REQUIREMENTS FOR
TRANSMISSION CONNECTED FACILITIES

Effective Date: October 3, 2016
(Previous Revision: June 17, 2013)

APPROVALS:

Jeffrey J. Mackauer  
Director, Energy Delivery Transmission Planning and Protection (ED TP&P)  
10/3/2016

John P. Syner  
General Manager, Planning (ED TP&P)  
9/25/2016

G. Phillip Bowers  
Manager, Compliance & Models (ED TP&P)  
9/30/2016

James R. Detweiler  
Manager, Protection (ED TP&P)  
10/3/2016

Michael J. Miller  
Manager, Protection (ED TP&P)  
9/22/2016
# Table of Contents

**GENERAL APPLICABILITY OF REQUIREMENTS** .......................................................... 1

1. **SERVICE APPLICATION (TRANSMISSION, GENERATION, AND END-USER)** .......... 4
   1.1 GENERAL ............................................................................................................. 4

2. **LOAD CONNECTION REQUIREMENTS (END-USER)** .............................................. 4
   2.1 GENERAL ............................................................................................................. 4
   2.2 TAP CONNECTION DEFINITION AND REQUIREMENTS ......................................... 4
       200 kV and Below ................................................................................................. 4
       230 kV 5 .............................................................................................................. 4
   2.3 LOOPED CONNECTION DEFINITION AND REQUIREMENTS .................................. 5

3. **INTERCONNECTIONS TO OTHER NETWORKED TRANSMISSION OR SUB-TRANSMISSION SYSTEMS (TRANSMISSION)** .............................................................. 6

4. **VOLTAGE LEVELS, SYSTEM CAPACITY, AND OPERATIONAL ISSUES (TRANSMISSION, GENERATION AND END-USER)** .............................................................. 6

5. **LOAD POWER FACTOR REQUIREMENTS (END-USER)** .............................................. 7

6. **FREQUENCY RANGE (TRANSMISSION, GENERATION, AND END-USER)** ............ 7

7. **POWER QUALITY (TRANSMISSION, GENERATION AND END-USER)** ................. 7
   7.1 HARMONICS AND FLICKER ............................................................................... 7
   7.2 SENSITIVE ELECTRICAL EQUIPMENT ................................................................... 8

8. **CONNECTING PARTY SUBSTATION EQUIPMENT REQUIREMENTS (TRANSMISSION, GENERATION, AND END-USER)** ................................................................. 8
   8.1 SIZE AND PULL-OFF TENSION OF LINE CONDUCTORS AND OVERHEAD GROUND WIRE .......... 8
   8.2 SHORT CIRCUIT DATA & INTERRUPTING DEVICES ............................................. 9
   8.3 OTHER DESIGN CRITERIA .................................................................................... 10
       8.3.1 Equipment Basic Insulation Levels ............................................................... 10
       8.3.2 Transformer Surge Protection (Lightning Arresters) ...................................... 10
       8.3.3 Ratings of Current Carrying Equipment ..................................................... 10
       8.3.4 Electrical Clearances (Outdoor) .................................................................. 10
       8.3.5 Insulators for Station .................................................................................. 11
       8.3.6 Horn Gap Switch(es) and Disconnect Switch(es) ......................................... 11
       8.3.7 Substation Fence Safety Clearances ............................................................ 11
       8.3.8 Grounding System Design and Test ............................................................. 11

9. **SYSTEM PROTECTION (TRANSMISSION, GENERATION AND END-USER)** ............ 12
   9.1 FE TRANSMISSION SYSTEM PROTECTION ...................................................... 12
   9.2 CONNECTING PARTY PROTECTION .................................................................... 13
   9.3 AUTOMATIC UNDERFREQUENCY AND UNDervoltage LOAD SHEDDING .............. 13

10. **REMOTE RELAY ACCESS AND DISTURBANCE MONITORING (TRANSMISSION, GENERATION AND END-USER)** ................................................................. 15
   10.1 LOOP OR NETWORK CONNECTED SUBSTATIONS .......................................... 15
   10.2 TAP CONNECTED SUBSTATIONS ..................................................................... 15

11. **SCADA REQUIREMENTS (TRANSMISSION, GENERATION AND END-USER)** .......... 15
11. TRANSMISSION INTERCONNECTION SUBSTATIONS ...............................................................15
   11.1 Loop and Network Connected Transmission Substations ............................................15
   11.1.1 Position Indication ....................................................................................................15
   11.1.2 Alarms ....................................................................................................................15
   11.1.3 Operational Metering ..............................................................................................16
   11.1.4 Non-Loop or Non-Network Connected Transmission Substations ......................16
   11.1.5 Tap Connected Substations ....................................................................................16

11.2 SCADA (OPERATIONAL METERING) REQUIREMENTS FOR GENERATION FACILITIES (GENERATION
AND END-USER) .....................................................................................................................17
   11.2.1 Generation connected directly to the transmission system .....................................17
   11.2.2 Position Indication ..................................................................................................17
   11.2.3 Alarms ....................................................................................................................17
   11.2.4 Operational Metering ............................................................................................17

12. REVENUE METERING REQUIREMENTS (TRANSMISSION, GENERATION, AND END-
USER) ........................................................................................................................................18
   12.1 REVENUE METERING EQUIPMENT .........................................................................18
      12.1.1 General Requirements ........................................................................................18
      12.1.2 Revenue Meters ..................................................................................................18
      12.1.3 Revenue Metering Current Transformers ..........................................................19
      12.1.4 Revenue Metering Voltage Transformers ...........................................................19
      12.1.6 Operational Metering Data from Revenue Meters ..............................................20
   12.2 REVENUE METERING ACCESS, SECURITY, AND TESTING ....................................20
   12.3 FACILITY-SPECIFIC REVENUE METERING REQUIREMENTS ................................20
      12.3.1 Adjacent Transmission Owner Facilities ............................................................20
      12.3.2 Wholesale Generation Facilities .........................................................................21
      12.3.3 End-User Facilities ............................................................................................22

13. COMMUNICATIONS (TRANSMISSION, GENERATION, AND END-USER) .......................23
   13.1 NORMAL VOICE COMMUNICATIONS ......................................................................23
   13.2 EMERGENCY VOICE COMMUNICATIONS .................................................................23

14. GENERATION CONNECTION REQUIREMENTS (GENERATION AND END-USER) ........24
   14.1 CONNECTION CONFIGURATIONS ..........................................................................24
   14.2 DESIGN REQUIREMENTS ........................................................................................24
      14.2.1 Reactive Power ......................................................................................................24
      14.2.2 Generator Frequency ..........................................................................................25
      14.2.3 System Grounding ..............................................................................................25
      14.2.4 Disconnecting Devices .......................................................................................26
      14.2.5 Transient Stability Performance .......................................................................26
      14.2.6 Connecting Transformer Requirements ............................................................26
      14.2.7 Communications Channel to FE Substation ......................................................27
   14.3 GENERATION CONTROLS .......................................................................................27
      14.3.1 Automatic Voltage Regulator ............................................................................27
      14.3.2 Reactive Compensation .....................................................................................27
      14.3.3 Overcurrent Limiter ...........................................................................................27
      14.3.4 Underexcitation Limiter .....................................................................................27
      14.3.5 Power System Stabilizer .....................................................................................27
ENERGY DELIVERY PLANNING AND PROTECTION

14.3.6 Speed Governing ............................................................................................................................. 27
14.3.7 Automatic Generation Control (AGC) .................................................................................................. 28

14.4 OPERATING REQUIREMENTS ........................................................................................................ 28
   14.4.1 Synchronization .............................................................................................................................. 28
   14.4.2 Voltage Schedule/Power Factor ..................................................................................................... 28
   14.4.3 Voltage Range .................................................................................................................................. 29
   14.4.4 Frequency Range ............................................................................................................................ 29
   14.4.5 Voltage Balance .............................................................................................................................. 29
   14.4.6 Net Demonstrated Real and Reactive Capabilities ......................................................................... 29
   14.4.7 Other Applicable Operating Requirements ..................................................................................... 30
   14.4.8 Operating Restrictions .................................................................................................................... 30

14.5 GENERATION PROTECTION REQUIREMENTS .................................................................................. 30

14.6 DISTRIBUTION CONNECTED GENERATION .................................................................................... 32

15. INSPECTION REQUIREMENTS (TRANSMISSION, GENERATION, AND END-USER) ........32

16. MAINTENANCE REQUIREMENTS (TRANSMISSION, GENERATION AND END-USER)........32

17. COORDINATION WITH OTHER CODES, STANDARDS, AND AGENCIES
   (TRANSMISSION, GENERATION, AND END-USER)........................................................................... 33

18. INDEMNIFICATION (TRANSMISSION, GENERATION AND END-USER)......................................... 33

19. REFERENCE TABLES AND FIGURES ............................................................................................. 34

TABLE 1 - SUBSTATION ELECTRICAL CLEARANCES AND INSULATION LEVELS .................34
TABLE 2 - EQUIPMENT RATINGS ............................................................................................................. 35
TABLE 3 - FIRSTENERGY STANDARD INSULATORS .................................................................. 35

GUIDE TO FIGURES MENTIONED IN REQUIREMENTS FOR TRANSMISSION
   CONNECTED FACILITIES ..................................................................................................................... 36

FIGURE 1A - TAPPED LOAD SUPPLY <100 KV .................................................................................... 37
FIGURE 1B - TAPPED LOAD SUPPLY >100 KV AND <200KV .......................................................... 37
FIGURE 1C - TAPPED LOAD SUPPLY 230KV ..................................................................................... 39
FIGURE 2 - LOAD LOOP SUPPLY ............................................................................................................ 40
FIGURE 3 - TAPPED LINE GENERATION ............................................................................................... 41
FIGURE 4 – INTENTIONALLY OMITTED .................................................................................................. 42
FIGURE 5 - LOOPED LINE GENERATION ENERGY EXPORT ............................................................. 43
FIGURE 6 - BUS CONNECTED MULTIPLE GEN. ENERGY EXPORT .................................................... 44
FIGURE 7 - METERING/SCADA REQUIREMENTS FOR TAP CONNECTION TO A
   CONNECTING PARTY WITH A TRANSMISSION SYSTEM AND CONNECTED
   GENERATION .......................................................................................................................................... 45

20. REVISIONS ........................................................................................................................................... 47
   20.1 REVISION PROCESS .......................................................................................................................... 47
   20.2 REVISION HISTORY TABLE ............................................................................................................. 47

ATTACHMENT A - PROCEDURE FOR CONNECTING NEW SUBSTATION OR LINES TO FE
   FACILITIES ............................................................................................................................................ 49

ATTACHMENT B - SUBSTATION CHECKOUT GUIDE ............................................................................. 51
ATTACHMENT C - BREAKER RING BUS DECISION PROCESS – GENERATION CONNECTIONS ................................................................. 54

ATTACHMENT D - FIRSTENERGY REVENUE METERING INSTALLATION REQUIREMENTS FOR TRANSMISSION CONNECTED RETAIL AND WHOLESALE LOAD CUSTOMER FACILITIES ............................................................................... 55

ATTACHMENT E – FIRSTENERGY REVENUE METERING REQUIREMENTS FOR GENERATION FACILITIES CONNECTED 69 KV AND HIGHER ............................................................................................................................... 58

ATTACHMENT F - FIRSTENERGY REVENUE METERING REQUIREMENTS FOR GENERATION FACILITIES CONNECTED 46 KV AND LOWER ........................................................................................................... 60

ATTACHMENT G – FIRSTENERGY REVENUE METERING REQUIREMENTS FOR 69 KV AND HIGHER ................................................................................................................................. 58

ATTACHMENT H - FIRSTENERGY REVENUE METERING REQUIREMENTS FOR BEHIND-THE-METER GENERATION FACILITIES PARTICIPATING IN THE PJM ENERGY OR CAPACITY MARKET ................................................................................................................................. 62

ATTACHMENT I – DISTRIBUTION POWER TRANSFORMER PROTECTION ......................................................................................................................... 64

10. DISTRIBUTION POWER TRANSFORMER PROTECTION ......................................................................................................................... 64

10.1 PROTECTIVE COORDINATION WITH TRANSMISSION LINE PROTECTION ......................................................................................................................... 64

10.1.1 POWER TRANSFORMERS CONNECTED TO A RADIAL TRANSMISSION LINE ......................................................................................................................... 64

10.1.2 POWER TRANSFORMERS TAPPED TO A LOOPED TRANSMISSION LINE WITH NON-PILOT RELAY PROTECTION ......................................................................................................................... 64

10.1.3 POWER TRANSFORMERS TAPPED TO A LOOPED TRANSMISSION LINE WITH PILOT RELAY PROTECTION ......................................................................................................................... 64

10.1.3.1 STATIONS WITH HIGH-SIDE CIRCUIT BREAKERS/SWITCHERS ......................................................................................................................... 65

10.1.3.2 STATIONS WITH HIGH-SIDE FUSES (LESS THAN 100 KV) ......................................................................................................................... 65

10.2 HIGH-SIDE POWER FUSES (LESS THAN 100 KV) ......................................................................................................................... 65

10.2.1 Transformer Connection ......................................................................................................................................................... 65

10.2.2 Fuse Interrupting Capability ......................................................................................................................................................... 65

10.2.3 Fuse Coordination ......................................................................................................................................................... 65

10.3 PROTECTIVE RELAYS AND FULLY RATED INTERRUPTING DEVICES ......................................................................................................................... 65

10.3.1 TRANSFORMER DIFFERENTIAL (87T) ......................................................................................................................................................... 66

10.3.1.1 Protective Relay ......................................................................................................................................................... 66

10.3.1.2 Source Input ......................................................................................................................................................... 66

10.3.1.3 Operating Functions ......................................................................................................................................................... 66

10.3.2 TRANSFORMER BACKUP PROTECTION (50/51, 50N/5IN, 51G) ......................................................................................................................................................... 66

10.3.2.1 Protective Relay ......................................................................................................................................................... 67

10.3.2.2 Operating Functions ......................................................................................................................................................... 68

10.3.3 High-Side Interrupting Device Failure to Trip Protection ......................................................................................................................................................... 68

10.4 BACKFEED REMOVAL ......................................................................................................................................................... 68

FIGURE 10.1 MINIMUM REQUIRED DIST TRANSFORMER PROTECTION USING CIRCUIT BREAKER ......................................................................................................................................................... 69
FIGURE 10.2 MINIMUM REQUIRED DIST TRANSFORMER PROTECTION USING CIRCUIT SWITCHER....70
General Applicability of Requirements

These Requirements for Transmission Connected Facilities (Requirements) constitute the facility connection requirements of all affiliates of FirstEnergy Corp. that own and operate transmission, sub-transmission and/or distribution systems and facilities. These Requirements will facilitate the safe, efficient and reliable integration of any electrical transmission, generation or end-user facility into the FE Transmission System. All facilities proposed for connection to the FE Transmission System will be evaluated to ensure compliance with these Requirements, all North America Electric Reliability Corporation (NERC), ReliabilityFirst (RF), FE planning criteria and PJM Interconnection, L.L.C. (PJM) requirements, if applicable. By submitting a request to connect transmission, generation and/or end-user 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 Restate Operating Agreement and other applicable PJM agreements, manuals and documents.

In these Requirements, the following definitions apply:

- **BES** - refers to the Bulk Electric System and 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 end-user facility to the FE Transmission System.

- **End-User Connection** – an electrical connection between the FE Transmission System and end-user facilities. These facilities are not a networked transmission system and might include behind-the-meter generation. These connections are typically referred to as Retail or Wholesale connections.

- **FE** – the affiliates of FirstEnergy Corp. that own and operate transmission, sub-transmission and/or distribution systems and facilities.

- **FE Transmission System** – the transmission, sub-transmission and/or distribution systems, lines, substations and other facilities owned and operated by FE for the purpose of transmitting and distributing electricity regardless of voltage, unless specifically stated otherwise.

- **Generation Connection** – an electrical connection between the FE Transmission System and a generation facility. This does not include behind-the-meter generation.
Transmission Connection – an electrical connection between the FE Transmission System and another transmission or distribution system such as the facilities of an adjacent transmission owner or a load serving entity.

These Requirements 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. These Requirements 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 end-user facilities connected to the FE Transmission System. 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: the Mid-Atlantic Area Council (MAAC), the East Central Area Coordination Agreement (ECAR), and the 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.

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. Additional provisions may be necessary as a result of the specific connection propose and the findings of FE and/or PJM studies performed, or other NERC, RF or PJM requirements that may be more restrictive. As an example, requirements for connection of an HVDC line will be considered on a case-by-case basis.

The planning and implementation of new or modified transmission, generation, and end-user facilities connected to the FE Transmission System are coordinated with the interconnected transmission system through the PJM Regional Transmission Expansion Process (RTEP), and the updated Multi-Regional Modeling Working Group Process (MMWG) base cases. The RTEP process is documented on the PJM web site (www.pjm.com). Initial Load Studies (ILS) and Detailed Load Studies (DLS) that will be performed by FE in association with any proposed new or modified transmission system connection will only evaluate its impact on the FE Transmission System. These studies are performed for End-User Connections and, in some instances, for Transmission Connections. FE will notify adjacent transmission owners, transmission customers, RTOs or others, including governmental authorities, that may be impacted by the proposed new or modified transmission, generation or end-user facilities as may be required by any existing tariff, interconnection agreement and/or the PJM process. FE will share its study results and data with the impacted parties as appropriate in accordance with applicable Standards, and Codes of Conduct. Any impacted party, at its discretion, 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.

Due to the evolution of the FE Transmission System, some existing FE 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. 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. All new switchyards must meet the current connection requirements.

The processing of transmission system load connection requests or preliminary reviews of Transmission Connection requests includes an evaluation to determine if an ILS and/or a DLS is required to analyze the impact of the proposed load connection facilities on the FE Transmission System.

An ILS is an assessment by FE of the capability of the existing system to accommodate the request for the new or modified connection facilities. An ILS typically includes but is not limited to the following:

- Load flow analysis,
- Short circuit level at point of interconnection,
- Consideration of special circumstances such as power quality (PQ) issues,
- Identification of direct connection requirements,
- Identification of network upgrades needed,
- Preliminary estimates of costs associated with direct connect and system upgrades,
- Consideration of multiple connection alternatives,
- Operational limitations, and
- Written report of results.

A DLS is an engineering study conducted by FE. A DLS typically includes but is not limited to the following:

- Consideration of one ILS connection alternative,
- Estimates of costs associated with direct connect and system upgrades,
- Specification of protection requirements,
- Specification of metering requirements,
- Operational limitations,
- Stability analysis as required, and
- Written report of results.

The processing of Generation Connection requests to participate in the PJM capacity and energy markets is defined within the PJM Regional Transmission Planning Process manuals which are available on the PJM web site (www.pjm.com).

The applicability of each main section of these Requirements to transmission, generation, and end-user facilities is identified in the title of each of the main sections.
1. **Service Application (Transmission, Generation, and End-User)**

   1.1 **General**

   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. Other Connecting Parties should contact the Manager, Agreements Support, FirstEnergy, 76 S. Main St., Akron OH 44308.

   Applications for Generation Connection service are available electronically from the PJM web site (www.pjm.com).

2. **Load Connection Requirements (End-User)**

   2.1 **General**

   One or more dedicated interrupting devices are required at all connecting facilities. All connections to the FE Transmission System must be designed such that, under normal operating conditions, faults at the Connecting Party's facility, with the exception of certain lines protected by a communications based protection scheme as noted below, will not result in an interruption of an FE Transmission System through path or the power flow of another entity connected to the FE Transmission System.

   For transmission lines protected with certain communications based protection schemes, an instantaneous communications based trip for a fault on the Connecting Party’s system is acceptable if automatic reclosing is in place at both transmission line terminals and the Connecting Party’s facility instantaneously trips for all faults where a FE instantaneous communications based trip is possible.

   2.2 **Tap Connection Definition and Requirements**

   A connection to the FE Transmission System that results in only the Connecting Party’s load passing through the connecting facilities under any condition is considered a tap connection.

   For tap supply configurations, the high side transformer winding configuration for connecting substation transformers must be either delta or ungrounded wye.

   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. Refer to Section 2.3 for the acceptable load connection configuration on these systems.

   **200 kV and Below**

   The attached Figures 1A and 1B illustrate a typical tap supply configurations, for FE transmission supply voltages at 200 kV and below, and some of the basic connection requirements. As indicated, line switches will be required at the tap
point to allow for sectionalizing the line without supply interruption to the Connecting Party. FE may require that motor operated mechanisms and Supervisory Control and Data Acquisition (SCADA) be installed with the switch in series with the customer load in order to minimize exposing the FE Transmission System to faults on the tapped line section. Motor operated mechanisms and SCADA control can be installed with the switches in line with FE’s transmission line at the Connecting Party’s request (and cost) in order to reduce the time required for restoration in the event of permanent line faults on the FE Transmission System.

230 kV

The attached Figure 1C illustrates a typical tap supply configuration for the FE 230 kV transmission supply voltage and some of the basic connection requirements. As shown, switches are required at the tap point to allow for sectionalizing the line without supply interruption to the Connecting Party. Due to concerns with the practical ability to reliably operate 230 kV line switches, FE requires these switches to be located in a substation environment. Therefore it is required that the FE transmission line be extended in a parallel manner, as indicated, to the substation switches. Motor operated mechanisms and SCADA control can be installed with the switches in line with FE’s transmission line at the Connecting Party’s request (and cost) in order to reduce the time required for restoration in the event of permanent line faults on the FE Transmission System.

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 (Interconnection Agreement).

2.3 Looped Connection Definition and Requirements

A connection to the FE Transmission System that requires FE transmission line load (through flow) to pass through the connecting facilities under any condition is considered a looped connection. 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.

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.

For looped supply configurations, 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.
3. **Interconnections to other Networked Transmission or Sub-transmission Systems (Transmission)**

A connection to the FE Transmission System that allows bi-directional energy and/or fault current flow between otherwise independent transmission or sub-transmission systems is considered a network connection (regardless of generation connected to the adjacent transmission system or load serving entity). This configuration requires the connecting substation to an FE transmission line be designed and built in either a ring bus or a breaker and a half configuration (similar to Figure 2 illustrating a loop supply configuration). The transformers shown in figure 2 could be connected to the independent transmission system or those station positions might be occupied by transmission line terminations originating from the connecting independent transmission system.

4. **Voltage Levels, System Capacity, and Operational Issues (Transmission, Generation and End-User)**

The Connecting Party’s facility will be supplied from FE’s transmission or sub-transmission system, which is designed to operate between the following percentages of nominal voltage under normal and single transmission element outage conditions.

<table>
<thead>
<tr>
<th>Voltage System</th>
<th>Voltage Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>500 kV System</td>
<td>(97.0%-110%)</td>
</tr>
<tr>
<td>345 kV and 230 kV Systems</td>
<td>(92.0%-105%)</td>
</tr>
<tr>
<td>138 kV and 115 kV Systems</td>
<td>(92.0%-105% if networked)</td>
</tr>
<tr>
<td>138 kV and 115 kV Systems</td>
<td>(90.0%-105% if non-networked)</td>
</tr>
<tr>
<td>69 kV/46 kV/34.5 kV Systems</td>
<td>(90.0%-105%)</td>
</tr>
<tr>
<td>25/23 kV Systems</td>
<td>(90.0%-107.5%)</td>
</tr>
</tbody>
</table>

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. Nominal system voltages currently are; 500 kV, 345 kV, 230 kV, 138 kV, 115 kV, 69 kV, 46 kV, 34.5 kV, 25 kV and 23 kV.

Under certain emergency conditions involving multiple system contingencies, the FE Transmission System may operate for a period of time outside of this range. 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 (www.pjm.com).

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 in the General Applicability section of these Requirements.

Operational issues associated with the proposed facilities will be analyzed and documented through the connection processes referenced in the General Applicability section of these Requirements.
5. **Load Power Factor Requirements (End-User)**

End-Users connected directly to the FE Transmission System should plan and design their systems to operate at close to unity power factor to minimize the reactive power burden on the FE Transmission System. The FE requirement for close to unity power factor is that the power factor at the point of interconnection shall be controlled to be within the range of 0.97 lagging to 0.99 leading.

Shunt capacitors are frequently used as a means to control the power factor of a Connecting Party’s facility. 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 in regard to control of these phenomena.

6. **Frequency Range (Transmission, Generation, and End-User)**

The FE Transmission System typically operates at a nominal 60 Hz with a variation of ±0.05 Hz. Under certain emergency conditions, the FE Transmission System may operate for a period of time outside of this range. The Connecting Party is responsible for providing any frequency sensing relaying required to protect its facilities during abnormal frequency operation.

7. **Power Quality (Transmission, Generation and End-User)**

7.1 **Harmonics and Flicker**

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


Flicker shall be measured as described in IEEE Std 1453-2004, "IEEE Recommended Practice for Measurement and Limits of Voltage Fluctuations and Associated Light Flicker on AC Power Systems". Pst is a measure of short-term perception of flicker obtained for a ten-minute interval. Plt is a measure of long-term perception of flicker obtained for a two-hour period calculated from 12 consecutive Pst values. The connected facility shall be designed and operated such that Pst does not exceed 0.8 and Plt 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 (see Annex A of IEEE Std. 1453-2004). 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.

7.2 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, 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.

8. Connecting Party Substation Equipment Requirements (Transmission, Generation, and End-User)

8.1 Size and Pull-Off Tension of Line Conductors and Overhead Ground Wire

The sizes and approximate pull-off or dead-end tension for each phase conductor and ground wire will be provided by FE for design of the takeoff structure. The exact pull-off tensions will be determined after the substation plans are finalized.

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

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.
The point of attachment of the line entrance conductors shall be of sufficient height to provide the basic 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.

8.2 Short Circuit Data & Interrupting Devices

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

<table>
<thead>
<tr>
<th>3 Phase Fault</th>
<th>AMPS or MVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Line-Ground Fault</td>
<td>AMPS*</td>
</tr>
<tr>
<td>System Impedance on 100 MVA Base</td>
<td>Z1%, Z0%</td>
</tr>
</tbody>
</table>

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

Substation 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.

While FE will endeavor, where possible, to anticipate future system changes which may affect the provided values, it 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.

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 in order 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.

For 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.

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.
8.3 Other Design Criteria

8.3.1 Equipment Basic Insulation Levels

The minimum required Basic Insulation Levels (BIL) are listed in Table 1. Substations in areas with significant airborne pollution may require a higher insulation level.

8.3.2 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. Metal oxide varistor (MOV) arrester application guide, IEEE Std 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.

8.3.3 Ratings of Current Carrying Equipment

For tap supply configurations, 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. Minimum current ratings will be provided by FE for looped or network supply configurations.

8.3.4 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 National Electrical Safety Code or applicable state and local codes.
8.3.5 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.

8.3.6 Horn Gap Switch(es) and Disconnect Switch(es)

A gang operated horn gap switch shall be installed on each transmission line supply entrance to 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 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 Std C37.30, ANSI C37.32, and IEEE Std C37.34.

8.3.7 Substation Fence Safety Clearances


8.3.8 Grounding System Design and Test

The grounding system shall be designed in accordance with IEEE Std 80 - latest revision, “IEEE Guide for Safety in AC Substation Grounding.” The
grounding system design and construction shall be verified by tests in accordance with IEEE Std 81, “IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Surface Potentials of a Ground System.”

Ground fault currents from FE sources are listed in Section 8.2, Short Circuit Data & Interrupting Device Ratings. Connecting Party equipment ground sources can contribute significant fault current independent of the ground fault values in Section 8.2. 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.

9. System Protection (Transmission, Generation and End-User)

9.1 FE Transmission System Protection

FE will provide relay requirements and functional specifications for all protective relays that have a potential impact on the reliability of the FE Transmission System. These relays include, but are not limited to, all relays that use source inputs (voltage or current) at the connecting transmission voltage level, that trip any interrupting device at the connecting transmission voltage level, plus intertie relays and transfer trip equipment. The criteria for these functional specifications will be based upon requirements set forth in Attachment I. FE also reserves the right to specify the type and manufacturer for these protective relays.

In order to provide adequate protection to the FE Transmission System, 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.

The specific recommendations and requirements for protection will be made by FE based on the individual substation location, voltage and configuration.

Those protective relays required by FE and any auxiliary-tripping relay associated with those relays shall be utility-grade devices. Utility grade relays are defined as follows:

2. Have relay test facilities to allow testing without unwiring or disassembling the relay.
3. Have appropriate test plugs/switches for testing the operation of the relay.
4. Have targets to indicate relay operation.
The relaying system and interrupting device control circuits shall have a reliable source of power independent from the AC system or immune to AC system disturbances or loss (e.g., dc battery and charger) to assure proper operation of the protection scheme.

FE will provide short circuit data for the specific point of connection for additional FE transmission facility outage contingencies as requested by the Connecting Party for use during the completion of power system studies.

FE will determine and provide documentation of settings for intertie relays and transfer trip equipment. FE review and approval is required for all settings on other protective relays that are required by FE. FE will also review settings for the Connecting Party’s internal relays in order to establish coordination between the facility protective equipment and the FE Transmission System relays.

9.2 Connecting Party Protection

It is the Connecting Party’s responsibility to assure protection, coordination and equipment adequacy within its facility for conditions including but not limited to:

1. Single phasing of supply
2. System faults
3. Equipment failures
4. Deviations from nominal voltage or frequency
5. Lightning and switching surges
6. Harmonic voltages
7. Negative sequence voltages
8. Separation from FE supply
9. Synchronizing generation
10. Synchronizing facilities between independent transmission system and FE Transmission System

It is the Connecting Party’s responsibility to determine that its internal protective equipment coordinates with the required FE protective equipment and is adequate to meet all applicable standards to which the Connecting Party may be subject. It should be noted that certain transformer configurations (such as the wye-grounded delta required for Generation Connections) will result in the FE Transmission System providing little or no backup protection to the connecting facility.

FE further reserves the right to require modification to relay settings when deemed necessary to avoid safety hazards to utility personnel or the public and to prevent any disturbance, impairment, or interference with FE’s ability to serve other customers.

9.3 Automatic Underfrequency and Undervoltage Load Shedding

FE applies automatic underfrequency load shedding relaying in compliance with the applicable NERC and PJM requirements and agreements.

For the FE operating companies 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, Section 2.3 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.

<table>
<thead>
<tr>
<th>Step</th>
<th>Frequency</th>
<th>Minimum Load Dropped (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>59.5 Hz</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>59.3 Hz</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>59.1 Hz</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>58.9 Hz</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>58.7 Hz</td>
<td>5</td>
</tr>
</tbody>
</table>

All End-User Wholesale Connecting Parties within the former ECAR region of the FE Transmission System shall have an automatic underfrequency load shedding plan in effect that meets NERC and PJM Manual 36, Section 2.3 requirements.

Connecting Parties proposing a Generation Connection within the former ECAR region of the FE Transmission System are required to remain interconnected to the FE Transmission System during frequency disturbances as prescribed by PJM Manual 36, Section 2.3.

For the FE operating companies within the former MAAC region (Jersey Central Power and Light, Met-Ed and Penelec), PJM Manual 36, 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.

<table>
<thead>
<tr>
<th>Step</th>
<th>Frequency</th>
<th>Minimum Load Dropped (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>59.3 Hz</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>58.9 Hz</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>58.5 Hz</td>
<td>10</td>
</tr>
</tbody>
</table>

All End-User 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, Section 2.3 requirements.

Connecting Parties proposing a Generation Connection within the former MAAC region of the FE Transmission System are required to remain interconnected to the FE Transmission System during frequency disturbances as prescribed by PJM Manual 36, Section 2.3.

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. End-User Wholesale and Retail Connecting Parties may be required to install undervoltage load shedding schemes as identified by FE through these special studies.

10.1 Loop or Network Connected Substations

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.

10.2 Tap Connected Substations

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

11. SCADA Requirements (Transmission, Generation and End-User)

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 System Control Center (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.

11.1.1.1 Control

The RTU shall provide FE with control of all circuit interrupting devices that are directly in the FE transmission path.

11.1.1.2 Position Indication

The RTU shall provide FE position indication of all transmission voltage circuit interrupting devices and motor operated disconnect devices.

11.1.1.3 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 might include breaker failure or bus differential relaying).

11.1.1.4 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 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 Regional Transmission Organization, via their respective 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 End-User)

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 will receive operational data regarding the generator interconnection via its ICCP data link to PJM.

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

11.2.1.1 Control

There is no FE SCADA control of breakers contained within the Connecting Party's generation facility.

11.2.1.2 Position 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.

11.2.1.3 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.

11.2.1.4 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 (instantaneous megawatts, instantaneous megavars, and b phase amps) will be provided to the FE. 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 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. **Revenue Metering Requirements (Transmission, Generation, and End-User)**

FE approved revenue metering equipment shall be installed for energy accounting and billing purposes. The revenue metering shall be located at the Connecting Party’s facility unless otherwise agreed to by FE, PJM, and the Connecting Party.

12.1 **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.

12.1.1 **General Requirements**

The revenue metering equipment shall meet or exceed all applicable industry standards (e.g., ANSI, IEEE, and 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 FE, PJM, 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 service 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.

12.1.2 **Revenue Meters**

The revenue meters shall be capable of recording, storing, and transmitting bidirectional MWh data and MVARh data (or kWh and kVARh data). The revenue meters shall record this data in fifteen-minute intervals.
12.1.3 Revenue Metering Current Transformers

The revenue meters shall be connected to 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. 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 ratings of the CTs.

The revenue meters shall generally be connected to dedicated metering CT secondary circuits and should not share the same circuits with relays or other devices.

In cases where power flow varies significantly (e.g., at wind generation facilities), the Connecting Party may be required to provide extended range CTs or additional metering equipment at its own expense.

12.1.4 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.
12.1.5 Revenue Metering Data Communications

The Connecting Party shall, at its own expense, install, operate, test, and maintain any communications equipment required to transmit data from the revenue metering at the Connecting Party’s facility.

FE will provide the Connecting Party access to bi-directional kWh and kVARh pulses from an FE revenue meter installed at a Connecting Party facility. The pulses will be provided upon request and at the Connecting Party’s expense. Instructions for meter pulse service requests and details regarding pulse installations are available on the FE web site: https://www.firstenergycorp.com/metering.html

12.1.6 Operational Metering Data from Revenue Meters

Operational metering data (e.g., real-time MW and MVAR) are generally not available from revenue meters that are provided by FE 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.

At facilities where the Connecting Party is responsible for the revenue metering equipment, the Connecting Party’s revenue meter may be used to provide the required operational metering data.

12.2 Revenue Metering Access, Security, and Testing

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 reasonable hours and for any reasonable purpose.

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

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.

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.

12.3 Facility-Specific Revenue Metering Requirements

12.3.1 Adjacent Transmission Owner Facilities
The Connecting Party shall 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.

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

The revenue metering shall be compensated for losses to the POI if the metering equipment is not located at the POI.

12.3.2 Wholesale Generation Facilities

Revenue metering is required at all generating facilities within the FE footprint. The revenue metering equipment shall be located at the Connecting Party’s facility unless otherwise agreed to by FE, PJM, and the Connecting Party. The revenue metering shall be compensated for losses to the POI if the metering equipment is not located at the POI.

The revenue metering CTs and VTs shall be installed on the transmission 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.

The specific revenue metering requirements for wholesale generation facilities will fall under one of the following categories:

- FE Revenue Metering Requirements for Generation Facilities Connected 69 kV and Higher – The Connecting Party shall install, own, operate, test, and maintain the revenue metering equipment as specified in Attachment E.
- FE Revenue Metering Requirements for Generation Facilities Connected 46 kV and Lower – FE shall generally provide, own, operate, test, and maintain the revenue metering at the Connecting Party’s expense as specified in Attachment F.
- FE Revenue Metering Requirements for Behind-The-Meter Generation Facilities Participating in the PJM Energy or Capacity Market – The revenue metering requirements will be reviewed by FE on a case-by-case basis for retail or wholesale load facilities with behind-the-meter generation participating in the PJM energy or capacity markets. In general, FE shall continue to own, operate, test, and maintain the revenue metering equipment at the retail or wholesale load facility’s POI to FE per the applicable retail tariff or wholesale load Interconnection Agreement. Any additional revenue metering equipment or metering data that PJM or FE may require for the behind-the-meter generation shall be the responsibility of the Connecting Party. Refer to Attachment G for details.
• FE Revenue Metering Requirements for Energy Storage Facilities Connected at Any Voltage (Direct Connections to FE Facilities or Connections Behind-the-Meter) – The Connecting Party of Energy Storage Facilities used in PJM’s frequency regulation market and settled via PJM’s ancillary market shall provide, own, operate, test, and maintain the revenue metering at theConnecting Party’s expense. The Connecting Party shall provide the revenue metering data to PJM and FE unless otherwise agreed to by FE and the Connecting Party.

• Revenue Metering Requirements for Existing Non-Utility Generator Facilities That Are Ending Power Purchase Agreements with FE – The revenue metering requirements will be reviewed on a case-by-case basis for existing non-utility generator (NUG) facilities that are ending power purchase agreements with FE and will sell their power in the PJM energy market. Refer to Attachment H for details.

12.3.3 End-User Facilities

Revenue metering is required at delivery points for wholesale electric customers (i.e. municipals, RECs) and Operating Companies’ end-use customers.

The revenue metering equipment for End-User Facilities shall generally be provided by FE and located at the Connecting Party’s facility as specified in the applicable tariffs or the Interconnection Agreement. Refer to Attachment D for details and installation requirements.

The revenue metering shall generally 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. The Connecting Party’s proposed metering installation design must be reviewed and accepted by FE.

The revenue metering may require compensation for losses if it is not located at or near the POI.

End-User Facilities with behind-the-meter wholesale generation shall follow the revenue metering requirements specified in Section 12.3.2. The revenue metering requirements for End-User Facilities with behind-the-meter generation used strictly for load shaving purposes will be reviewed by FE on a case-by-case basis.

Any End-User Facilities with behind-the-meter generation may be required to provide additional revenue metering at the output of the generation equipment. The Connecting Party shall install, own, operate, test, and maintain this equipment as specified in the applicable tariffs or Interconnection Agreement. The Connecting Party is also responsible for providing FE with the generation revenue metering data if required.
13. Communications (Transmission, Generation, and End-User)

13.1 Normal Voice Communications

When required by FE, the Connecting Party shall provide a dedicated voice communication circuit to the SCC. Such a dedicated voice communication circuit would originate from the Connecting Party’s 24 hour manned operations office and would be 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.

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.

13.2 Emergency Voice Communications

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.

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.

The Connecting Party is responsible for providing the assigned FE SCC a “Connecting Party Contact List” Containing 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. Connecting Parties will be provided an unlisted FE phone number to be used for emergency or routine operations. Operational emergencies (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.

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.
14. **Generation Connection Requirements (Generation and End-User)**

Generation facilities directly or indirectly connected to and operated in synchronism with the FE Transmission System will have additional requirements beyond those specified in Sections 1 through 13. Those requirements are described in this section.

14.1 **Connection Configurations**

New Generation Connections at transmission voltage levels will require detailed system studies to determine the feasibility of the proposed connection point and the specific connection requirements. The figures referenced in Section 14.5 show typical connections for the Connecting Party’s substations and associated generation. Refer to Attachment C for additional information about the configuration of the connected facilities.

14.2 **Design Requirements**

The Connecting Party is responsible for specifying appropriate equipment and facilities such that the parallel generation is compatible with the FE Transmission System. The Connecting Party is also responsible for meeting any applicable federal, state, and local codes. The minimum FE Transmission System connection design requirements for parallel generation are as follows.

14.2.1 **Reactive Power**

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 the table below. This requirement will be measured at either the POI or generator terminals as specified in the table below. 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 the table. This requirement will be measured at either the POI or generator’s terminals as specified in the table below. 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 needed.
<table>
<thead>
<tr>
<th>Generation Type</th>
<th>New / Increase</th>
<th>Size</th>
<th>Power Factor Requirement</th>
<th>Measurement Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronous</td>
<td>New</td>
<td>&gt; 20 MW</td>
<td>0.95 leading to 0.90 lagging</td>
<td>Generator’s Terminals</td>
</tr>
<tr>
<td>Synchronous</td>
<td>New</td>
<td>&lt;= 20 MW</td>
<td>0.95 leading to 0.90 lagging</td>
<td>Point of Interconnection</td>
</tr>
<tr>
<td>Wind or Non-Synchronous</td>
<td>New</td>
<td>All</td>
<td>0.95 leading to 0.95 lagging</td>
<td>Generator’s Terminals(^1)</td>
</tr>
<tr>
<td>Synchronous</td>
<td>Increase</td>
<td>&gt; 20 MW</td>
<td>1.0 (unity) to 0.90 lagging</td>
<td>Generator’s Terminals</td>
</tr>
<tr>
<td>Synchronous</td>
<td>Increase</td>
<td>&lt;= 20 MW</td>
<td>1.0 (unity) to 0.90 lagging</td>
<td>Point of Interconnection</td>
</tr>
<tr>
<td>Wind or Non-Synchronous</td>
<td>Increase</td>
<td>All</td>
<td>0.95 leading to 0.95 lagging(^2)</td>
<td>Generator’s Terminals</td>
</tr>
</tbody>
</table>

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 (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.

### 14.2.2 Generator Frequency

Connected generation shall be designed to produce balanced, three-phase, 60 Hz voltages and currents.

### 14.2.3 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 will be 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 will be 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. MOV arresters on the affected FE circuit(s) will be evaluated against their temporary overvoltage (TOV) capability characteristic. The Connecting Party will be 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.

\(^1\) For projects that entered PJM’s New Service Queue prior to May 1, 2015, the power factor requirement will be measured at the Point of Interconnection.

\(^2\) For projects that entered PJM’s New Service Queue prior to May 1, 2015, the power factor requirement is 1.0 (unity) to 0.95 lagging.
14.2.4 Disconnecting Devices

As previously specified in Section 8.3.6, an FE approved, gang operated switch shall be installed on each transmission line supply entrance to the Connecting Party’s facility in order 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 for the visibly assured electrical isolation of the generation. The disconnecting means 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 by FE personnel 24 hours a day. The disconnecting device(s) shall be designed such that the switch is lockable in the open position with a FE padlock and shall be identified with a FE designated equipment number(s).

14.2.5 Transient Stability Performance

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

14.2.6 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 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.

Inverter-based generation that is UL1741 certified for anti-islanding protection connected to the FE Transmission System at <100kV 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 FE Transmission System at <100kV shall have a transmission-side winding determined by FE on a case-by-case basis.

For generator connections at Distribution voltage, refer to FE document “Interconnection of Customer-Owned Generation to the FirstEnergy Distribution System”.

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.

14.2.7 Communications Channel to FE Substation

Redundant fiber optic based communications channels shall be installed and maintained between the Connecting Party’s generating facility and the interconnecting FE substation. These channels will be used for all control, relay and direct transfer trip (DTT) signals and other communication as agreed by FE and the Connecting Party. The two redundant paths may need to be physically isolated. This shall be determined on a case by case basis by FirstEnergy.

14.3 Generation Controls

14.3.1 Automatic Voltage Regulator

All generators connected to the FE Transmission System shall be equipped with an automatic voltage regulator (AVR) and shall be operated with the AVR activated and controlling voltage to the voltage schedule provided by FE.

14.3.2 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.

14.3.3 Overcurrent Limiter

The excitation system is to be provided with a current limiting device, which will supersede or act 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. This device must not prevent the exciter from going to and remaining at the positive ceiling for 0.1 seconds following the inception of a fault on the power system.

14.3.4 Underexcitation Limiter

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

14.3.5 Power System Stabilizer

Power system stabilizers shall be installed on all generating units of 70 MW or larger when required by PJM or FirstEnergy.

14.3.6 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.

14.3.7 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 SCC AGC system may be required. This determination will be made on a case-by-case basis.

14.4 Operating Requirements

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.

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

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

14.4.1 Synchronization

The Connecting Party shall assume 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.

14.4.2 Voltage Schedule/Power Factor

Specification of the generator voltage schedule will be 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.

14.4.3 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. During emergency and/or transient system conditions, voltages may temporarily be outside of these ranges.

14.4.4 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 (See also section 9.3).

14.4.5 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.”

14.4.6 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 assure 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 M-21: Rules and Procedures for Determination of Generating Capability and PJM Manual M-14D Generator Operational Requirements.

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.

Note that a failure of the Connecting Party to show a compliance with the generator reactive power requirements as identified by test or from monitored operation will be subject to the terms of section 14.2.1 of these Requirements. The Connecting Party will be required to install supplemental reactive resources to resolve such deficiencies and meet its system obligations.

14.4.7 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.

14.4.8 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.

14.5 Generation Protection Requirements

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.

<table>
<thead>
<tr>
<th>Relay</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>To detect underfrequency and overfrequency operation.</td>
</tr>
<tr>
<td>Overvoltage</td>
<td>To detect overvoltage operation.</td>
</tr>
<tr>
<td>Undervoltage</td>
<td>To detect undervoltage operation.</td>
</tr>
<tr>
<td>Ground Fault Detector</td>
<td>To detect a circuit ground on the FE Transmission System.</td>
</tr>
<tr>
<td>Phase Fault Detector</td>
<td>To detect phase to phase faults on the FE Transmission System.</td>
</tr>
<tr>
<td>Transfer Trip Receiver</td>
<td>To provide tripping logic to the generation owner for isolation of the generation upon opening of the FE supply circuits.</td>
</tr>
<tr>
<td>Directional Power</td>
<td>To detect, under all system conditions, a loss of FE primary source. The relay shall be sensitive enough to detect transformer magnetizing current supplied by the generation</td>
</tr>
<tr>
<td>Breaker Failure</td>
<td>To detect a stuck breaker condition at the generation substation and 1-send a trip signal to the remote ends of the connected line via transfer trip or 2-to trip a high speed ground switch.</td>
</tr>
</tbody>
</table>

In order to provide adequate protection to the FE Transmission System, FE may require that the Connecting Party furnish and install at its expense a transfer trip receiver(s) at its facility to receive any tripping signals originating from any FE location(s). This additional protection would 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.

The drawings listed below including devices from this list and show the typical minimum level of protection required. Additional relays may be required by FE to provide adequate protection for the FE Transmission System.

<table>
<thead>
<tr>
<th>Figure Number</th>
<th>Typical Generation Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Tap connected generation with generating capacity exceeding customer minimum load (energy export).</td>
</tr>
<tr>
<td>3</td>
<td>Tap connected generation with generating capacity less than the facility minimum load (load shaving).</td>
</tr>
<tr>
<td>5</td>
<td>Loop connected generating facility</td>
</tr>
<tr>
<td>6</td>
<td>Bus connected generating facility</td>
</tr>
</tbody>
</table>
Special Protection Schemes (Remedial Action Schemes)

Special protection schemes shall not be used to either eliminate or minimize the need for otherwise required transmission system upgrades.

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. This determination shall be made solely by FE. Such facilities shall be required to meet all other, non-protection related requirements of this document.

14.6 Distribution Connected Generation

Any Generation Connection to a load serving entity’s distribution system that is 1 MVA or larger requires review to determine any resulting impact on the FE Transmission System. For details on the requirements for Generation Connections on the FE Transmission System at distribution voltages, refer to the latest version of the FE document “Interconnection of Customer-Owned Generation to the FirstEnergy Distribution System”.

15. Inspection Requirements (Transmission, Generation, and End-User)

Before a Connecting Party owned substation can be energized, it must pass a final inspection by FE personnel. This inspection concentrates on all substation equipment up to and including the first protective fault interrupting device and the ground system. This may include circuit breakers, circuit switchers, power fuses, instrument transformers, switches, surge arresters, bushings, and relays and associated equipment (including battery and battery chargers). The 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 Std 81 “Recommended Guide for Measuring Ground Resistance and Potential Gradients in the Earth”.

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

16. Maintenance Requirements (Transmission, Generation and End-User)

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 “Transmission and Generation Protection System Maintenance and Testing”.

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.

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.

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.

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.

17. **Coordination with Other Codes, Standards, and Agencies (Transmission, Generation, and End-User)**

These Requirements are supplementary to and are not intended to conflict with or supersede the National Electrical Code (NEC), the National Electrical Safety Code (NESC), or such federal, state and local laws, ordinances, rules, regulations codes, etc. as may be applicable in the areas where the FE Transmission System operates. It is the responsibility of the Connecting Party to comply with all federal, state and local laws, ordinances, rules, regulations, codes, etc. that may be applicable to its operations and the facilities it seeks to connect to the FE Transmission System.

18. **Indemnification (Transmission, Generation and End-User)**

The use and reliance upon these Requirements shall in no way relieve the Connecting Party from the responsibility to meet NEC and NESC requirements.

The Connecting Party, for itself, its affiliates, officers, directors, employees, agents, contractors, subcontractors, successors and assigns agrees to indemnify and save FE, its affiliates, officers, directors, employees, agents, contractors, subcontractors, successors and assigns, harmless from and against any and all court costs and litigation expenses, including legal fees, incurred or related to the defense of any action asserted by any person or persons for bodily injuries, death or economic or property damage arising or in any manner growing out of the use and reliance upon these Requirements. Reliance upon these Requirements shall not relieve the Connecting Party from responsibility for the protection and safety of the general public.
19. Reference Tables and Figures

Table 1 - Substation Electrical Clearances and Insulation Levels

<table>
<thead>
<tr>
<th>Rated Maximum Voltage Between Phases</th>
<th>Rated Basic Impulse Insulation Level (BIL)</th>
<th>Electrical Clearances (inches)</th>
<th>Vertical Clearance of Unguarded Live Parts</th>
<th>Horizontal Clearance of Unguarded Live Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>kV rms</td>
<td>kV Crest</td>
<td>Minimum</td>
<td>Design</td>
<td>Ground</td>
</tr>
<tr>
<td>--------</td>
<td>----------</td>
<td>---------</td>
<td>--------</td>
<td>--------</td>
</tr>
<tr>
<td>25.8</td>
<td>150</td>
<td>10</td>
<td>12</td>
<td>15</td>
</tr>
<tr>
<td>38</td>
<td>200</td>
<td>13</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>48.3</td>
<td>250</td>
<td>17</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>72.5</td>
<td>350</td>
<td>25</td>
<td>29</td>
<td>31</td>
</tr>
<tr>
<td>121</td>
<td>550</td>
<td>42</td>
<td>45</td>
<td>53</td>
</tr>
<tr>
<td>145</td>
<td>550</td>
<td>42</td>
<td>45</td>
<td>53</td>
</tr>
<tr>
<td>242</td>
<td>900</td>
<td>71</td>
<td>80</td>
<td>89</td>
</tr>
<tr>
<td>362 5</td>
<td>1300</td>
<td>104</td>
<td>106</td>
<td>119</td>
</tr>
<tr>
<td>550 5</td>
<td>1800</td>
<td>144</td>
<td>152</td>
<td>222 5</td>
</tr>
</tbody>
</table>

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.
### Table 2 - Equipment Ratings

<table>
<thead>
<tr>
<th>Nominal System Voltage (kV)</th>
<th>Current Carrying Equipment</th>
<th>Surge Arresters</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1) Continuous Amps</td>
<td>Momentary Asymmetrical Withstand</td>
</tr>
<tr>
<td>500</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>345</td>
<td>N/A</td>
<td>61 kA</td>
</tr>
<tr>
<td>230</td>
<td>600</td>
<td>61 kA</td>
</tr>
<tr>
<td>138</td>
<td>600</td>
<td>40 kA</td>
</tr>
<tr>
<td>115</td>
<td>600</td>
<td>40 kA</td>
</tr>
<tr>
<td>69</td>
<td>600</td>
<td>40 kA</td>
</tr>
<tr>
<td>46</td>
<td>600</td>
<td>40 kA</td>
</tr>
<tr>
<td>34.5</td>
<td>600</td>
<td>40 kA</td>
</tr>
<tr>
<td>23</td>
<td>600</td>
<td>40 kA</td>
</tr>
</tbody>
</table>

**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>
<thead>
<tr>
<th>Reference Class kV</th>
<th>Standard BIL Level kV</th>
<th>Standard Strength</th>
<th>High Strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>150</td>
<td>208</td>
<td>2000</td>
</tr>
<tr>
<td>34.5</td>
<td>200</td>
<td>210</td>
<td>2000</td>
</tr>
<tr>
<td>46</td>
<td>250</td>
<td>214</td>
<td>2000</td>
</tr>
<tr>
<td>69</td>
<td>350</td>
<td>216</td>
<td>1500</td>
</tr>
<tr>
<td>115 &amp; 138</td>
<td>550</td>
<td>286</td>
<td>1700</td>
</tr>
<tr>
<td>230</td>
<td>900</td>
<td>304</td>
<td>950</td>
</tr>
<tr>
<td>345</td>
<td>1300</td>
<td>324</td>
<td>1000</td>
</tr>
<tr>
<td>500</td>
<td>1800</td>
<td>391</td>
<td>1450</td>
</tr>
</tbody>
</table>
Guide to Figures Mentioned in Requirements for Transmission Connected Facilities

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

The following chart provides additional clarifying descriptions for additional SCADA and metering requirements for a generation facility connecting to the FE Transmission System.

<table>
<thead>
<tr>
<th>Voltage</th>
<th>69 kV &amp; below</th>
<th>115 kV &amp; 138 kV</th>
<th>230 kV</th>
<th>345 kV</th>
<th>500 kV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Metering/SCADA Requirements</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmission system w/ gen on tapped connection</td>
<td>Figure 7</td>
<td>If deemed non-critical refer to Figure 7</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Transmission system w/ gen on looped connection</td>
<td>Figure 8</td>
<td>If deemed non-critical refer to Figure 8</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

*May require a ring bus or equivalent connection type (Figure 5 and 6) based on process referenced in Attachment C.
Figure 1A - Tapped Load Supply <100 kV

NOTES:

1. Must meet FE Facility Connection Standards. FE will provide one span of conductor to pull into the connecting party’s substation facility. Additional length to connecting party’s substation to be approved by FE.
2. Switches at option of FE (typically required) at connecting party’s expense. Supplemental interrupting device (e.g., vacuum interrupter) may be required. SCADA control at customer’s option and expense.
3. Switch may be required depending on tap length.
4. Fully rated interrupting device (e.g., breaker, circuit switcher or fuses). Utilization of fuses is subject to review from FE.
5. Revenue Metering per Section 12.
6. Line trap may be required at tap location (if source stations utilize power line carrier scheme).
FIGURE 1B - Tapped Load Supply >100 kV and <200kV

NOTES:
(1) Must meet FE Facility Connection Standards. FE will provide one span of conductor to pull into the connecting party's substation facility. Additional length to connecting party's substation to be approved by FE.
(2) Switches at option of FE (typically required) at connecting party's expense. Supplemental interrupting device (eg. vacuum interrupter) may be required. SCADA control at customer's option and expense.
(3) Switch may be required depending on tap length.
(4) For connection to circuit of 100 kV or higher, a circuit breaker and failure-to-trip relaying is required.
(5) Revenue Metering per Section 12.
(6) Must be protected by two independent high-speed protection schemes
(7) Line trap(s) required at tap location if the high-speed ground switch option is used in place of transfer trip (if source stations utilizes power line carrier scheme).
(8) Line trap required at this location [supersedes location (7)] if transfer trip option is utilized (only one line trap location required).
FIGURE 1C - Tapped Load Supply 230kV

TRANSMISSION LINE

SUBSTATION

NOTES:

1. Must meet FE Facility Connection Standards. FE will provide one span of conductor to pull into the connecting substation facility. Additional length to connecting substation to be approved by FE.

2. Where devices are operated by the Connecting party, position indication sent to FE via SCADA.

3. Switches required at connecting party’s expense. Switches under FE control and required to be located in a substation environment. Supplemental interrupting device (eg. vacuum interrupter) may be required. Transmission current path must be maintained to FE standards. SCADA control at connecting party’s option and expense.

4. For connection to circuit of 100 kV or higher, a circuit breaker and breaker failure-to-trip relaying is required.

5. Revenue Metering per Section 12.

6. Must be protected by two independent high-speed protection schemes

7. Line trap required at tap location if the high-speed ground switch option is used in place of transfer trip (if source stations utilizes power line carrier scheme).

8. Line trap required at this location [supersedes location (7)] if transfer trip option is utilized (only one line trap location required).
FIGURE 2 - Loop Load Supply

NOTES:
(1) Must meet FE Facility Connection Standards. FE will provide one span of conductor to pull into the connecting substation facility. Additional length to connecting substation to be approved by FE.
(2) SCADA (Operational Metering) per Section 11.
(3) Revenue Metering per Section 12.
(4) Breaker under FE SCADA control ☐. Breaker failure-to-trip 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.
FIGURE 3 - Tapped Line Generation

**Fiber Optic Communication Channel**
Required between FE and connecting facility

**Intertie Relay**
- Functions
  - Trip 2: Time Delay, 3 or 4
  - Trip 81: Under Freq, 3 or 4
  - Trip 27: Under Volt, 3 or 4
  - Trip 59: Over Volt, 3 or 4
  - Trip 59: Grid Detect, 3 or 4
  - Trip 32: Dir Power, 3 or 4
  - Trip 67: Dir DC
  - Trip 671: Instantaneous

**Transfer Trip Receiver**
Trips 3 or 4

**Transfer Trip Transmitter**
Connecting party Gen. Protection Trips Breaker 4

**Breaker Position Indication**
To SCC (Section 11)

**Notes:**
1. Connecting party responsible for protection of own equipment.
2. Requirement for the protective equipment shown above is to be determined by FE.
3. COMM to SCC (Section 11)
4. Revenue Metering per Section 12
5. DPOM to SCC (MW, MVAR, AMPS, VOLTS)
6. Switches at option of FE (typically required) at connecting party's expense. Supplemental interrupting device (e.g., vacuum interrupter) may be required. SCADA control optional.

**Tapped Line Generation**

**Generator Synchronizing**

**Operational Metering (OM)**

**Revenue Metering (RM)**
(If required)

(Typically 20 MW or less)

**For New Installations**
(Represents a combined load & generation facility)
FIGURE 4 – Intentionally Omitted
FIGURE 5 - Looped Line Generation Energy Export

**Notes:**
1. Connecting party responsible for protection of his own equipment.
2. Requirement for the protective equipment shown above is to be determined by Fe.
3. GPM per Section 12
4. GOM (Section 11)
5. Switchyard SCADA per FE standards
6. DPOM to SCC (MW, MVAR, AMPs, VOLTS)
FIGURE 6 - Bus Connected Multiple Gen. Energy Export

NOTES:

1. CONNECTING PARTY RESPONSIBLE FOR PROTECTION OF HIS OWN EQUIPMENT
2. GCM TO SCC (SECTION 11)
3. GRM REVENUE METERING PER SECTION 12
4. DPOM TO SCC (MW, MVAR, AMPS, VOLTS)
5. TRANSFORMER WINDING CONNECTIONS TO BE DETERMINED BY STUDY

(REPRESENTS A GENERATION FACILITY)
FIGURE 7 - Metering/SCADA Requirements for Tap Connection to a Connecting Party with a Transmission System and Connected Generation

- Breaker Position Indication to SCC (Section 11)
- GOM = Generation Operational Metering and AGC to SCC (Section 11)
- DPOM = Delivery Point SCADA (Operational Metering) to SCC (MW, MVAR, Amps, Volts) per Section 11
- DPRM = Delivery Point Revenue Metering (Section 12)
- GRM = Generation Revenue Metering (if required) per Section 12

NOTES:
1. DPOM required only if backfeed is possible from internal generation or if connecting party’s system also connects to another utility system.
2. This configuration is only for existing delivery points subject to FE approval per Section 11 & 12.
FIGURE 8 - Metering/SCADA Requirements for Loop Connection to a Connecting Party with a Transmission System and Connected Generation

- Breaker Position Indication to SCC (Section 11)
- SCADA Breaker Control and Position Indication to SCC (Section 11)
- GOM = Generation Operational Metering and ASC to SCC (Section 11)
- DPOM = Delivery Point SCADA (Operational Metering) to SCC (MW, MVAR, Amps, Volts) per Section 11
- DPRM = Delivery Point Revenue Metering (Section 12)
- GRM = Generation Revenue Metering (if required) per Section 12

Interconnection to Another Utility System or Continuation of End-User’s Electric System
20. Revisions

20.1 Revision Process

All major and minor revisions of this document are reviewed and approved by the applicable Manager(s) and the Director of ED Transmission Planning and Protection. The revision process is described below:
1) The revisions/clarifications are determined as major or minor by the Director, ED Transmission Planning and Protection.
2) The document changes are maintained by a redline version.
3) The date, type, description, and author of the revision are recorded in the Revision History Table.

20.2 Revision History Table

<table>
<thead>
<tr>
<th>Revision Date</th>
<th>Revision Type</th>
<th>Revision Description</th>
<th>Revision Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-1-13</td>
<td>Major</td>
<td>Section 14.2.1: Reactive Power: added text and chart regarding power factor requirements.</td>
<td>John Syner and Jim Detweiler</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 14.2.6: Connecting Transformer Requirements: added text concerning effectively and not effectively grounded transmission systems.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 14.5: Generation Protection Requirements: added text regarding IEEE 1547.1 testing by third party.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Attachment C: revised text regarding connections to networked and radial transmission system locations.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Revised grammar throughout document.</td>
<td></td>
</tr>
<tr>
<td>6-17-13</td>
<td>Minor</td>
<td>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.</td>
<td>Jim Detweiler</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Revised Figures 1B and 2 regarding ownership.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Revised Figure 6 making revenue metering optional for auxiliary transformer associated with breaker 2.</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Type</td>
<td>Section/Section Name</td>
<td>Date</td>
</tr>
<tr>
<td>--------</td>
<td>--------</td>
<td>-------------------------------------------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>10-03-16</td>
<td>Major</td>
<td>Section 9.3: Revised UFLS to include PJM Manual 36 references.</td>
<td>M Miller</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 10.1: Added reference to NERC PRC-002-2.</td>
<td>G. McDonald</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 11: Miscellaneous updates</td>
<td>J. Janosek</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 11.1: Added detailed accuracy requirements for operational metering and reference to PJM Manual 01.</td>
<td>G. Marchewka</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Removed requirement for RTU access to revenue metering.</td>
<td>M. Miller</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 12.1: Miscellaneous updates.</td>
<td>G. Marchewka</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 12.3.1: Added the POI as the required metering equipment location.</td>
<td>M. Miller</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 12.3.2: Miscellaneous updates.</td>
<td>G. Marchewka</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 12.3.3: Major update.</td>
<td>M. Miller</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 14.2.1 Major update</td>
<td>G. Marchewka</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Section 19: Revised Figures 1A, 1B, 2, and 6. Added Figure 1C.</td>
<td>M. Miller</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Attachment I: Updated to latest version of the Transmission System Protection Practices document.</td>
<td>M. Miller</td>
</tr>
</tbody>
</table>
Attachment A -  
Procedure for Connecting New Substation or Lines to FE Facilities

Please note that 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 (www.pjm.com).

1. A Connecting Party desiring to connect a new substation or line to the FE Transmission System will enter into a Construction Service Agreement and an Interconnection Service Agreement (for a wholesale customer) with FE after the Initial Load Study (ILS) and Detailed Load Study (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 and facility ratings. The Construction Service Agreement and the Interconnection Service Agreement will also specify details of all the protective relay or fuse requirements for the new facility for those portions of the new substation or line which will connect to the FE Transmission System.

2. Following receipt of the signed Construction Service Agreement and an Interconnection Service Agreement (for a wholesale customer), the FE will appoint a project manager to oversee the connection details and act as FE’s representative to insure the connection meets FE’s standards.

3. At the conclusion of the design process, the project manager will supply a functional one-line 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 the project manager. “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 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 will be supplied to the FE protection engineer.

4. Following receipt of the functional one line, an FE provided check-off list will detail those items which will need to be checked or tested prior to final release and energizing of the new facilities. The project manager will supply this list to the Connecting Party and insure 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 will provide 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.

5. FE will require that for 115, 138, 230, 345 or 500 kV connections, the connected equipment and check-off list be inspected and released by FE. For 69 kV and below connections, 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 the check-off list.

6. After being satisfied that the connected facilities have been properly inspected and released, the FE inspection representative will notify the SCC or the FE project manager that it is permissible to energize the new facilities – provided all of the SCC’s other clearance requirements are satisfied. This release of equipment may take the form of release for service or release for test. The SCC will not release its clearance on the new facilities until it receives notification from the FE inspection representative or FE project manager.
## Attachment B - Substation Checkout Guide

**Attachment B**  
**CONNECTING SUBSTATION—EXAMPLE**  
Substation Checkout Guide

<table>
<thead>
<tr>
<th>ITEM</th>
<th>ACTION/INFORMATION</th>
<th>BY</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Substation Ground Resistance (remote earth)</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Safety and equipment grounding</td>
<td>Visual Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Ground grid point-to-point checks</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. FE ID Nameplates for Breakers &amp; Switches</td>
<td>Visual Inspection</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 5. Airbreak and Disconnect Switches  
  a. A-26  
    1. Alignment | Visual Inspection |     |      |
    2. Ductor Ground Mat (where applicable) | Review Test Results |     |      |
  b. D-4  
    1. Alignment | Visual Inspection |     |      |
    2. Ductor Ground Mat (where applicable) | Review Test Results |     |      |
| 6. Circuit Breakers  
  a. B_________ kV Breaker  
    1. Gas filled | Visual Inspection |     |      |
    2. Timing Tests | Review Test Results |     |      |
    3. Ductor | Review Test Results |     |      |
    4. Doble Test | Review Test Results |     |      |
    5. CT Ratios & Polarities | Review Test Results |     |      |
    6. Breaker Alarms | Detailed Inspection |     |      |
| 7. Circuit Switcher  
  a. CS_________ kV Transformer  
    1. Hipot Test | Review Test Results |     |      |
    2. Timing Tests | Review Test Results |     |      |
    3. Ductor | Review Test Results |     |      |
| 8. Fuses  
  a. ______ kV Transformer  
    1. Rating/Type (as specified) | Visual Inspection |     |      |
    2. Air Flow Test | Review Test Results |     |      |
| 9. Power Transformers  
  a. TR# ___ kV ___ MVA  
    1. CT Ratio & Polarity | Review Test Results |     |      |
<table>
<thead>
<tr>
<th>ITEM</th>
<th>ACTION/INFORMATION</th>
<th>BY</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. CCVT/VT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. CCVT/VT_____ kV Line</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Doble Test</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Potential Polarizing Test</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Ratio &amp; Polarity Test</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. CCVT/VT_____ Bus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Doble Test</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Potential Polarizing Test</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Ratio &amp; Polarity Test</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Phasing</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. _____ kV Main Bus</td>
<td>Detailed Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Batteries and Charger</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. DC Battery and Charger</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Battery Acceptance</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Intercell Resistance Test</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Charger Settings</td>
<td>Visual Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Ground Detector</td>
<td>Detailed Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. SCADA</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Function Tested with SCC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Control</td>
<td>Detailed Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Indication</td>
<td>Detailed Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Alarms</td>
<td>Detailed Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Metering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Detailed Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Relay and Control Schemes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. _____ kV Exit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Correct CT/PT Ratios &amp; Settings Applied</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Calibration Test</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Trip Test</td>
<td>Detailed Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. In-Service Load Angles</td>
<td>Detailed Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Remote Relay Communications</td>
<td>Detailed Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. End-to-End Functional Test</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Annunciators and Alarms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Set Undervoltage &amp; Time Delay Relays</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Function Tested</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Potential Transfer Selector Switch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Functional test (make before break)</td>
<td>Review Test Results</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Miscellaneous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Inspect Alignment on Rod Gaps</td>
<td>Visual Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITEM</td>
<td>ACTION/INFORMATION</td>
<td>BY</td>
<td>DATE</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------------</td>
<td>------</td>
<td>--------</td>
</tr>
<tr>
<td>b. Line Arresters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Sized as specified</td>
<td>Visual Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Located as specified</td>
<td>Visual Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Clearances</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. ______ kV---Phase to Ground</td>
<td>Visual Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. ______ kV---Phase to Phase</td>
<td>Visual Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Wave Traps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Sized as specified</td>
<td>Visual Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Located as specified</td>
<td>Visual Inspection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Frequency sweep response of trap to verify tuned frequency as specified</td>
<td>Visual Inspection</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17. After the checkout is completed as needed for substation energization, the protection engineer must be notified before the equipment is released by the field engineer for energization.
Attachment C -

Breaker Ring Bus Decision Process – Generation Connections

Main Concepts for Applying a Breaker Ring Bus

- Where a breaker ring bus is mentioned in this Attachment, a breaker and a half configuration is an acceptable alternative.
- Problem at a generation facility does not impact the FE Transmission System.
- Maintenance of a FE line or substation does not require a generation facility outage.
- Proposed connection does not compromise the protection of the FE Transmission System.

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.

- 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.
- 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.
- 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.
- 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.

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:

- 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.
- 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.
Attachment D -

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

- This Attachment D 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 Studies.

- After applying for connection to the FE Transmission System, the Connecting Party shall consult with the FE Transmission Planning engineer 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 loads (initial and future), 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.

- FE will furnish and maintain the revenue metering equipment for each transmission connected retail or wholesale facility as specified in the electric service tariff or service agreement. The metering equipment furnished and maintained by the 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, enclosures, and conduits necessary for the metering installation. The Connecting Party is responsible for mounting the instrument transformers, conduits, enclosures, and meter socket(s).

- 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.

- If the metering will be connected to a system voltage rated 69 kV or higher, then the Connecting Party shall provide, install, and maintain a padlockable weatherproof enclosure containing a three-pole circuit breaker and a three-pole potential disconnect switch for connection to the voltage transformer secondary wires. The enclosure shall include a 12-point terminal block with 10-32 studs for termination of voltage and/or current transformer secondary wires. See the figure below for device details and general arrangement. The enclosure shall be mounted in a readily accessible location below the instrument transformers and shall be used for FE wiring only. The enclosure shall be secured with a FE-owned padlock. This enclosure may in some cases be required for metering connected to a system voltage rated 23 kV, 25 kV, 34.5 kV or 46 kV.
• Instrument transformers must be readily accessible to authorized FE representatives for secondary wiring installation. Location of transformers shall be such that the heights of transformer bases do not exceed 20 feet above grade.

• Conduit shall be 1-1/2 inch galvanized rigid steel conduit. Flexible galvanized steel (liquid tight) conduit may be used between instrument transformers.

• 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 the FE will permit, by contacting a customer representative who is capable of providing access within a reasonable time period.

• The meter socket(s) shall be installed by the Connecting Party generally within 50 feet of the instrument transformers unless an alternate design has been approved by the FE Meter Services section.

• A meter socket shall be mounted such that the centerline of the meter is approximately five feet above final grade.

• When applicable, the Connecting Party shall provide, at its sole cost and expense, the installation, operation, and maintenance of the required communication link(s) for the FE billing meter data collection system (MV-90). The specifications for the typical telephone communication link are as follows:
  - Standard voice grade (analog) with dial tone. No digital telephone line(s) permitted.
  - Two-pair or four-conductor with RJ-11 / Male termination. FE will make final connection to the meter.
Must be able to receive in-coming calls.
Must be direct line to meter, with no operator interception or operation required.
Install telephone line and associated conduit between telephone company source and meter socket or enclosure.
Telephone line must be tagged with phone number, including area code.
Telephone line must be installed and operational prior to the customer’s service being energized.

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

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.
Attachment E –
FirstEnergy Revenue Metering Requirements for Generation Facilities Connected
69 kV and Higher

This Attachment E addresses the revenue metering requirements for new generation-only facilities connected to FE Transmission System at voltages of 69 kV and higher. This Attachment E is not intended for existing retail or wholesale load facilities where behind-the-meter generation is being installed.

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

The revenue metering equipment shall be located at the Point of Interconnection (POI) 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.

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.

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.

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

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

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

- Facility one line and revenue metering installation drawings (schematics, wiring diagrams, etc.)
- Estimated power flows to and from the facility at the revenue metering point(s)
- Current transformer and voltage transformer specifications, including manufacturer, type, nameplate drawings, and certified accuracy test reports
- Revenue meter specifications including manufacturer, type, model number, and certified accuracy test report
- Revenue meter loss compensation data (if applicable)
- 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)
- Revenue meter telephone number
The Connecting Party shall install the revenue metering equipment such that the revenue meter registers delivered (positive) power when real power is flowing from the generation facility to FE unless otherwise agreed to by FE and the Connecting Party.

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.

The Connecting Party shall provide FE with prior notification of any modifications at the facility that will affect the revenue meter measurements, including substation reconfigurations and meter program changes.
Attachment F -
FirstEnergy Revenue Metering Requirements for Generation Facilities Connected 46 kV and Lower

This Attachment F addresses the revenue metering requirements for new generation-only facilities connected to the FE Transmission System voltages of 46 kV and lower. This Attachment F is not intended for existing retail or wholesale load facilities where behind-the-meter generation is being installed.

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

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

The revenue metering equipment shall be located at the Point of Interconnection (POI) 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.

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.

After completing an engineering review of the proposed generation facility design FE may, in limited cases, determine that it is more appropriate for the Connecting Party to provide, own, operate, test, and maintain the revenue metering equipment at the generation facility. If so, the requirements in Attachment E (FirstEnergy Revenue Metering Requirements for Generation Facilities Connected 69 kV and Higher) shall apply.

The Connecting Party shall provide and install the mounting structures (or enclosures) and conduits necessary for the FE metering installation unless otherwise agreed to by FE. The conduit shall be 1-1/2 inch galvanized rigid steel conduit. Flexible galvanized steel (liquid tight) conduit may be used between instrument transformers. FE will install the wiring in the conduit between the instrument transformers and the meter socket.

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.

The bidirectional revenue meter provided and installed by FE will record billing data in fifteen-minute intervals. When applicable, the Connecting Party shall provide, at its sole cost and expense, the installation, operation, and maintenance of the communication link required by the FE
MV-90 interval data collection system for access to the meter. The specifications for the typical telephone communication link are as follows:

- Standard voice grade analog circuit (or equivalent) with dial tone. No digital telephone lines are permitted.
- Two-pair or four-conductor with RJ-11 / Male termination. FE will make final connection to the meter.
- Must be able to receive incoming calls.
- Must be a direct line to the meter with no operator interception or operation required.
- Install the telephone circuit and associated conduit between the telephone company source and the meter socket or enclosure.
- The telephone circuit must be tagged with a phone number, including the area code.
- The telephone circuit must be installed and operational prior to the Connecting Party’s service being energized.

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.

FE will provide the Connecting Party access to bidirectional kWh and kVARh pulses from the FE revenue meter at the Connecting Party’s expense if requested.

The Connecting Party shall provide FE with prior notification of any modifications at the facility that could affect the FE revenue meter measurements (substation reconfigurations, generator additions, etc).
FirstEnergy Revenue Metering Requirements for Behind-The-Meter Generation Facilities Participating in the PJM Energy or Capacity Market

This Attachment G addresses the revenue metering requirements for retail or wholesale load facilities with behind-the-meter generation that will participate in the PJM energy or capacity market.

The revenue metering requirements will be reviewed by FE on a case-by-case basis.

In general, FE shall continue to own, operate, test, and maintain the revenue metering equipment at the retail or wholesale load facility’s existing Point of Interconnection (POI) per the applicable retail tariff or wholesale load Interconnection Agreement.

The Connecting Party must provide FE with a facility one line and the estimated bidirectional power flow at the existing FE metering point.

The existing FE revenue meter at the POI will be replaced with a bidirectional revenue meter if the existing meter is not capable of bidirectional operation. The FE metering current transformers will be replaced with higher capacity units if required. This work will generally be completed at the Connecting Party’s expense.

The bidirectional revenue meter provided and installed by FE at the existing POI will record billing data in fifteen-minute intervals. If applicable, the Connecting Party shall continue to provide, at its sole cost and expense, the communication link required by the FE MV-90 interval data collection system for access to the meter.

The Connecting Party shall, at its expense, install, own, operate, test, and maintain any additional metering and telemetry equipment at the facility that may be required by PJM or FE.

FE will provide the Connecting Party with access to bidirectional kWh and kVARh pulses from the FE revenue meter at the Connecting Party’s expense if requested.

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

Revenue Metering Requirements for Existing Non-Utility Generator Facilities That Are Ending Power Purchase Agreements with FirstEnergy

This Attachment H addresses the revenue metering requirements for existing non-utility generator (NUG) facilities that are ending power purchase agreements with FE and will sell their power in the PJM energy or capacity market.

FE will generally continue to own, operate, test, and maintain the existing FE revenue metering equipment at the Connecting Party’s expense if the metering is located at or adjacent to the existing NUG facility. In this case the FE revenue meter’s real-time kWh and kVARh data will be made available to the Connecting Party for submittal to PJM.

If the existing FE revenue metering equipment is located in a remote FE facility rather than at or adjacent to the NUG facility the Connecting Party will generally be required to provide, own, operate, test, and maintain a new revenue metering point at the Connecting Party’s facility. Any of the special communications equipment required for the Connecting Party to obtain real-time kWh and kVARh data from the FE revenue meter over the significant distance between the facilities will not be provided or supported by FE.

The requirements in Attachment E (FirstEnergy Revenue Metering Requirements for Generation Facilities Connected 69 kV and Higher) shall apply if the Connecting Party is to provide, own, operate, test, and maintain the revenue metering equipment at the Connecting Party’s facility for the aforementioned reason. In this case the Connecting Party’s revenue metering will functionally replace the existing revenue metering at the FE facility.

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

Any real-time metering and SCADA communications equipment provided, installed, and maintained by FE at the NUG facility under a previous agreement will in general no longer be maintained or supported by FE. This equipment may be retired in place or removed if necessary.

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

10.1 Protective Coordination with Transmission Line Protection

10.1.1 Power Transformers Connected to a Radial Transmission Line

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.

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

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.

When one end of a looped transmission line is operated normally open, then the protective coordination requirements of Section 10.1.1 apply. These requirements shall apply to both terminals of the transmission line taken individually.
10.1.3 Power Transformers Tapped to a Looped Transmission Line with Pilot Relay Protection

10.1.3.1 Stations with High-Side Circuit Breakers/Switchers

(Note that for facilities connected at 100kV or above, circuit breakers are required. Circuit switchers may only be used for facilities less than 100kV). 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.

10.1.3.2 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. Energy Delivery Planning and Protection Department will determine when tapping a fused transformer to a transmission line with pilot protection is permissible.

10.2 High-Side Power Fuses (less than 100kV)

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

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

10.2.2 Fuse Interrupting Capability
The power fuse must have adequate fault interrupting capability at the point of application.

10.2.3 Fuse Coordination
The power fuse must coordinate with the transmission protective devices as described in Section 10.1.

10.3 Protective Relays and Fully Rated Interrupting Devices
When the criteria of Section 10.2 cannot be met, a fully rated high-side interrupting device and protective relay schemes consistent with Section 10.1 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 CT’s shall be used for the primary differential and the backup overcurrent relays. 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. See Figure 10.1 if a high-side breaker is used or Figure 10.2 if a circuit switcher is used.

10.3.1 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 100kV) 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.

10.3.1.1 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.

10.3.1.2 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.

10.3.1.3 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 10.3.3)
- Block operation of transformer cooling fans and pumps
- Alarm to SCADA

10.3.2 Transformer Backup Protection (50/51, 50N/5IN, 51G)

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 ANSI/IEEE C57.109, IEEE Guide for Transformer Through-Fault Current Duration.
10.3.2.1 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 10.3.2.

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 ANSI/IEEE C57.109, IEEE Guide for 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 3 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.

10.3.2.2 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 100kV), 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 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.
10.3.2.3 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 10.3.3
- Alarm to SCADA

10.3.3 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 100kV
up to 230kV, a breaker failure to trip scheme (See Section 5.0) must be installed. Direct
transfer trip (See 14.0) to initiate remote tripping and a motor-operated disconnect switch
locally is the required method at 230kV and the preferred method below 230kV of
implementing the breaker failure to trip protection. If 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.

10.4 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 Energy Delivery Planning and Protection.
Figure 10.1 Minimum Required Dist Transformer Protection Using Circuit Breaker
Figure 10.2 Minimum Required Dist Transformer Protection Using Circuit Switcher