting communication equipment.
3. Revenue metering per Section 9.
4. Generation operational metering and SCADA indication per Section 12.
5. Switchyard SCADA per FE standards.
6. DPOM to SCC (MW, MVAR, Amps, Volts)
7. Tap switch at Connecting Party's expense unless noted by FE. SCADA control required.

BY: MER	FirstEnergy® Transmission Planning & Protection	DIST. CODE:	PARENT DOCUMENT: FIRSTENERGY REQUIREMENTS FOR TRANSMISSION CONNECTED FACILITIES
APP:			
DATE: 10/30/2025		SCALE: NS	TITLE: LOOPED LINE GENERATION ENERGY EXPORT
ISSUE:		SIZE: 8.5x11	
REVISION NOTES:			DWG NO.: FIGURE 5 / FILE NAME: Standards (2025-10-30).vsdx / REV.: E

Figure 6 – Generation Connection: FE Substation Bus

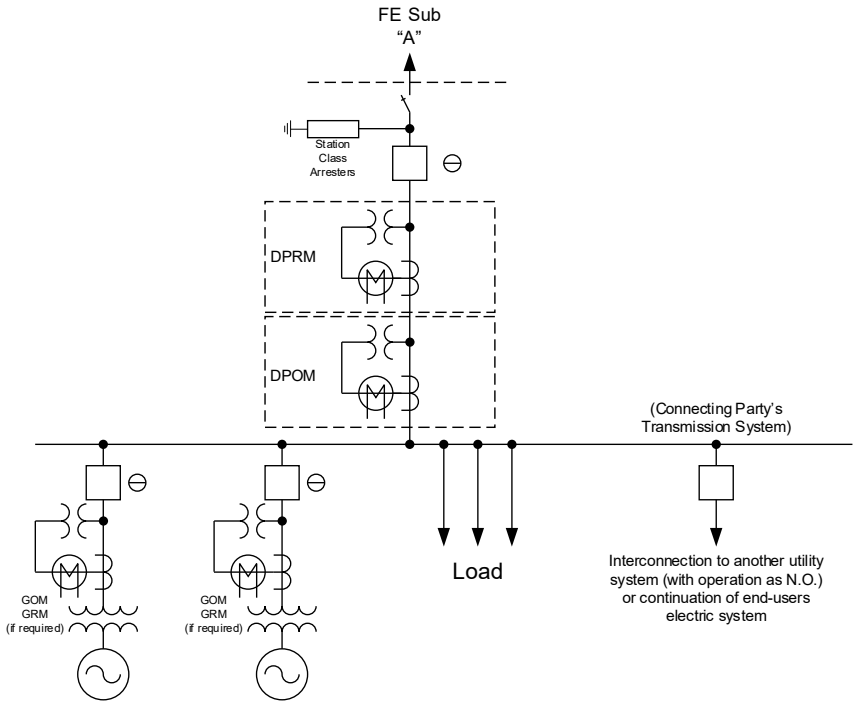


Device/ Relay	ANSI C37.2 Device Number	Function	Trips
GD1	51G	Grd. Detector	A and B
PD1	51Vor21	Ph. Detector	A and B
GD2	51G	Grd. Detector	C
PD2	51Vor21	Ph. Detector	C
⊖	Breaker Position to SCC (Section 3.7)		
◒	Breaker Position and Control to SCC (Section 3.7)		

Notes:
1. Connecting Party is responsible for protection of own equipment.
2. GOM to SCC. See Section 12.
3. Revenue metering per Section 9.
4. DPOM to SCC (MW, MVAR, Amps, Volts). See Section 12 for additional metering and SCADA requirements.
5. Typical transformer winding configurations shown.
6. Tap switch at Connecting Party's expense unless noted by FE. SCADA control required.

BY: MER APP: DATE: 10/30/2025 ISSUE: REVISION NOTES:	FirstEnergy® Transmission Planning & Protection	DIST. CODE: SCALE: NS SIZE: 8.5x11	PARENT DOCUMENT: FIRSTENERGY REQUIREMENTS FOR TRANSMISSION CONNECTED FACILITIES TITLE: BUS CONNECTED MULTIPLE GENERATION ENERGY EXPORT CONNECTION TO AN EXISTING FE SUBSTATION
			DWG NO.: FIGURE 6 / FILE NAME: Standards (2025-10-30).vsdx / REV.: H

Figure 7 – Transmission Interconnection: Generation and Load – FE System Tie Line

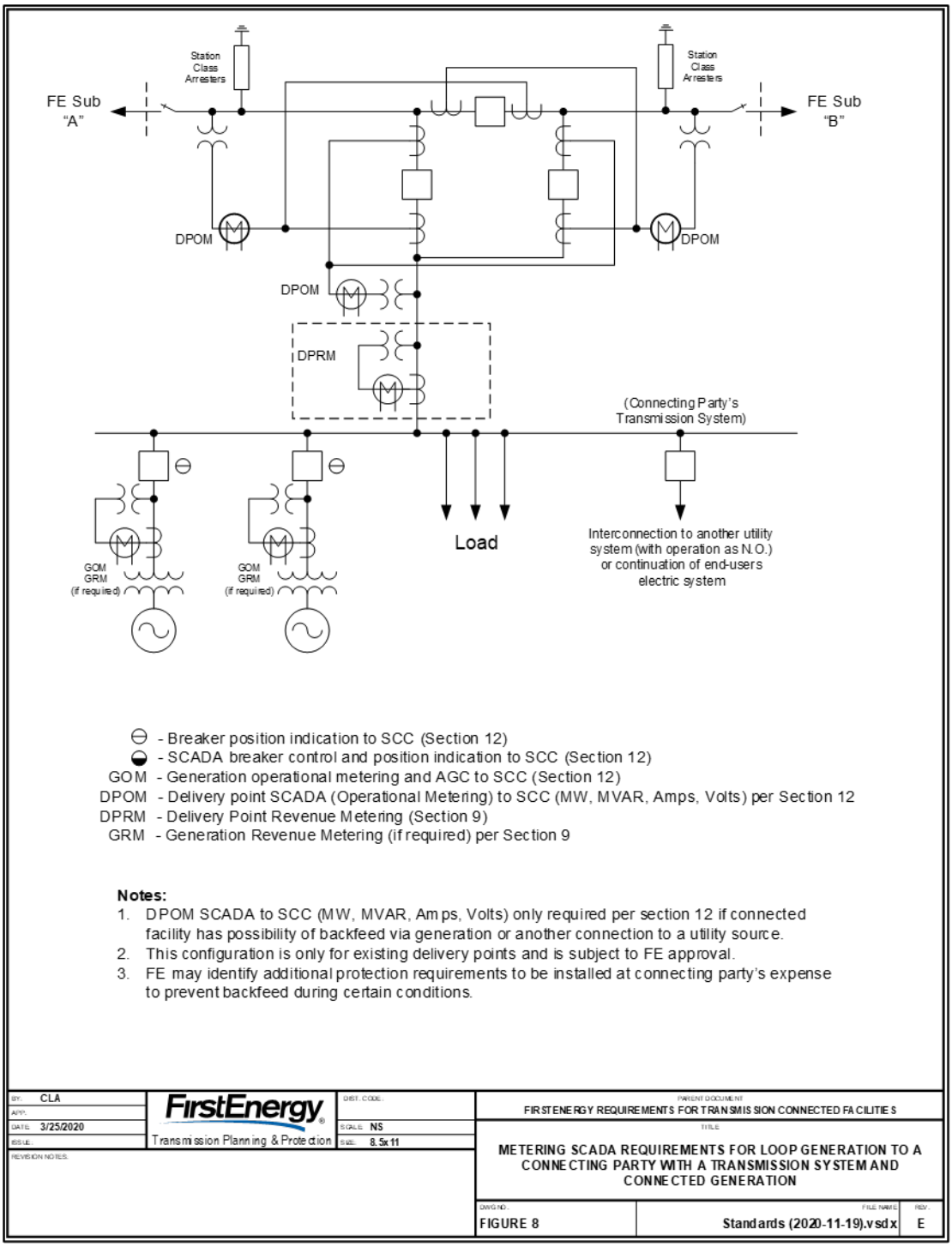


⊖ - Breaker position indication to SCC (Section 12)
◒ - SCADA breaker control and position indication to SCC (Section 12)
GOM - Generation operational metering and AGC to SCC (Section 12)
DPOM - Delivery point SCADA (operational metering) to SCC (MW, MVAR, Amps, Volts) per Section 12
DPRM - Delivery Point Revenue Metering (Section 9)
GRM - Generation Revenue Metering (if required) per Section 9

Notes:
1. DPOM SCADA to SCC (MW, MVAR, Amps, Volts) only required per section 12 if connected facility has possibility of backfeed via generation or another connection to a utility source.
2. This configuration is only for existing delivery points and is subject to FE approval.
3. FE may identify additional protection requirements to be installed at connecting party's expense to prevent backfeed during certain conditions.

BY: CLA APP: DATE: 3/25/2020 ISSUE: REVISION NOTES:	FirstEnergy® Transmission Planning & Protection	DIST. CODE: SCALE: NS SIZE: 8.5x11	PARENT DOCUMENT: FIRSTENERGY REQUIREMENTS FOR TRANSMISSION CONNECTED FACILITIES TITLE: METERING SCADA REQUIREMENTS FOR TAP CONNECTION TO A CONNECTING PARTY WITH A TRANSMISSION SYSTEM AND CONNECTED GENERATION DWG NO: FIGURE 7 / FILE NAME: Standards (2020-11-19).vsdx / REV: D

Figure 8 – Transmission Interconnection: FE Line Tap (Ring Bus)



Appendix A: Procedure for Connecting New Substation or Lines to FE Facilities

1. The procedure defined below does not pertain to Generation Connection requests for generation facilities that plan to participate in the PJM capacity and energy markets. The processing of such requests is set forth in the PJM Open Access Transmission Tariff and Manuals which are available on the PJM web site via www.pjm.com.

2. A Connecting Party desiring to connect a new substation or line to the FE Transmission System will enter into a Construction Service Agreement and/or an Interconnection Service Agreement (for a wholesale customer) with FE after the DLS and other required studies have been favorably completed by FE. The Construction Service Agreement and the Interconnection Service Agreement will define the project scope. FE will specify all details and requirements for the protective relaying or fuse equipment requirements for the new facility for those portions of the new substation or line which will connect to the FE Transmission System.

3. Following receipt of the signed Construction Service Agreement and an Interconnection Service Agreement (for a wholesale customer), FE will appoint an individual to oversee the connection details and act as FE's representative to ensure the connection meets FE's standards.

4. At the conclusion of the design process, the FE appointee will work with the Connecting Party to supply a functional one-line diagram showing devices, wire sizes, equipment types and ratings, and specific relay types and styles for those items which will be connected to the FE facility. For network connections, the relay styles, and types to be used will be either provided or approved by the FE protection engineer. For projects which are not engineered by FE, the Connecting Party will be responsible for providing the functional one-line to FE. "Connected to the FE facility" is defined as any device that is in the primary current path of the connection or any device that is tapped to the FE Transmission System that if it were to fail, would cause a fault and potential outage to any part of the FE Transmission System. Where appropriate, equipment numbers will be assigned to devices in the current path of the connection. This one-line diagram is to be supplied to the FE protection engineer.

5. Following receipt of the functional one-line diagram, an FE provided check-off list similar to *Appendix B, Substation Checkout Guide* will detail those items which will need to be checked or tested prior to final release and energizing of the new facilities. The FE appointee supplies this list to the Connecting Party and ensures that all items on the list are checked and tested to the satisfaction of the FE representative releasing the equipment. This check-off and testing can be performed by the Connecting Party or its representative.

   The FE protection engineer provides protective relay and/or fuse settings for those relays that are used in a network application or are necessary for proper protective coordination with the FE transmission system.

6. FE requires that for connections greater than 100 kV, the connected equipment and check-off list be inspected and released by FE. For connections less than 100 kV, FE will require that the connected equipment and check-off list be inspected and released by a FE Operating Company representative. For new connections involving circuit breakers or circuit switchers, the FE inspection representative will observe the functional trip testing of the protective device and its protective relays. The relays must have the FE recommended settings applied before testing begins. If phasing is required, the FE inspection representative will observe the phasing test. If deemed necessary, the FE inspection representative has the authority to observe or conduct any test required by FE.

7. After being satisfied that the connected facilities have been properly inspected and released, the FE inspection representative will notify the FE project manager that it is permissible to energize the new facilities, provided all of the operational clearance requirements are satisfied. The FE project manager or their designee will notify the FE Operations team of successful inspection and testing in preparation for energization or test. This release of equipment may take the form of release for service or release for test. The FE Operations team will not release its clearance on the new facilities until it receives notification from the FE project manager.

Appendix B: Substation Checkout Guide

This guide represents an example of the guidelines for connecting a customer substation and only serves as a sample of the necessary process to be followed. FE reserves the right to provide and require additional tests outside of these guidelines.

Energy Delivery Substation Maintenance	Effective Date 02/26/2010	Page 27-AA-8
FirstEnergy	Revision Date 11/29/2017	FirstEnergy Substation Methods
		Section 27M – Commissioning

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Customer Substation Checkout Guide:

Note: This checklist is not intended to be a comprehensive list. Every situation is different and good engineering judgment must apply in determining the necessary detail when inspecting the customer's station. Substations connecting to First Energy lines rated 115KV and higher must be released for service by a Substation Tech Support Engineer. The document published by Energy Delivery Planning and Protection "Requirements for Transmission Connected Facilities" should be followed. It is available on their Web page. Also review the Detailed Load Study that is specifically written for the Customer Substation. Contact the EDPP Engineer for this document.

1. **Verify that the appropriate departments have been notified of the customer's intent to energize and communicate to those departments the intended sequence for energization.**
   - ☐ Dispatching
   - ☐ Regional Engineering
   - ☐ Meter
   - ☐ System protection

2. **Grounds/GRID**
   - ☐ Grounds on all equipment
   - ☐ Fence Grounds
   - ☐ Ground grid point to point checks using a 100A micro-ohm tester (Ductor)
   - ☐ Fall of Potential Test (new installations/major changes)
   - ☐ Confirm a three-inch base layer of No.4 stone with a three-inch layer of No.57 washed limestone on top.

3. **MOABS/Disconnect Switches**
   - ☐ Alignment (Check with Manufacturer's Settings and Table 1)
   - ☐ Travel/Stop
   - ☐ Micro-ohm test (Ductor) Ground Mat
   - ☐ Close switch and Micro-ohm test (Ductor). Include pads from HV leads
   - ☐ Piercing Screws Set
   - ☐ Switch Lockable by FE
   - ☐ Equipment ID signs Installed

4. **Circuit Breakers Operated at 23KV and above**
   - ☐ Fill with SF_6 Gas (GCBs)
   - ☐ Moisture Test on SF_6 Gas (GCBs)
   - ☐ Purity Test on SF_6 Gas (100 kV and up)
   - ☐ Verify Interrupter Rating is Adequate (See Table 2)
   - ☐ Micro-ohm test (Ductor)
   - ☐ Power Factor Test (Doble)
     a) Open Breaker Test, GND
     b) Closed Breaker Test, GND
     c) Open Breaker Tests, UST for each bushing
   - ☐ Analyze Breaker - Time and Travel
   - ☐ Verify Breaker Alarms (Test from Sensor to Annunciator and SCADA if applicable)
   - ☐ Current Transformers
     a) Ratio
     b) Polarity
     c) Megger
     d) Unused CT's Shorted
     e) CT Grounding Matches Print

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5. **Circuit Switchers**
   - ☐ Verify SF_6 Gas is filled
   - ☐ Hipot Open Interrupters at appropriate voltage (see manufacturer's IB)
   - ☐ Timing Tests
   - ☐ Micro-ohm test (Ductor)
   - ☐ If Shunt Trip Device is Used, Verify Proper Operation during Functional Testing and Timing
   - ☐ Perform Power Factor testing if equipped with grading or shunt capacitors

6. **Power Fuses**
   - ☐ Verify Proper Fuse Size/Type
   - ☐ Air-Flow Test

7. **Transformers**
   - ☐ Current Transformers
     a) Ratio
     b) Polarity
     c) Megger
     d) Unused CT's Shorted
     e) CT Grounding Matches Print
   - ☐ Verify Proper Grounding
   - ☐ Proper Phasing based on ABC or ACB rotation
   - ☐ Transformer No-Load Tap Set Correctly
   - ☐ Verify Plans for Customer to check low-side phasing
   - ☐ Arresters Sized Correctly (See Table 2)

8. **CCVTs**
   - ☐ Doble %PF Tests (Per Instruction Manual)
   - ☐ Potential Polarizing Test (If applicable)
   - ☐ Verify Voltage Switch Position before energization
   - ☐ Verify Carrier Switch Position before energization
   - ☐ Check in-service phasing of secondary voltages
   - ☐ Verify Ground at CCVT

9. **Batteries & Chargers**
   - ☐ Visual Inspection
   - ☐ Measure Specific Gravity
   - ☐ Measure Cell Voltage
   - ☐ Intercell Resistance Test
   - ☐ Check Ground Detector

10. **SCADA**
    - ☐ Functional Test (coordinated with Communications Group)
      a) Trip
      b) Close
      c) Indication
      d) Alarms
    - ☐ Verify all Metering Settings are Correct
    - ☐ Secondary Load all Metering
    - ☐ EMS Screens built (Verify with Real Time Systems)

11. **Metering**
    - ☐ Verify with Metering Department that Metering equipment is set up

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12. **Relaying & Controls**
    - ☐ Relays
      a) Verify Relay Settings
      b) Verify CT/PT Ratios
      c) Verify TRIP/OUT Equations on Microprocessor Relays make sense
      d) Calibrate Relays by testing all in service elements
    - ☐ Functional Trip Check
    - ☐ Perform Trip Testing through all paths (Recommend listing each path on checklist)
    - ☐ Verify Sufficient Voltage applied to Trip Coil (relay taps set properly)
    - ☐ Verify Interlocks for SCADA Closing (Control Handle Slip Contact)
    - ☐ Verify any Automatic Transfer Schemes are tested and Verify Intertie Settings
    - ☐ Check Reclosing (Operate Breakers through all reclosing cycles)
    - ☐ Current Polarizing Test (if equipped)
    - ☐ Potential Polarizing Test (if equipped)
    - ☐ End to End Satellite Testing for communication tripping schemes
    - ☐ Remote Dial Functional for SEL 2020
    - ☐ Verify Port Settings and Baud Rates for SEL 2020

13. **Misc**
    - ☐ Rod Gap Inspection
    - ☐ Line Arresters Sized (See Table 2)
    - ☐ Clearances Line to Line (See Table 1)
    - ☐ Clearances Line to Ground (See Table 1)
    - ☐ Wave Traps
      a)Sized as Specified
      b)Located as Specified
      c)Frequency Sweep response of trap to verify it is tuned to correct frequency

14. **Pre-Energization**
    - ☐ Verify Switching Orders
    - ☐ Verify Equipment Labeling
    - ☐ Fence
      a) Gates Secured/Lockable with Lock
      b) Proper Height/Allowable Gaps
      c) Proper Signage
    - ☐ All protective grounds removed
    - ☐ Final Walkdown/Checklist Reviewed

15. **Energization**
    - ☐ Release for Test
      a) Correct Phasing
      b) In-service Metering Matches Load
      c) In-Service Load Angle Readings of Line Relaying
      d) Current/Voltage Contributions of Differential Relaying
      e) Neutral Unbalance Measurements of Capacitor Banks
      f) Verify SCADA Metering and Indication are Correct
      g) Release for Service

16. **Post Energization**
    - ☐ One Line Diagram – Get copy to Dispatching
    - ☐ Transformer Nameplate – Get Copy to EDPP
    - ☐ Commissioning test results – Keep Copy
    - ☐ Relay Test Reports – Keep Copy
    - ☐ Record or verify the type, model and S/N and other nameplate data in the Cascade system for all commissioned equipment

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Appendix C: Breaker Ring Bus Decision Process – Generation Connections

1. Main Concepts for Applying a Breaker Ring Bus

   1.1. Where a breaker ring bus is mentioned in this appendix, a breaker and a half configuration is an acceptable alternative.

   1.2. Problem at a generation facility does not impact the FE Transmission System.

   1.3. Maintenance of a FE line or substation does not require a generation facility outage.

   1.4. Proposed connection does not compromise the protection of the FE Transmission System.

2. Criteria for Requiring a Breaker Ring Bus

   For the purposes of evaluating the requirement for a breaker ring bus, an existing transformer connection on a radial line that has either generation, networked circuits, circuits that can be networked under emergency conditions, or has other sources of bi-directional energy and/or fault current flow into the FE Transmission System from the transformer low side is considered a network connection.

   2.1. For a generation-only connection to the networked FE Transmission System at a nominal voltage greater than or equal to 100 kV, a ring bus is required regardless of the MW rating of the generation.

   2.2. For a generation-only connection to the networked FE Transmission System at a nominal voltage less than 100 kV, a ring bus is required for facilities with a total generating capacity rated greater than 20 MW.

   2.3. For a generation-only connection to a radial tap on a networked line, a ring bus is required, subject to the voltage and capacity guidance listed above. For this configuration, the location of the ring bus will be determined on a case-by-case basis.

   2.4. For a generation-only connection to a radial line the installation must be evaluated for the need of a breaker ring-bus, in accordance with the process for evaluating the remaining installations described below.

3. Process for Evaluating the Remaining Installations

   All other installations, including all connections to facilities with both generation and load (other than generator auxiliary loads) must be evaluated for the need of a breaker ring-bus. This technical evaluation will include the following:

   3.1. Verification that the proper protection of the FE Transmission System can be maintained by the line relaying at the remote terminals considering the effects of fault current sources from the generation facility. These fault currents tend to reduce the sensitivity of the line relaying at the remote terminals.

   3.2. Verification that the FE Transmission System can accommodate the overvoltage to ground associated with ground faults if the FE Transmission System is not effectively grounded when supplied only from the generation facilities.

Appendix D: FirstEnergy Revenue Metering Installation Requirements for Transmission Connected Retail and Wholesale Load Customer Facilities

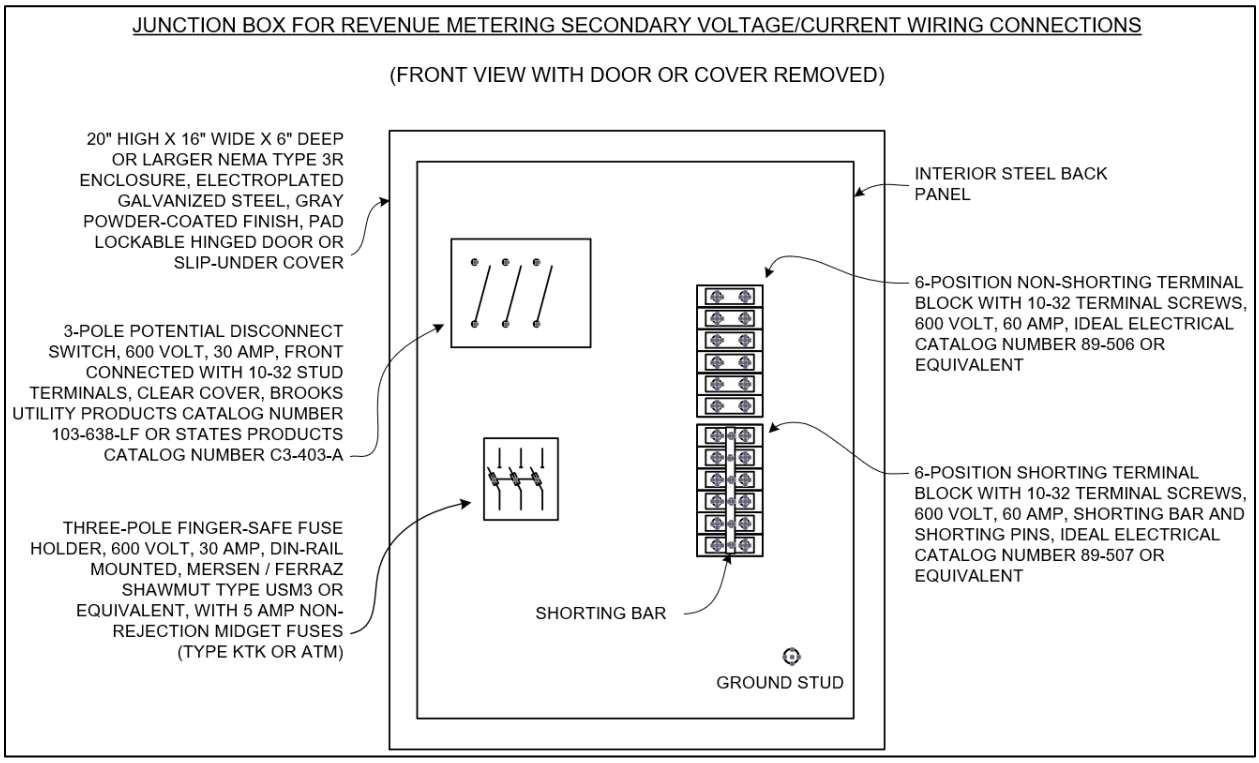
1. This appendix is intended to address detailed revenue metering installation requirements for transmission connected retail and wholesale load customer facilities. These requirements are in addition to the revenue metering requirements outlined in the FE “Requirements for Transmission Connected Facilities” and the Detailed Load Study reports.

2. After applying for connection to the FE Transmission System, the Connecting Party shall consult with FE Transmission Planning, FE Meter Services, and FE Meter Engineering to determine the appropriate revenue metering installation design. The Connecting Party must provide FE with detailed facility information including the proposed substation one-line, substation layout, expected initial and future loads, and required in-service date to ensure proper specification of metering equipment. It is critical for this information to be provided as early in the facility design phase as possible so that FE has a reasonable period of time to purchase and install the metering equipment prior to the in-service date.

3. FE will provide and maintain the revenue metering equipment for each transmission connected retail or wholesale load customer facility as specified in the electric service tariff or Interconnection Agreement. The revenue metering equipment provided and maintained by FE includes, but is not limited to, the instrument transformers, secondary wires, meter(s), and meter socket(s). The Connecting Party shall provide, at its own expense, the space, structures, junction box, and conduits necessary for each metering installation. The Connecting Party is responsible for mounting the instrument transformers, conduits, junction box, and meter socket for each revenue meter installation.

4. FE will provide and install the secondary wiring between the instrument transformers and the meter socket(s). The Connecting Party may pull the wiring through the conduit if requested by FE.

5. If the revenue metering will be connected to a system voltage rated 69 kV or higher, then the Connecting Party shall provide, install, and maintain a pad lockable weatherproof junction box containing a three-pole DIN-rail mounted, finger-safe type USM fuse holder and a three-pole potential disconnect switch for connection to the voltage transformer secondary wires. The junction box is to include a 6 position non-shorting terminal block and a 6 position shorting terminal block with 10-32 screws for termination of voltage and/or current transformer secondary wires. Refer to the figure below for device details and general arrangement. The junction box shall be mounted in a readily accessible location below the instrument transformers and shall be used for FE wiring only. The junction box shall be secured with a FE-owned padlock. This junction box may in some cases be required for revenue metering connected to a system voltage rated 23 kV, 25 kV, 34.5 kV, or 46 kV.



6. Instrument transformers must be readily accessible to authorized FE representatives for the secondary wiring installation. Location of the instrument transformers shall be such that the height of their bases does not exceed 20 feet above grade.

7. Conduit between the junction box and the instrument transformers shall be 1-inch galvanized rigid steel conduit. A Myers Hub shall be used for any conduit connections at the junction box. Flexible galvanized steel (liquid tight) conduit may be used between instrument transformers. PVC Conduit must not be used. There shall be 2-inch minimum galvanized rigid steel conduit installed directly between the junction box and meter socket.

8. Meter sockets shall be installed in readily accessible locations approved by the FE Meter Services section. This includes locations inside the substation if authorized FE representatives can gain access by use of a standard FE lock or, if FE Meter Services will permit, by contacting a customer representative who can provide access within a reasonable time period.

9. The meter socket(s) shall be installed by the Connecting Party generally within 100 feet of the instrument transformers unless an alternate design has been approved by FE Meter Services.

10. A meter socket shall be mounted such that the centerline of the meter is approximately five feet above final grade. The Connecting Party shall consult with FE Meter Services regarding equipment requirements when requesting energy pulse service from the meter.

11. Most FE revenue meters are equipped with a wireless communication card that is used to provide remote access for FE's billing data collection system. If wireless service is not sufficient in a particular location, the Connecting Party, at its own expense, shall provide a dialup telephone line for FE's remote connection to the revenue meter. The Connecting Party shall consult with FE regarding the telephone line, but the general specifications are as follows:

    11.1. Standard analog voice grade telephone line or equivalent with dial tone.

    11.2. The telephone line shall be a two-pair or four-conductor with RJ-11/Male termination. FE makes the final connection to the meter.

    11.3. Must be able to receive incoming calls.

    11.4. Must be a direct line to the meter with no operator interception or operations required.

    11.5. Install necessary telephone cable and associated conduit between telephone company source and meter socket or enclosure.

    11.6. Telephone line must be tagged with phone number, including area code.

    11.7. Telephone line must be installed and operational prior to the customer's service being energized.

12. Where vehicle traffic may interfere with or damage metering equipment, the Connecting Party must install concrete filled steel barrier posts to protect such equipment.

13. Before the metering equipment installation is started, the customer/contractor must contact FE Meter Services or Meter Engineering to coordinate installation details, material delivery, and construction schedule.

Appendix E: Requirements for FirstEnergy-Owned Revenue Metering at Generation Facilities

This appendix addresses the requirements for FE-owned revenue metering located at generation facilities connecting directly to the FE System that have a tapped connection to a FE line. See *Figure 3* and *Section 8, Revenue Metering Requirements.*

1. FE shall provide, own, operate, test, and maintain the revenue metering equipment at the Connecting Party's expense.

2. The revenue metering equipment includes, but is not limited to, current transformers, voltage transformers, secondary wires, meter socket, bi-directional revenue meter, and associated devices.

3. The revenue metering equipment shall be located at the POI unless otherwise agreed upon by FE. The revenue metering will be compensated for electrical energy losses if it is not located at or near the POI.

4. The Connecting Party must provide FE with a facility one line, the estimated bidirectional power flow at the revenue metering point, and any loss compensation data.

5. The Connecting Party shall provide and install the mounting structures, conduits, and junction box necessary for the FE metering installation unless otherwise agreed to by FE. The conduit shall be 1-1/2 inch (minimum) galvanized rigid steel conduit. Flexible galvanized steel (liquid tight) conduit may be used between instrument transformers. FE will install the secondary wiring in the conduit between the instrument transformers, the junction box, and the meter socket. The Connecting Party shall consult with FE regarding the specifications for the junction box.

6. The Connecting Party shall mount the FE instrument transformers unless otherwise agreed to by FE. The instrument transformers and meter socket shall be installed in a location that is readily accessible to authorized FE representatives. If for any reason the meter socket and/or associated devices must be mounted in a weatherproof enclosure, it shall be provided and installed by the Connecting Party. The meter socket shall be installed generally within 50 feet of the instrument transformers unless an alternate design has been approved by FE. The meter socket shall be mounted such that the centerline of the meter is approximately five feet above final grade. Where vehicle traffic may interfere with or damage any revenue metering equipment, the Connecting Party must install concrete filled steel barrier posts to protect such equipment.

7. The bidirectional revenue meter provided and installed by FE will record billing data in fifteen-minute intervals unless otherwise agreed to by FE and the Connecting Party. If necessary, the Connecting Party shall provide, at its own expense, a dialup telephone line for FE's remote access to the revenue meter data. The Connecting Party shall consult with FE regarding the telephone line, but the general specifications are as follows:

    7.1. Standard analog voice grade telephone line or equivalent with dial tone.

    7.2. The telephone line shall be two-pair or four-conductor with RJ-11/Male termination. FE will make the final connection to the meter.

    7.3. Must be able to receive incoming calls.

    7.4. Must be a direct line to the meter with no operator interception or operations required.

    7.5. Install necessary telephone circuit and associated conduit between the telephone company source and the meter socket or enclosure.

    7.6. The telephone circuit must be tagged with a phone number, including the area code.

    7.7. The telephone circuit must be installed and operational prior to the Connecting Party's service being energized.

8. The Connecting Party shall, at its expense, install, own, operate, test, and maintain any metering and telemetry equipment at the generation facility that may be required to provide real-time meter data to PJM and/or FE.

9. The Connecting Party shall consult with FE regarding data communications with the FE revenue meter.

10. The Connecting Party shall provide FE with prior notification of any modifications at the facility that could affect the FE revenue meter measurements (e.g., substation reconfigurations, generator additions, etc.).

Appendix F: FirstEnergy Requirements for Customer-Owned Revenue Metering at Generation Facilities

This appendix addresses the FE requirements for customer-owned revenue metering located at new generation-only facilities connecting to the FE Transmission System.

1. The Connecting Party shall provide, install, own, operate, test, and maintain the necessary revenue metering equipment when agreed upon by FE. This includes current transformers, voltage transformers, mounting structures, wiring, meters, communication circuits, and associated devices. The metering equipment must meet PJM and FE specifications.

2. The revenue metering equipment shall be located at the Point of Interconnection unless otherwise agreed to by PJM, FE, and the Connecting Party. The revenue metering will be compensated for electrical energy losses if it is not located at or near the POI.

3. The revenue metering equipment shall be capable of recording, storing, and transmitting bidirectional MWh and MVARh data (or kWh and kVARh data). The revenue meters shall record this data in fifteen-minute intervals unless otherwise agreed to by FE and the Connecting Party.

4. The Connecting Party shall provide FE with remote access to the recorded bidirectional billing data in the revenue meter via a dedicated voice-grade analog telephone circuit or equivalent. The telephone circuit must be installed and operational prior to the Connecting Party's service being energized. The Connecting Party shall make a reasonable effort to correct a revenue meter telephone communication problem within the period of 30 days from the date of discovery or a date mutually agreed upon by FE and the Connecting Party.

5. The Connecting Party shall provide FE with contact information for the person or persons responsible for revenue metering equipment operation and maintenance.

6. The revenue meter clock shall be set to Eastern Standard Time (EST) with no adjustments for Daylight Saving Time unless otherwise agreed to by FE and the Connecting Party.

7. The Connecting Party shall consult with FE regarding the revenue metering system design and provide the following information:

    7.1. Facility one line and revenue metering installation drawings (schematics, wiring diagrams, etc.)

    7.2. Estimated power flows to and from the facility at the revenue metering point(s)

    7.3. Current transformer and voltage transformer specifications, including manufacturer, type, nameplate drawings, and certified accuracy test reports

    7.4. Revenue meter specifications including manufacturer, type, model number, and certified accuracy test report

    7.5. Revenue meter loss compensation data, if applicable

    7.6. Revenue meter program information, including but not limited to: CT and VT ratios, clock setting, and recorder channel setup (required to ensure successful collection of the meter's interval data by the FE MV-90 system)

    7.7. Revenue meter telephone number

8. The Connecting Party shall install the revenue metering equipment such that the revenue meter registers delivered (i.e., positive) power when real power is flowing from FE to the generation facility.

9. The Connecting Party shall, at its expense, install, own, operate, test, and maintain any metering and telemetry equipment at the generation facility that may be required to provide real-time meter data to PJM and/or FE.

10. The Connecting Party shall provide FE with notification of any modifications at the facility that will affect the revenue meter measurements, including substation reconfigurations and meter program changes.

11. The Connecting Party shall provide FE with accumulator data if the generator's maximum capacity is greater than 20 MW.

Appendix G: Distribution Power Transformer Protection

This section specifies the minimum distribution transformer protection necessary to assure that faults on the load side of the transformer high-side interrupting device do not adversely affect the transmission system. These requirements do not necessarily provide adequate transformer or distribution equipment protection; they are intended to provide adequate protection for the transmission system by minimizing the impact of faults on tapped distribution equipment.

1. Protective Coordination with Transmission Line Protection

1.1. Power Transformers Connected to a Radial Transmission Line

1.1.1. For all faults within the zone of the transformer protective device(s), it is preferred that the total clearing time of the transformer protection occur with a minimum of six cycle margin of the operating time of the transmission line protection. Transmission line ground relay characteristics shall be allowed to cross distribution transformer high-side fuses, particularly on larger transformers where complete coordination is not possible. These transmission line ground relays should be set to cross the fuse characteristics at less than 50% of the maximum high-side, phase-to-ground fault current when the ground instantaneous protection is set short of the transformer fuse. Simultaneous operation of the transformer protection with the transmission instantaneous or time delayed protection is tolerable provided there is automatic reclosing or SCADA control of the transmission line power circuit breaker. Coordination requirements of radial transmission system relays with distribution substation protective relays may be waived for first contingency conditions. This may result in non-selective operation of the transmission relays during some operating conditions for distribution substation faults.

1.2. Power Transformers Tapped to a Looped Transmission Line with Non-Pilot Relay Protection

1.2.1. For all faults within the zone of the transformer protective device(s), the transformer protection must totally clear the fault before both ends of the transmission line protection operate. The simultaneous trip operation of only one end of the transmission line protection is tolerable provided there is automatic reclosing or SCADA control of the tripped transmission line circuit breaker.

1.2.2. When one end of a looped transmission line is operated normally open, then the protective coordination requirements of *Section 1.1* of this appendix apply. These requirements shall apply to both terminals of the transmission line taken individually.

1.3. Power Transformers Tapped to a Looped Transmission Line with Pilot Relay Protection

1.3.1. Stations with High-Side Circuit Breakers/Switchers

- For facilities connected at 100 kV or above, circuit breakers are required. Circuit switchers may only be used for facilities less than 100 kV.
- For all faults within the zone of the transformer protective device(s), the transformer protection must operate to isolate the fault prior to or simultaneously with the initial operation of the transmission line pilot relay protection schemes. The fault shall be isolated locally before any subsequent automatic transmission line high-speed reclosing occurs. Lockout of the transmission line for faults within and beyond the transformer zone of protection is not acceptable.

1.3.2. Stations with High-Side Fuses (less than 100 kV)

- For high-side faults external to the transformer, the transformer fuse must operate to isolate the fault prior to or simultaneously with the initial operation of the transmission line pilot relay protection schemes. Lockout of the transmission line for faults within the transformer zone of protection is generally not acceptable. TPP will determine when tapping a fused transformer to a transmission line with pilot protection is permissible.

2. High-Side Power Fuses (less than 100 kV)

   A distribution power transformer may be protected by a high-side power fuse if all the following conditions are met.

   2.1. Transformer Connection

      2.1.1. The connected transformer must not contribute zero sequence fault current to faults on the transmission system. This requires the use of an ungrounded transformer high-side connection.

   2.2. Transformer Rating

      2.2.1. Maximum load carrying rating must be no greater than 15 MVA

   2.3. Fuse Interrupting Capability

      2.3.1. The power fuse must have adequate fault interrupting capability at the point of application.

   2.4. Fuse Coordination

      2.4.1. The power fuse must coordinate with the transmission protective devices as described in *Section 1.1* of this appendix.

3. Protective Relays and Fully Rated Interrupting Devices

   When the criteria of *Section 1.2* of this appendix cannot be met, a fully rated high-side interrupting device and protective relay schemes consistent with *Section 1.1* of this appendix must be used. A backup protective relay scheme consisting of high-side time and instantaneous overcurrent relay elements, a low side transformer neutral time overcurrent relay element, plus a primary transformer differential relay are required. Independent CTs shall be used for the primary differential and the backup overcurrent relays. A set of three phase VTs (PTs or CCVTs) shall be installed between the interrupting device and the transformer and supply the backup overcurrent relays which can also function as intertie protection. The protective scheme required will vary slightly depending on the interrupting device and the location of current transformers on either side of the power transformer. Refer to *Figure 10A and 11A* of this appendix if a high-side breaker is used or *Figure 10B and 11B* of this appendix if a circuit switcher is used.

   3.1. Transformer Differential (87T)

      When a circuit breaker is used as the high side interrupting device, the differential zone of protection will encompass the circuit breaker and the power transformer from the breaker source-side bushings to the transformer low-side bushings or to the distribution feeder breakers load-side bushings. When a circuit switcher is used (below 100 kV) as the high side interrupting device, the differential zone of protection will encompass the power transformer from the high-side to the low-side bushings or to the distribution feeder breakers load-side bushings.

      3.1.1. Protective Relay

         - The primary protection for the transformer shall be a variable percentage differential relay with harmonic restraint. An instantaneous differential overcurrent trip shall be provided.

3.1.2. Source Input

- Relay accuracy CTs shall be used and must be of a CT class that will exceed the burden capability needed for the tap ratio in use. These CTs are to be located so that the transformer differential zone of protection overlaps the adjacent zones of protection. The CT ratio used shall have a minimum continuous current rating that is greater than the maximum anticipated transformer loading. The CT ratios shall allow the differential relays to be set without using auxiliary CTs and shall allow for a relay setting whereby the thermal rating of the relay is not exceeded for the maximum anticipated transformer loading. CTs shall be connected or compensation settings used such that no misoperation shall result from ground current flow in the transformer neutral for faults external to the differential zone of protection.

3.1.3. Operating Functions

- The transformer primary differential relay shall operate a manual, hand reset lockout relay (86T), which shall perform the following:
  - Trip and block closing of the high-side interrupting device(s)
  - Initiate high-side device failure to trip protection (See *Section 3.3* of this appendix.)
  - Block operation of transformer cooling fans and pumps
  - Alarm to SCADA

3.2. Transformer Backup Protection (50/51, 50N/5IN, 51G) and Intertie Protection (32, 27, 59, 81)

This protection is provided by relays other than the transformer differential relays as back-up for the transformer differential relay scheme and as a backup for a low side feeder device failure to trip. When a circuit breaker is used as the high-side interrupting device, these relays also provide lead protection for the transformer high-side leads. In addition, these backup relays can provide transformer protection for through-faults per ***IEEE C57.109, IEEE Guide for Liquid-Immersed Transformers Through-Fault-Current Duration***. These relays can also provide intertie protection to prevent back feed into a faulted transmission system.

3.2.1. Protective Relay

- Transformer high-side phase and ground instantaneous and time overcurrent relay elements (50/51, 50N/5IN) and one low-side transformer neutral time overcurrent relay element shall be used to provide the protection described in *Section 3.2* of this appendix.
- The phase instantaneous element shall have a pickup of 130% or greater of the maximum secondary three phase fault. The phase time overcurrent relay elements must be set to have a pickup of at least 2.6 times the transformer base OA rating. The time lever setting of the overcurrent relays shall be set at the minimum possible and still achieve satisfactory coordination with the distribution line exit protection.
- The total clearing time (relay time plus breaker operating time) for all faults greater than three times the transformer base OA rating shall be no greater than the infrequent through-fault current protection curve for the appropriate Category transformers per ***IEEE C57.109, IEEE Guide for Liquid-Immersed Transformer Through-Fault-Current Duration***. The minimum bolted three phase fault levels available on the low- side of the power transformer should be no less than three times the pickup setting of these phase relay elements.

- The transformer high-side ground elements can be set sensitively due to the requirement for the transformer high-side winding configuration being ungrounded wye or delta. The ground instantaneous element should have a pickup of 20% or more of the maximum secondary three phase fault to not operate on CT ratio errors. The ground time overcurrent relay element should be set to have a pickup of 40% or more of the transformer base OA rating to avoid operation on CT ratio errors under maximum loading. The time lever setting of the ground time overcurrent relay can be set at a time dial setting of 1.0 (U3 curve) for a time delay of about 8 cycles at 10 times pickup.
- The transformer neutral time overcurrent relay element (51G) pickup shall be set to provide sensitive enough backup feeder protection. The minimum bolted phase-ground fault on the power transformer should be at least 5 times the neutral relay pickup setting due to the greater probability of resistance occurring in the fault. The lever of the neutral relay shall be set such that the relay will operate in less than 180 cycles for a low voltage bus fault and will coordinate with the distribution line exit protection.
- The intertie elements (32, 27, 59, 81) will be set to prevent sustained back feed into a faulted transmission system. Typical settings are 27: 0.74 p.u. – 120 cyc., 59: 1.20 p.u. – 10 cyc., 59G: 1.10 p.u. – 6 cyc., 81U: 57 Hz – 10 cyc., and 81O: 61.8 Hz – 10 cyc.

3.2.2. Source Input

- When a circuit breaker is used as the high side interrupting device, the phase overcurrent CT's will be located on the source side bushings of the circuit breaker and shall include the primary transformer differential zone of protection. If a circuit switcher is used as the high side interrupting device (below 100 kV), the phase overcurrent CT's will be located on the high-side bushings of the transformer and include the primary transformer differential zone of protection. The neutral overcurrent CT will be located in the transformer neutral. Relay accuracy CTs shall be used and must be of a CT class that will meet the burden capability needed and will not experience any significant saturation for maximum faults in the relay zone of protection. A set of three phase VTs (PTs or CCVTs) shall be installed between the interrupting device and the transformer and supply the backup overcurrent relays which can also function as intertie protection.

3.2.3. Operating Functions

- The transformer high-side phase time overcurrent relays and the transformer neutral time overcurrent relay shall perform the following:
  - Trip and block closing of the high-side interrupting device(s)
  - Initiate high-side device failure to trip protection (See *Section 3.3* of this appendix.)
  - Alarm to SCADA
- The intertie functions shall perform the following:
  - Trip and block close of the feeder breaker with generation or send DTT to the generator
  - The block close function will reset after the transmission returns to normal voltage
  - Alarm to SCADA

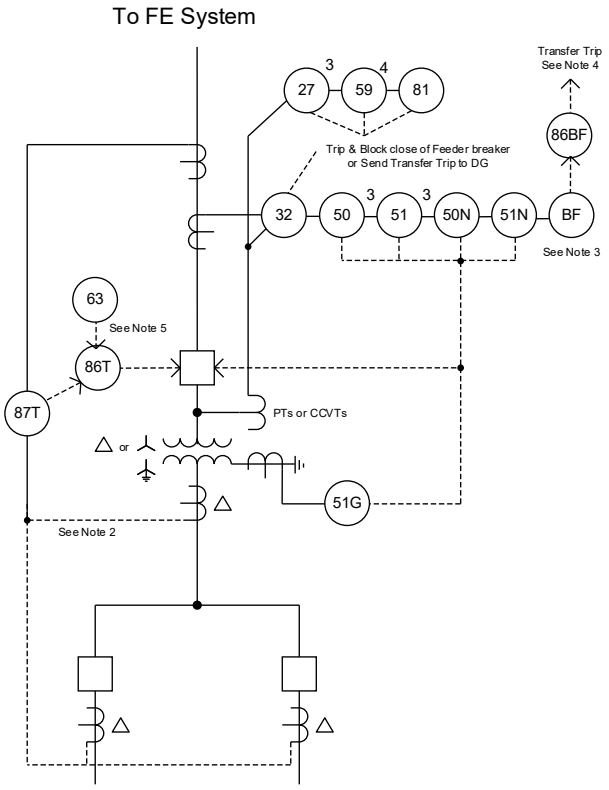
3.3. High-Side Interrupting Device Failure to Trip Protection

- When a high-side circuit breaker is used for a power transformer tapped to a line at 100 kV up to 230 kV, a breaker failure to trip scheme must be installed. Direct transfer trip to initiate remote tripping and a motor-operated disconnect switch locally is the required method at 230 kV and the preferred method below 230 kV of implementing the breaker failure to trip protection. FE's preference is to install direct fiber for communication of transfer trip signals. In some cases, it may be possible to install power line carrier for this function at 100 kV and above. FE will study and recommend the use of fiber or power line carrier where appropriate. At less than 230 kV, where installing direct transfer trip is not practical, then a high-speed ground switch and a motor-operated disconnect switch combination shall be provided. Once the motor-operated disconnect switch opens to isolate the high-side interrupting device, then the line shall be capable of being restored. The ground switch shall have an associated disconnect switch to facilitate testing.

3.4. Backfeed Removal

- This protection is required when a transformer can backfeed into the transmission system (that is, become energized from the low side) under normal operating conditions. Examples would include transformers with parallel secondaries that are supplied from different transmission sources, distribution circuits that are normally connected to other sources, distribution circuits with unsupervised automatic hot transfer schemes, or distribution circuits with connected dispersed generation. This protection operates during high-side faults to remove the local contribution and to eliminate the possibility of energizing the transmission line through the transformer from the low side. The required protective devices, source inputs and operating functions will be based upon the substation and system configurations and will be determined by Transmission Delivery Planning and Protection. See *Section 3.2* of this appendix on Transformer Backup Protection and Intertie Protection.

Figure 10A – Minimum Required Transformer Protection High Side Circuit Breaker

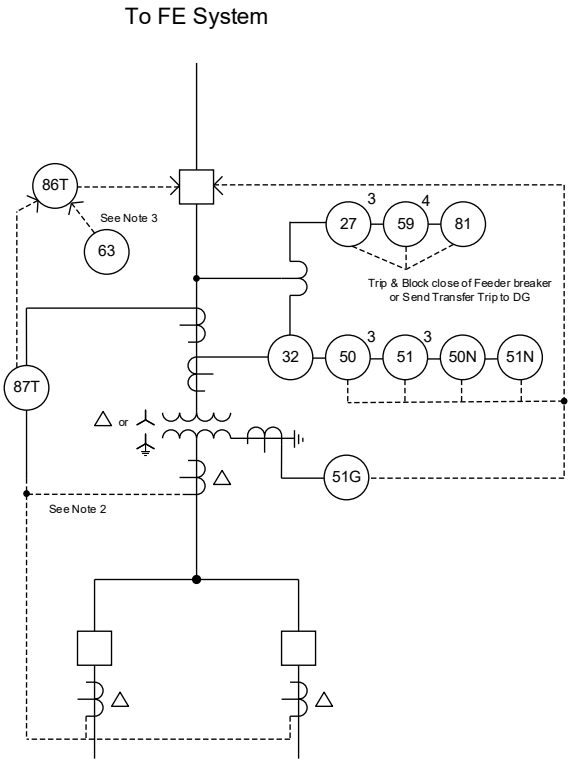


Notes

1. FE System connection could be to a line, ring bus position or other approved connection as determined by this document.
2. A CT connection to either the low side of the transformer or the CTs on the feeder breakers is acceptable.
3. Breaker Failure protection is required at all connections greater than 100 kV.
4. Remote FE breakers must receive trip for local breaker failure at the Connecting Party facility. Transfer trip from Connecting Party facility is required via communication medium or via high speed ground switch.
5. Transformer sudden pressure relay to trip lockout relay.
6. Additional requirements must be followed if behind the meter generation is installed.

BY: JLM APP: DATE: 11/17/25 ISSUE: REVISION NOTES:	FirstEnergy Transmission Planning & Protection	DIST. CODE: SCALE: NS SIZE: 8.5x11	PARENT DOCUMENT FIRSTENERGY REQUIREMENTS FOR TRANSMISSION CONNECTED FACILITIES TITLE MINIMUM REQUIRED TRANSFORMER PROTECTION HIGH SIDE CIRCUIT BREAKER
			DWG NO.: FIGURE 10A FILE NAME: Standards (2025-11-17).vsdx REV.: H

Figure 10B – Minimum Required Transformer Protection High Side Circuit Switcher

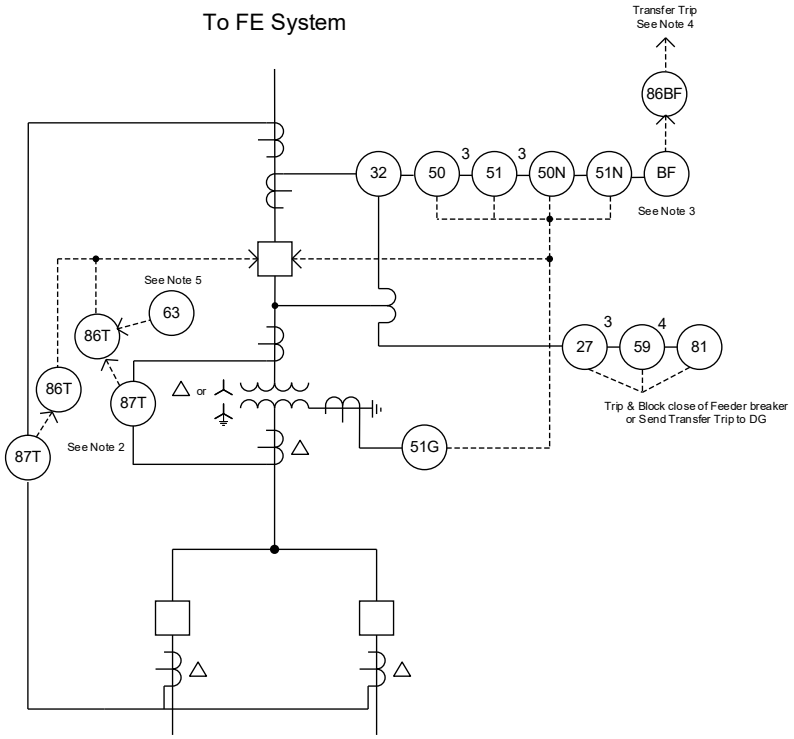


Notes

1. FE System connection could be to a line, ring bus position or other approved connection as determined by this document.
2. A CT connection to either the low side of the transformer or the CTs on the feeder breakers is acceptable.
3. Transformer sudden pressure relay to trip lockout relay.
4. Circuit switchers are only acceptable at connections less than 100 kV.
5. Additional requirements must be followed if behind the meter generation is installed.

BY: JLM APP: DATE: 11/17/25 ISSUE: REVISION NOTES:	FirstEnergy® Transmission Planning & Protection	DIST. CODE: SCALE: NS SIZE: 8.5x11	PARENT DOCUMENT: FIRSTENERGY REQUIREMENTS FOR TRANSMISSION CONNECTED FACILITIES TITLE: MINIMUM REQUIRED TRANSFORMER PROTECTION HIGH SIDE CIRCUIT SWITCHER DWG NO.: FIGURE 10B / FILE NAME: Standards (2025-11-17).vsdx / REV.: H

Figure 11A – Minimum Required Transformer Protection High Side Circuit Breaker – Transformer >15 MVA

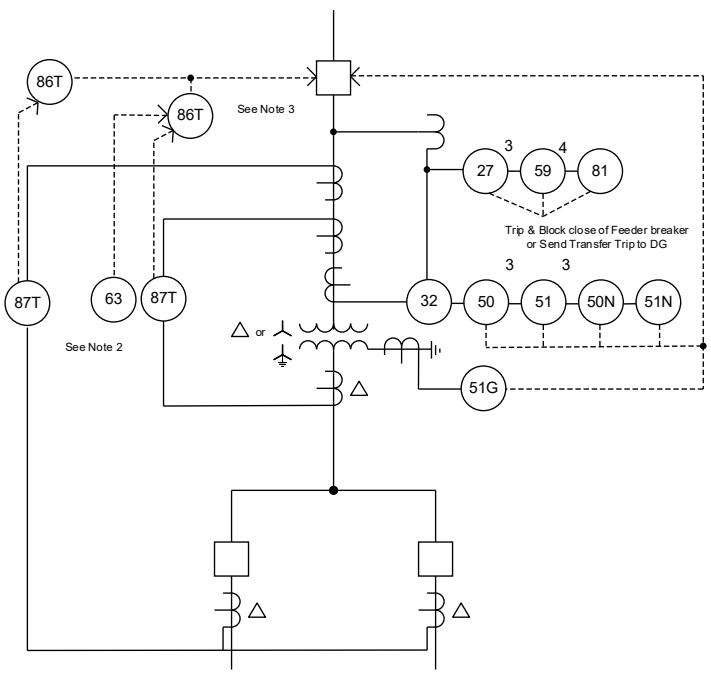


Notes

1. FE System connection could be to a line, ring bus position or other approved connection as determined by this document.
2. Two independent high speed transformer protection schemes are required.
3. Breaker Failure protection is required at all connections greater than 100 kV.
4. Remote FE breakers must receive trip for local breaker failure at the Connecting Party facility. Transfer trip from Connecting Party facility is required via communication medium or via high speed ground switch.
5. Transformer sudden pressure relay to trip lockout relay.
6. Additional requirements must be followed if behind the meter generation is installed.

BY: JLM APP: DATE: 11/17/25 ISSUE: REVISION NOTES:	FirstEnergy® Transmission Planning & Protection	DIST. CODE: SCALE: NS SIZE: 8.5x11	PARENT DOCUMENT FIRSTENERGY REQUIREMENTS FOR TRANSMISSION CONNECTED FACILITIES TITLE MINIMUM REQUIRED TRANSFORMER PROTECTION HIGH SIDE CIRCUIT BREAKER TRANSFORMER LARGER THAN 15 MVA
			DWG NO.: FIGURE 11A FILE NAME: Standards (2025-11-17).vsdx REV.: H

Figure 11B – Minimum Required Transformer Protection High Side Circuit Switcher – Transformer >15 MVA



Notes

1. FE System connection could be to a line, ring bus position or other approved connection as determined by this document.
2. Two independent high speed transformer protection schemes are required.
3. Transformer sudden pressure relay to trip lockout relay.
4. Circuit switchers are only acceptable at connections less than 100 kV.
5. Additional requirements must be followed if behind the meter generation is installed.

BY: JLM APP: DATE: 11/17/25 ISSUE: REVISION NOTES:	FirstEnergy® Transmission Planning & Protection	DIST. CODE: SCALE: NS SIZE: 8.5x11	PARENT DOCUMENT FIRSTENERGY REQUIREMENTS FOR TRANSMISSION CONNECTED FACILITIES TITLE MINIMUM REQUIRED TRANSFORMER PROTECTION HIGH SIDE CIRCUIT SWITCHER TRANSFORMER LARGER THAN 15 MVA
			DWG NO.: FIGURE 11B FILE NAME: Standards (2025-11-17).vsdx REV.: H

Appendix H: Dynamic Modeling Requirements for Inverter-based Resources

This section specifies the dynamic modeling requirements for all IBR interconnection Connecting Parties (including solar, wind, BESS, and hybrids) seeking to connect to the FE Transmission System.

1. **Model Submission and Validation**
   - Owners must provide an acceptable, validated model during each study phase and whenever plant changes result in a model update.
   - The models should include both positive sequence (phasor domain) and EMT models.
   - Models must be validated at both the individual inverter and plant level to ensure they match expected in-service performance.
   - Proof of model accuracy and validation reports (using actual product performance) must be supplied, stamped by a licensed Professional Engineer (PE) in the state of interconnection.
   - Any changes to plant or model parameters must be submitted to FE for study before implementation to ensure transmission system reliability.
   - On an annual basis, FE will survey all IBR owners for model updates or verification of no changes.
2. **Model Types and Formats**
   - Owners must provide a positive sequence phasor domain (PSPD) dynamic model in PSS®E format, compatible with the current MMWG model build cycle.
   - Preference is for equipment-specific positive-sequence dynamic models; if a standard library model is used, it must be from the MMWG approved list and benchmarked against equipment-specific models.
   - Reports benchmarking standard models against equipment-specific models must be stamped by a licensed PE.
   - EMT models must be provided in PSCAD™ format.
3. **Equipment-Specific Model Requirements**
   - Equipment-specific models must include compiled .dll files. No additional compilation is required.
   - Sufficient documentation must be provided to allow proper integration, understanding of controls, ratings, capabilities, and initialization in reliability studies.
   - Benchmarking reports comparing actual performance to EMT and positive-sequence models are required and must be PE-stamped.
   - Updated models must be provided if the PSS®E version changes.
4. **Model Quality and Verification**
   - Detailed model quality check tests and pass/fail criteria must be established, covering a range of operational conditions (e.g., voltage dips/rises, fault-clearing duration, system strength).
   - Processes for requesting and verifying model data must be in place to ensure models used in studies represent the commissioned plant.
   - Mechanisms for “modeling true-up” should be established to address inaccuracies during the interconnection process.
   - Requirements are expected to mirror PJM’s requirements and align with FERC Large Generator Interconnection Procedures (LGIP) and Small Generator Interconnection Procedures (SGIP)

5. **Documentation and Reporting**

- For each generator, the following must be provided:
  - A positive sequence library model (not on the NERC unacceptable list, Appendix A of the NERC Dynamic Modeling Guidance).
  - An equipment-specific PSPD model.
  - An equipment-specific EMT model, if EMT analysis is performed.
  - A benchmarking report comparing all models and actual product performance, documenting discrepancies. The report should document any discrepancies across the models.
  - Benchmarking reports must be available to neighboring Transmission Planners (TPs) and Planning Coordinators (PCs).
  - All documentation and reports must be stamped by a licensed PE.

Key Terms and Definitions

Term	Definition
Bulk Electric System (BES)	Generally refers to electrical systems 100 kV and above.
Connecting Party	A person or entity seeking to establish a new or modify an existing connection of a transmission, generation, and/or load connection facility to the FE Transmission System.
Load Connection	An electrical connection between the FE Transmission System and connecting party's facilities where the connecting party receives power from the electric system. The connecting party's facilities are not a networked transmission system (i.e., the facilities are radial in nature) and might include behind-the-meter generation that is designed to prevent export of real power at the point of interconnection. These connections are typically referred to as Retail or Wholesale Load Connections.
FirstEnergy (FE)	The affiliates of FirstEnergy Corp that own and operate transmission, transmission < 100 kV, and/or distribution systems and facilities.
Frequency Ride-Through	The capability of a facility (especially an inverter-based resource) to remain connected and operational during abnormal system frequency events, rather than disconnecting immediately.
Generation Connection	An electrical connection between the FE Transmission System and a generation facility. This does not include behind-the-meter generation.
Inverter-based Resource (IBR)	A generation or energy storage facility that connects to the electric power system using power electronic inverters, rather than synchronous machines. Examples include battery energy storage systems, solar photovoltaic arrays, and wind turbines. IBRs are characterized by fast-acting controls and the ability to provide grid services such as frequency regulation, voltage support, and ride-through during disturbances.
Load Tap Changer (LTC)	A device installed on a power transformer, typically a distribution transformer, that automatically adjusts the transformer's tap settings to regulate output voltage in response to changes in system voltage or load. LTCs help maintain stable voltage for customers but can experience excessive operations if subjected to frequent or large voltage swings.
Looped Connection	A connection to the FE Transmission System that requires an FE transmission line(s) and system load flow to pass through the connecting facilities under any condition.
Network Connection	A connection to the FE Transmission System that allows bi-directional energy and/or fault current flow between otherwise independent transmission or transmission < 100 kV systems is considered a network connection (regardless of generation connected to the adjacent transmission system or load serving entity).
Point of Measurement (POM)	The location on the electric power system where compliance with power quality standards (such as harmonics, flicker, and RVC limits) is assessed for a connecting facility.
PJM	PJM Interconnection, L.L.C.; Regional Transmission Organization (RTO)

Term	Definition
Rapid Voltage Change (RVC)	A sudden change in voltage magnitude over a short period, typically caused by fast-acting resources such as inverter-based batteries or solar facilities. RVCs are measured and limited to prevent adverse impacts on system equipment and customer power quality.
Transmission < 100 kV System	The Non-tariffed transmission system.
System Control Center (SCC)	One or more facilities hosting operating personnel that monitor and control the Bulk Electric System (BES) in real-time to perform the reliability tasks, including their associated data centers, of: 1) a Reliability Coordinator, 2) a Balancing Authority, 3) a Transmission Operator for transmission Facilities at two or more locations, or 4) a Generator Operator for generation Facilities at two or more locations.
Tap Connection	A connection to the FE Transmission System that results in only the Connecting Party's load or generation passing through the connecting facilities under any condition.
Transmission Interconnection	An electrical connection between the FE Transmission System and another utility's transmission system.

Related Documents

Title
ANSI C37.32
ANSI C84.1, American National Standard for Electric Power Systems and Equipment – Voltage Ratings, 60 Hertz
IEEE C57.13 Standard Requirements for Instrument Transformers
IEEE Standard 1453, Annex A
IEEE Standard 1453, IEEE Recommended Practice for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems
IEEE Standard 1547, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems
IEEE Standard 519, IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems
IEEE Standard 80, IEEE Guide for Safety in AC Substation Grounding
IEEE Standard 81, IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Surface Potentials of a Ground System
IEEE Standard C2, National Electrical Safety Code
IEEE Standard C37.30
IEEE Standard C37.34
IEEE Standard C62.22, Metal Oxide Varistor (MOV) Arrester Application Guide,
Interconnection of Customer-Owned Generation to the FirstEnergy Distribution System
MOD-024 – Verification of Generator Gross and Net Real Power Capability
MOD-025 – Verification of Generator Gross and Net Reactive Power Capability
NERC PRC-002-2
NERC PRC-005 "Transmission and Generation Protection System Maintenance and Testing"
PJM Manual 01 – Control Center and Data Exchange Requirements
PJM Manual 07 - PJM Protection Standards
PJM Manual 14A

Title
PJM Manual 14G
PJM Manual 36, Section 2.3
PJM Manual M-14D Generator Operational Requirements
PJM Manual M-21: Rules and Procedures for Determination of Generating Capability
PJM Open Access Transmission Tariff
RF_Criteria_PRC-002 – Disturbance Monitoring and Reporting Criteria
VAR-002 – Generator Operation for Maintaining Network Voltage Schedules

Revision History

Rev.	Effective Date	Preparer	Comments
7	03/04/2026	T. Schafer	Errata Update Updated Footer language to reflect Revision 6.
7	01/27/2026	T. Schafer	Off-Cycle Review SME(s): D. Adomaitis, A. Buanno, J. Bueno, M. Dougherty, J. Gatto, M. Jundi, D. Kibler, J. Moff, M. Robison, J. Salem, K. Semple - Updated protection requirements for Load Connections, Transmission Line Looped Connection. - Updated Generator Connection requirements including connecting transformer, communication channel, and protection. - Updated requirements for Generator Connections to the distribution system. - Updated transmission line protection requirements. - Updated Appendix G on Distribution Power Transformer Protection regarding limitations on high-side power fuse usage and intertie protection. - Corrected and updated multiple figures associated with protection (3, 4, 5,10A, 10B, 11A, and 11B). - Added reference to PJM Manual 07. - Added new Appendix H: Dynamic modeling requirements for inverter-based resources. - Removed 23 kV (Penn Power) from Transmission Facilities Table at beginning of document. - Added definitions for IBR, LTC, RVC, Frequency Ride-Through, POM - 2.1.3 - Added references to IEEE 2800 in section load connection applications with generation. - 3.4.2 – Added gen operating requirements that address battery energy storage systems adhering to IEEE 519, 1453, & 2800. - 5.5.3 – Added section on power quality, specifically for IBRs. - 5.5.4 – Added requirements for PMUs and PQ Metering for Large Load Studies. - Corrected multiple drawings/figures: - Figure 3 – corrected SCADA symbols, transformer config. - Figure 5 – corrected SCADA symbols, added future 4th breaker, to align with figure 2 and show correct positioning of line terminals (future), modified title in procedure to align with drawing title “Generation Connection: FE Looped Line Interconnection” - Figure 6 – corrected SCADA symbols - Misc other minor edits throughout document. - Updated to current C&P format.

Rev.	Effective Date	Preparer	Comments
6	12/19/2024	T. Schafer	Off-Cycle Revision SME: B. Bedada Table in Section 1.5 has been changed to reflect recent FE addition of KATCo. Section 2.7: Paragraph has been added to outline requirements of Load Connections w/r/t UFLS. Section 3.6: Paragraph has been added to outline requirements of Generator Connections w/r/t UFLS.
5	01/18/2023	M. Smaby	Minor: Date Review Started: 09/05/2022 Section 2.1.3: Added requirements for load connections with generation intending to export to the transmission system. Figure 1A, 1B, 1C, 2: Removed second and third sentence in Note 1 to eliminate confusion. Throughout: Minor copy editing.
4	08/06/2021	L.Koshar	Major: Date Review Started: 08/19/2020 Reformatted document to align with current practice. Entire document revised due to updated policies and procedures regarding FirstEnergy requirements for load and generation interconnection, including appendices. tables and figures. Document reorganized to simplify finding resources and standards. Created Purpose and Background from General Applicability of Requirements. Section 1: Added Key Terms and Definitions. Section 1.5: Updated table with FE Transmission System facilities. Section 2: Updated requirements for in-line switches. Section 3: Removed Reactive Power Table and replaced with reference to PJM Manual 14G. Section 3.2.3 Transformer Requirements: Added information on wye grounded and delta connected windings. Section 3.5: Updated Generation Connection - Protection Requirements. Section 4: Updated Transmission Line Interconnection – Protection Requirements. Sections 2, 3, & 4: Added Real Estate requirements for connections. Section 6: Updates made and added required information from Connecting Party Section 7.4.7: Additional fencing requirements added for non-FE owned interconnection facilities. Section 9: Metering Requirements and ownership updated to reflect new company standards. Figures 1A-11B: Redrawn and updated in accordance with new practices. Attachments changed to Appendices. Retirement of Attachments G and H.

Rev.	Effective Date	Preparer	Comments
3	10/03/2016	J. Janosek G. Marchewka G. McDonald M. Miller	Major: Revised UFLS to include PJM Manual 36 references in Section 9.3. Added reference to NERC PRC-002-2 in Section 10.1. Updated Section 11. Added detailed accuracy requirements for operational metering and reference to PJM Manual 01 in Section 11.1. Removed the requirement for RTU access to revenue metering in Section 11.2 Updated Section 12.1. Added the POI as the required metering equipment location in Section 12.3.1. Updated 12.3.2. Updated 12.3.3. Updated 14.2.1. Revised Figures 1A, 1B, 2, and 6 and added Figure 1C in Section 19. Updated Attachment I to the latest version of the Transmission System Protection Practices document.
2	06/17/2013	Jim Detweiler	Minor: Revised Section 2.3 regarding ownership: Any interrupting or switching device which is in the through path of FE power flow shall be owned by and under operational authority and control of FE as defined in the Interconnection Agreement or Operating Agreements. Revised Figures 1B and 2 regarding ownership. Revised Figure 6 making revenue metering optional for auxiliary transformer associated with breaker 2.
1	02/01/2013	Jim Detweiler John Snyder	Major: Added text and chart regarding power factor requirements to Section 14.2.1: Reactive Power. Added text concerning effectively and not effectively grounded transmission systems to Section 14.2.6: Connecting Transformer Requirements. Added text regarding IEEE 1547.1 testing by third party to Section 14.5 Generation Protection Requirements. Revised text regarding connections to networked and radial transmission system locations to Attachment C. Revised grammar throughout document.
0			Major: Initial procedure creation.

Approvals

This document was reviewed and approved electronically. Records are available upon request through the Transmission Operations Support Compliance & Procedures group.

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