Virginia Electric and Power Company - (DP, TO)
Electric Transmission
(d.b.a. Dominion Energy Virginia)

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</tbody>
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Level 1 - Public Information
TABLE OF CONTENTS

1. PURPOSE AND INTRODUCTION PER NERC FAC-001 R1..........................................................4
   1.1. Generation facilities ..............................................................................................................4
   1.2. Transmission facilities .......................................................................................................4
   1.3. End-user facilities ..............................................................................................................4

2. FAC-001 R2..............................................................................................................................4

3. INTERCONNECTION REQUIREMENTS PER NERC FAC-001 R3.........................................5
   3.1. Procedures for coordinated studies of new or materially modified existing interconnections and their impacts on affected system(s) (FAC-001-2 R3.1) .................................................................6
   3.2. Procedures for notifying those responsible for the reliability of affected system(s) of new or materially modified existing interconnections (FAC-001-2 R3.2) .................................................................8
   3.3. Procedures for confirming with those responsible for the reliability of affected systems of new or materially modified transmission Facilities are within a Balancing Authority Area’s metered boundaries ....9
   3.4. Additional items per FAC-001 Application Guidelines and Technical Basis .........................9
       3.4.1. Procedures for requesting a new Facility interconnection or material modification to an existing interconnection .......................................................... 9
       3.4.2. Data required to properly study the interconnection ...................................................... 9
       3.4.3. Voltage level and MW and MVAR capacity or demand at point of interconnection ......... 9
       3.4.4. Breaker duty and surge protection .............................................................................. 9
       3.4.5. System protection and coordination .......................................................................... 10
       3.4.6. Metering and telecommunications ............................................................................ 12
       3.4.7. Grounding and safety issues .................................................................................... 19
       3.4.8. Insulation and insulation coordination ..................................................................... 21
       3.4.9. Voltage, Reactive Power, and power factor control ................................................... 22
       3.4.10. Power quality impacts ............................................................................................. 23
       3.4.11. Equipment Ratings .................................................................................................. 24
       3.4.12. Synchronizing of facilities ...................................................................................... 25
       3.4.13. Maintenance coordination ....................................................................................... 27
       3.4.14. Operational issues (abnormal frequency and voltages) ........................................... 28
       3.4.15. Inspection requirements for new or materially modified existing interconnections .... 28
       3.4.16. Communications and procedures during normal and emergency operating conditions ... 29

4. FAC-001 R4...........................................................................................................................30

5. TRANSMISSION LINE CONNECTIONS – GENERATION .....................................................30
   5.1. Single circuit interconnections to a transmission line ..........................................................31
   5.2. Transmission interconnections located remote from a transmission line .............................32
   5.3. Interconnection to radial transmission line or radial transmission tap ..................................34
       5.3.1. Connection to radial transmission lines .................................................................. 34
       5.3.2. Interconnection to radial transmission tap ............................................................... 35
   5.4. Substation interconnection requirements .............................................................................36
   5.5. Transmission interconnection breakers ..............................................................................36
   5.6. Generation interconnection breakers ..................................................................................37
   5.7. Interconnection Requirements for Distribution Connected Generation ..............................38
6. LOAD CRITERIA – END USER

6.1. Tapping line for loads below 100 MW

6.2. Tapping lines for loads 100 MW and greater

6.3. Prohibited arrangements and allowable alternatives

6.4. Tapping Company’s bus

7. APPLICABILITY

8. DEFINITIONS

8.1. Definitions

8.2. Abbreviations

9. REVISION HISTORY

EXHIBIT A - Dominion Energy – Electric Transmission Planning Criteria
EXHIBIT B - Customer Request Form
EXHIBIT C - Dominion Energy Electric Transmission Generator Interconnection Protection Requirements
1. PURPOSE AND INTRODUCTION PER NERC FAC-001 R1

This Virginia Electric and Power Company Facility Interconnection Requirements (FIR) document is publically available on the company’s web site “www.dominionenergy.com” to provide guidance to Interconnection Customers seeking to connect to its Transmission System. It also serves as evidence that Virginia Electric and Power Company documents facility interconnection requirements, updates them as needed, and makes them available upon request, as required by NERC Reliability Standard FAC-001.

Virginia Electric and Power Company is commonly referred to as Dominion Energy Virginia (DEV) within Virginia and North Carolina. Virginia Electric and Power Company is referred to in this document as “Dominion Energy” or “Company”.

1.1. Generation facilities

This document complies with FAC-001 1.1 by addressing interconnection requirements for generation facilities for each subrequirement of FAC-001 R3. (See Section 3 below for additional explanation)

1.2. Transmission facilities

This document complies with FAC-001 1.2 by addressing interconnection requirements for transmission facilities for each subrequirement of FAC-001 R3. (See Section 3 below for additional explanation)

1.3. End-user facilities

This document complies with FAC-001 1.3 by addressing interconnection requirements for end-user facilities for each subrequirement of FAC-001 R3. (See Section 3 below for additional explanation)

The provisions of this document apply to Interconnection Customers seeking to connect to Dominion Energy’s Transmission System, except as may be otherwise provided for in applicable tariffs or agreements, or as may be otherwise agreed by Dominion Energy and the Interconnection Customer.

Document structure. To simplify compliance reviews, this document is structured to align with the numbering scheme of NERC Reliability Standard FAC-001.

2. FAC-001 R2

FAC-001 R2 applies only to Generator Owner registration.
3. INTERCONNECTION REQUIREMENTS PER NERC FAC-001 R3

Dominion Energy has prepared this document for the purpose of complying with NERC’s Reliability Standards, specifically standard FAC-001. It has been written to individually address the interconnection requirements of generation, transmission, and electricity end-user facilities. These facility interconnection requirements shall be adhered to by any requesting Interconnection Customer who wishes to establish a connection to the Company’s transmission facilities. The Company will also adhere to these same requirements as it constructs additions to its Transmission System. These requirements should be evaluated as a whole when determining the actions necessary to develop a complete interconnection request.

Transmission connections covered by this document include all generation resources, ties with transmission facilities owned by others, and Interconnection Customer substations at voltages of 69 kV or greater. It is not practical to include the particular requirements applicable to every possible transmission connection scenario since each connection is specific to the party requesting the connection and the Transmission System at the point of customer connection. There are several factors to be considered when connecting the Company’s Transmission System to (1) another transmission system, (2) new or additional generation, and (3) new or additional customer load. The evaluation of these factors requires a power system analysis of the transmission network as described in Exhibit A – Dominion Energy Electric Transmission Planning Criteria.

The standards in this document apply to new facilities and to modification of existing facilities. The standards in effect at the time a facility was constructed or modified shall continue to apply to such facility until it is subsequently modified, or until Dominion Energy or PJM determine the facility must be upgraded to the current standard to avoid unacceptable risk to the reliability or operation of the Transmission System, or to the safety of workers or the public.

Typical connections are provided in Exhibit A – Dominion Energy Electric Transmission Planning Criteria.

This section identifies the requirements and subrequirements of NERC Reliability Standard FAC-001 R3, along with additional information per the standard’s associated Application Guidelines. Unless otherwise noted, details under each topic in this section apply globally to generation facilities, transmission facilities, and end-user facilities. For topics warranting additional, specific requirements regarding generation facilities, transmission facilities, and/or end-user facilities, an associated sub header is clearly provided for the reader.
3.1. Procedures for coordinated studies of new or materially modified existing interconnections and their impacts on affected system(s) (FAC-001-2 R3.1)

Utility Interconnections

One of the roles of the Dominion Energy’s Electric Transmission Planning group is to perform planning studies to ensure delivery of bulk power to a continuously changing customer demand under a wide variety of operating conditions.

Should Dominion Energy receive an interconnection request that may impact a neighboring interconnected transmission system, Dominion Energy will initiate contact with that neighboring system for the purpose of coordinating those joint interconnection studies required to assess the impact of the interconnection request on the transmission systems of all affected parties.

Studies are performed in coordination with Dominion Energy’s Regional Transmission Organization (PJM Interconnection, L.L.C.), and in accordance with NERC Reliability Standards, which promote and maintain the reliability and security of the interconnected bulk power system.

In order to fulfill this role, Dominion Energy has entered into various Inter-Area Reliability Agreements with neighboring utilities. The major purpose of these agreements is to further augment reliability and security of each member’s bulk power supply system through coordination of planning and operation of their generation and bulk power transmission facilities. The following is a list of groups with which Dominion Energy engages in joint transmission interconnection activities:

- SERC East-RFC (SER) Studies under the Eastern Interconnection Reliability Assessment Group (ERAG) Agreement
- SERC Intra-Regional Near-Term Studies
- SERC Intra-Regional Long-Term Studies
- ERAG – MMWG (Multi-Regional Modeling Working Group)

Each of these groups has various Working Groups, Study Groups, Committees, Task Forces etc. that deal with various aspects of power system reliability and security issues. Various studies performed by these groups at the interconnection level include; power flows, stability, transfer capabilities, voltage collapse scenarios, tie-line re-closing angles, etc. The basic purpose of these studies is to measure the ability of the transmission network to reliably transfer power in bulk amount from one area to another under the most limiting contingency assumptions that are judged to be credible. These studies can be used in identifying any deficiencies and the needed corrective actions, either through short term operating procedures or by future system upgrades. Transmission interconnections are planned such that the amount of power that can be transferred between and among the utilities, in addition to firm transactions, will be adequate to withstand the most severe credible generation and transmission contingency.

Wholesale Delivery Points

Dominion Energy provides transmission service to wholesale delivery points throughout its service area under Mutual Operating Agreement(s) (MOA). The criteria for serving wholesale Interconnection Customers is the same as that used to serve Dominion Energy’s other customers and is predicated on “Good Utility Practice” and sound engineering and economic principles without regard for the ownership of the facilities.

Regardless of the generation source of supply to wholesale customers in the company’s service area, all supplies are delivered over the company’s transmission facilities. Therefore, it is essential that
wholesale Interconnection Customer load requirements be included in the company’s planning process.

The following criteria apply to all joint planning between Dominion Energy and its wholesale Interconnection Customers:

- Contractual obligations must be observed.
- Studies must be based on sound engineering and economic principles consistent with long range system plans.
- All applicable sections of the Dominion Energy Electric Transmission Planning Criteria as stated in Exhibit A of this document shall apply to the connection of any wholesale Interconnection Customer to the Dominion Energy’s Transmission System.

Joint planning should be conducted periodically with each wholesale Interconnection Customer. This joint plan includes a review of each company’s construction program based on annually updated load forecasts for the general area. The procedure should be similar to the following:

- Load forecasts for each year up to ten years will be prepared by the wholesale Interconnection Customer for their area and by the company for the general area around the Interconnection Customer.
- Special emphasis should be given to identify high load growth areas.
- Existing distributed generation output for both conventional and alternative (solar, wind, etc.) sources, indicating the maximum output of each unit/site, and the output of each unit/site that is coincidental to the summer and winter peak day and time for the Dominion Energy zone.
- The Interconnection Customer and the company will each prepare preliminary studies of their respective systems for meeting the future load requirements identified by the forecasts.
- The Interconnection Customer and the company will exchange study information and, based on joint analysis, prepare a long-range plan.

There will be instances where deviations from the long-range joint planning process will be necessary to accommodate third party delivery point requests. In these cases, the Dominion Energy’s Electric Transmission Planning Department and, as needed, entities interconnected with Dominion Energy’s transmission facilities, will expedite review of appropriate elements of the long-range plan in order to address such projects.

All delivery point requests should include a completed “Customer Request Form” as shown in Exhibit B.
3.2. Procedures for notifying those responsible for the reliability of affected system(s) of new or materially modified existing interconnections (FAC-001-2 R3.2)

The Interconnection Customer shall notify Dominion Energy of planned additions of new facilities, or modifications to existing electrical facilities which have the potential to impact the reliability of the interconnected transmission systems. Interconnection Customers shall provide such notification as soon as it is feasible for them to do so, even if the information is in a preliminary form. Prompt notification is important so that Dominion Energy can begin any needed coordination with other entities responsible for the reliability of interconnected transmission systems. The “Customer Request Form” as shown in “Exhibit B” shall be completed for initial requests as well as subsequent changes.

The form shall be submitted with sufficient advance notice to allow Dominion Energy to:

- review the proposed addition or modification,
- conduct the necessary studies to assess the impact of the change on Dominion Energy’s Transmission System and/or neighboring facility owners,
- respond to the requesting facility owner, and
- complete any necessary modifications to Dominion Energy facilities including ownership demarcation of equipment and/or Protection System(s) elements.

Subsequent changes to the approved design basis are interpreted to include, but are not limited to:

- changes to electrical equipment ratings
- changes to primary conductor(s) or connectors
- changes to transformer tap settings
- changes impacting Protection Systems such as:
  - significant source impedance changes at the interconnection point
    - modifications to Protection System communications equipment
    - modifications to Protection System relay settings
    - changes to breaker reclosing times
- Interconnection of new generating facilities, including distribution connected generation

As modifications are determined to impact other parties, such as power generators, end users, and interconnect parties, Dominion Energy will make appropriate notifications and pursue mutually agreeable resolutions as necessary.
3.3. Procedures for confirming with those responsible for the reliability of affected systems of new or materially modified transmission Facilities are within a Balancing Authority Area’s metered boundaries

PJM Compliance Bulletin CB028 NERC Standard FAC-001-3 – Facilities within the metered boundaries of a Balancing Authority states the following:

“…it is PJM’s opinion that the presence of any one of PJM’s New Service Agreements (ISA, UCSA) is affirmative evidence of compliance of adherence to NERC Standard FAC-001-3. A PJM issued ISA/UCSA is FERC approved evidence that can be used by each Interconnection Customer as confirmation that their new or materially modified facilities are within the PJM Balancing Authority Area’s metered boundaries.”

3.4. Additional items per FAC-001 Application Guidelines and Technical Basis

3.4.1. Procedures for requesting a new Facility interconnection or material modification to an existing interconnection

To install, modify, or remove Dominion Energy Facilities, or to modify the capacity or characteristics required at a Delivery Point, or to discontinue the delivery of electricity to a Delivery Point, Customer shall initiate requests in writing using the Request/Notification for Changes Impacting Dominion Energy Facilities form included in this document. Customer shall also submit a Request Form when making changes to Customer’s Facilities that are reasonably anticipated to (i) lead to a modification to Dominion Energy’s Facilities or (ii) impact the operation of Dominion Energy’s Facilities. See Exhibit B - Request/Notification For Changes Impacting Dominion Energy’s Facilities.

3.4.2. Data required to properly study the interconnection

The Request Form shall be submitted by Customer as soon as useful information is available. As additional or updated information becomes available, Customer shall make timely submission of a revised Request Form. For Request Forms submitted with notations of “(E)” or “TBD by [date]” as described below, Dominion Energy and Customer shall determine a schedule for the provision of complete and final information. See Exhibit B - Request/Notification For Changes Impacting Dominion Energy’s Facilities, pages B-3 thru B-5.

3.4.3. Voltage level and MW and MVAR capacity or demand at point of interconnection

Except as may be otherwise provided for in applicable tariffs or agreements, or as may be otherwise agreed by Dominion Energy and the Interconnection Customer, the Interconnection Customer should use the Customer Request Form shown in Exhibit B to provide Dominion Energy with the necessary information regarding the voltage level and MW and MVAR capacity or demand at point of connection. Since voltage and interconnection points are site-and project-specific, Dominion Energy will perform studies and exercise engineering judgment to determine appropriate voltage levels, interconnection points, and system capabilities.

3.4.4. Breaker duty and surge protection

Electrical circuit breakers shall be designed to meet or exceed the expected load and short circuit currents on the Interconnection Customer’s transmission system. High voltage circuit
breakers and other current interrupting devices shall be designed to clear (interrupt) the worst case short circuit fault calculated for the protection zone as determined using fault analysis engineering programs.

All current carrying equipment and devices shall be designed to carry the maximum loads that are predicted by load flow analysis. Loads exceeding "nameplate" or "normal" design capacities are only acceptable when allowed by manufacturers design documentation or standard industry practices.

Circuit breakers shall be designed and tested according to the latest IEEE C37 collection of standards.

Shielding, and surge protective devices shall meet the requirements as determined by lightning and switching surge analysis, and the latest IEEE C62 standards.

Basic Impulse Levels (BIL) for electrical equipment and high voltage substation buses shall meet or exceed Dominion Energy’s standard values listed below.

<table>
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<th>Nominal KV (phase to phase)</th>
<th>Basic Impulse Level (BIL)</th>
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<tr>
<td>115</td>
<td>550</td>
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<tr>
<td>138</td>
<td>650</td>
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<tr>
<td>230</td>
<td>900</td>
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<td>500</td>
<td>1550</td>
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The Interconnection Customer must meet the following design requirements described in NERC Reliability Standard FAC-001 and its SERC Guideline:

- Each party is responsible for designing equipment to meet the short circuit capabilities on their facilities.
- Each party is responsible for the ratings of their own interrupting devices. It is the responsibility of the Interconnection Customer to coordinate their relays and devices with Dominion Energy’s Transmission System.
- Parties shall provide existing and future fault current levels when requested.
- It is the responsibility of the Interconnection Customer to notify Dominion Energy of any changes in their facilities that may cause an increase in fault currents (generator and transmission Interconnection Customers).

3.4.5. System protection and coordination

The Interconnection Customer is responsible for providing a properly designed and tested Protection System that will safeguard the general public, protect its equipment against disturbances on Dominion Energy’s system, and minimize the effects of disturbances from its facilities on Dominion Energy’s equipment and Transmission System. Protection Systems installed by the Interconnection Customer are expected to follow the latest IEEE C37 and C57 guides and standards for protective relaying systems and adhere to all NERC and PJM
standards related to system protection. The Interconnection Customer’s Protection System shall coordinate with the interconnected Protection System owned by Dominion Energy. NERC Reliability Standards, operating voltage and proximity to a generating unit will be major considerations for establishing the required protection scheme on a transmission line that connects to Dominion Energy’s transmission grid. For more information on generator interconnection, see Exhibit C – Dominion Energy Electric Transmission Generator Interconnection Protection Requirements.

Prior to the development of the Protection System, the Interconnection Customer should complete all appropriate studies, including, but not limited to, grounding studies, short circuit studies, stability studies, and power quality studies. These studies should be completed using Good Utility Practice and the results made available to Dominion Energy upon request.

In addition, Dominion Energy performs studies on existing Protection Systems which may require changes to the Interconnection Customer’s Protection System. In such cases, those customers will be notified and consulted regarding the changes required to ensure the reliable operation of Dominion Energy’s transmission facilities.

**Protection System Design**

The Interconnection Customer shall design the Protection System to minimize the effects of disturbances from its facilities affecting Dominion Energy's interconnected Transmission System or customers. The Protection System shall: be adequately sensitive to detect all faults and abnormal conditions, provide coordination between protection zones, and operate quickly in order to achieve Transmission System reliability. In some cases, Dominion Energy may require the Interconnection Customer to install additional equipment as necessary to address issues such as, but not limited to: relay overreach, transformer penetration, weak source, source impedance ratio (SIR), anti-islanding, and power quality. Dominion Energy shall own and maintain transmission Protection System elements necessary to protect the transmission portion of the interconnection; however, Dominion Energy is not responsible for protection of the Interconnection Customer’s equipment and other electrical assets.

The Protection System shall protect against or minimize the effects of abnormal conditions including, but not limited to, over/under-voltage, over/under-frequency, harmonics, overload, short circuits, open circuits, phase imbalance, switching surges, lightning surges, and other harmful electrical conditions. Utility grade protective relays and fault clearing systems are to be provided on the interconnected power system. All protective relays shall meet or exceed ANSI/IEEE Standard C37.90. Mechanical and electrical logic, interlocking mechanisms, and operational data may be required between interconnected facilities to ensure safe and reliable operation. Examples of mechanical and electrical logic, interlocking mechanisms, and operation data include, but are not limited to, breaker and switch auxiliary contacts, synch-check relays, physical locking devices, solar irradiance, and inverter operating modes or setpoints.

The following defines Dominion Energy’s protection requirements for protecting transmission elements connecting to Dominion Energy’s transmission grid.

**Dual Primary Phase and Ground Protection Systems**

Protection Systems classified as Dual Primary are required for all transmission elements connecting to Dominion Energy’s transmission grid. This scheme will require two independent high-speed, phase and ground fault Protection Systems designated System 1
and System 2. Together these systems provide a redundant set of all normal primary and backup functions.

**Breaker Failure Protection**

A breaker failure function is required for all interrupting devices of transmission elements connecting to a Dominion Energy transmission bus as defined by the protection scheme. For Generation Interconnections, there are additional requirements as outlined in Exhibit C-Electric Transmission Generator Interconnection Protection Requirements (Section 3 Interconnection Protection Requirements).

**Protection System Components**

The Interconnection Customer’s Protection System, including the protective relays, associated communication systems, voltage and current sensing devices, station batteries and DC control circuitry, must be compatible with Dominion Energy’s standard design for common equipment and/or common zones of protection. Compatibility includes protection application, redundancy, operating speed, communication type, and communication medium.

The Protection System must be powered by a DC battery for reliability. The battery shall be sized to power continuous loads for a minimum of 8 hours and power all momentary tripping loads without a charger available. The battery sizing calculation shall be in accordance with IEEE 485. A DC under-voltage alarm must be provided for remote monitoring by the facilities owner, who shall take immediate action to restore power to the protective equipment.

**Protection System Misoperations**

The interconnection customer shall investigate all Protection System operations and misoperations, affecting the interconnected facility and will provide Dominion Energy with the findings of the investigations upon request. Likewise, Dominion Energy will cooperate with the Interconnection Customer and will provide any necessary findings related to Protection System operations and misoperations directly affecting the interconnected facility subject to code of conduct restrictions.

### 3.4.6. Metering and telecommunications

**Metering**

Dominion Energy approved revenue metering equipment shall be installed for energy accounting and billing purposes. Except as may be otherwise provided for in applicable tariffs or agreements, or as may be otherwise agreed by Dominion Energy and the Interconnection Customer, the Interconnection Customer shall install, own, operate and maintain all revenue metering equipment as set forth below.

Interconnection Customers that will be a PJM market participant shall install metering that shall be of sufficient quality to meet the applicable requirements as defined in PJM Manuals 14A – Generation and Transmission Interconnection Process, 14C – Generation and Transmission Interconnection Facility Construction, 14D – Generator Operational Requirements, and 01 – Control Center and Data Exchange Requirements. Additional requirements may be applicable on a case-by-case basis.
Facility Interconnection Requirements

**NERC Standard/Requirement: FAC-001 (R1, R3)**

**NERC ID:** NCR01214  **REVISION #:** 16.0  **EFFECTIVE DATE:** 03/15/2019  **Page 13 of 53**

Revenue metering equipment includes, but is not limited to, current transformers, voltage transformers, revenue meters, meter sockets, test switches, communication circuits and associated devices. The revenue metering equipment shall be located at the Interconnection Customer’s facility unless otherwise agreed to by Dominion Energy, PJM, and the Interconnection Customer (referred to collectively in this section as the “Parties”). The revenue metering equipment shall meet or exceed all applicable industry standards (e.g., NERC, PJM, 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 unless otherwise agreed to by the Parties. The revenue metering installation shall meet all applicable industry standards for phase-to-phase and phase-to-ground electrical clearances.

Dominion Energy will provide the Interconnection Customer with manufacturer’s installation information for the current and voltage transformers when these devices will be furnished by Dominion Energy and installed by the Interconnection Customer.

### Revenue Meters

The revenue meters shall be capable of recording, storing, and transmitting bidirectional megawatt-hour (MWh) data and megavar-hour (MVARh) data. However, if required by the applicable tariffs, or if mutually agreed by the Parties, the revenue meters shall instead record bi-directional kilowatt-hour (kWh) data and kilovar-hour (kVARh) data. In general, this data shall be recorded in hourly intervals unless other interval lengths are required by the applicable tariffs or agreed upon by the Parties.

The revenue meters shall have an accuracy class of 0.2% standards as defined in ANSI C12.20. In addition, the revenue meter should meet ANSI C12.1 and C12.10 standards. Testing of meters in service may be requested by Dominion Energy, any regulatory agency having jurisdiction over the interconnection, or any other lawfully constituted authority having jurisdiction over meter accuracy.

### Revenue Metering Current Transformers

The revenue meters shall be connected to current transformers (CTs) having a minimum metering accuracy class of 0.15% (as defined in IEEE C57.13) at a minimum burden designation of B-1.8 from 1% of nameplate to rating factor. CTs with standard accuracy and/or lower burden designations may be allowed by Dominion Energy in special cases, but the secondary burden on the CTs must not exceed the nameplate burden rating. In addition, the CTs should meet the ANSI C12.11 standard. 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 mechanical and short time thermal limits 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 Interconnection Customer may be required to provide extended range CTs or additional metering equipment at their own expense.

### 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) with a minimum burden on the VTs or CCVTs that exceeds the circuit burden. In addition, the VTs and CCVTs should meet the ANSI C12.11 standard.

**Level 1 - Public Information**
The revenue meters shall be connected to dedicated metering VT or CCVT secondary circuits and should not share the same circuits with relays or other devices; however, if the VTs or CCVTs have separate secondary windings used for relays or other devices, the revenue meters may be connected to dedicated secondary windings of such VTs or CCVTs. VTs are preferred for revenue metering. The use of CCVTs for revenue metering shall be limited to facilities connecting to Dominion Energy system voltages 115 kV and higher or where Dominion Energy has determined it is impractical to use VTs for technical reasons.

Revenue Metering Data Communications

The Interconnection Customer shall, at its own expense, install, operate, test, and maintain any communications equipment required by Dominion Energy to remotely retrieve revenue metering data from the Interconnection Customer’s facility on a real-time or periodic basis as specified in the sections below for wholesale generation facilities, transmission facilities, and end user facilities. The communication capability of remote interrogation of the revenue data should be compatible with commonly used billing data systems such as MV-90 and Primestone. The Interconnection Customer shall also be responsible for any high voltage isolation equipment that the local telecommunications company may require at the Interconnection Customer's facility to protect their communications systems from damaging transient voltages that can occur in electrical substations and generation facilities.

Dominion Energy will provide the Interconnection Customer access to bi-directional kWh and kVARh pulses from the Dominion Energy revenue meters installed at Interconnection Customer facilities. The pulses, which will be provided upon request, shall be used as the source of the revenue metering data where applicable. Alternatively, kWh and kVARh register accumulator data may be provided by other means, e.g. DNP, MODBUS or similar protocol, to the Interconnection Customer facilities, in lieu of, or in addition to, analog kWh and kVARh pulses, if such arrangements are agreed upon by both Parties.

Operational Metering Data from Revenue Meters

Operational metering data (e.g., MW and MVAR) is generally not available from Dominion Energy revenue meters that are provided by Dominion Energy at Interconnection Customer facilities. Except as may be otherwise provided for in applicable tariffs or agreements, or may be otherwise agreed by Dominion Energy and the Interconnection Customer, the Interconnection Customer shall, at its own expense, install, operate, test, and maintain any metering and communications equipment necessary to provide operational metering data required from the Interconnection Customer's facility by one or more of the Parties.

Revenue meters shall be capable of communicating with data acquisition system (“DAS”) equipment such as Remote Terminal Unit (“RTU”) to provide the following real-time bi-directional power and energy data for operational purposes:

- instantaneous power flows
- per phase and three-phase averaged Root-Mean-Squared (“RMS”) voltages
- per phase and three-phase averaged RMS currents with at least two decimal points

A continuous accumulating record of active and reactive energy flows shall be provided by means of the registers on the meters. The revenue meter(s) shall be capable of providing bi-
directional energy data flow in either kyz pulse signals format, or accumulated counters to RTU. Energy data flow accumulator counters may also include register accumulator data delivered to RTU via DNP, MODBUS or similar protocol. All Parties shall share the same data register buffers regardless of the types of employed data communication methods. If the accumulation counter method is used, the owner of the meter shall be responsible for freezing the accumulator buffers and no other Party shall freeze them. The accumulator freezing signals shall be synchronized to Universal Time Coordination ("UTC") within 1/2 seconds.

The revenue meters' internal clocks and real-time DAS equipment shall be synchronized with Universal Time Coordination ("UTC") with 15 seconds resolution.

Revenue Metering Access, Security, and Testing

Where Dominion Energy provides revenue metering equipment, the Interconnection Customer shall grant Dominion Energy employees and authorized agents' access to the equipment at all reasonable hours and for any reasonable purpose. Regardless of meter ownership, the Interconnection Customer 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.

The revenue metering shall be tested for accuracy as specified by the applicable interconnection service agreement, PJM requirements or regulatory commission regulations by the owner of the metering equipment.

Wholesale Generation Facilities

For the interconnection facilities of Wholesale Generators, except as may be otherwise provided for in applicable tariffs or agreements, or as may be otherwise agreed by Dominion Energy and the Interconnection Customer, the revenue metering equipment shall be located at the Interconnection Customer's facility. The revenue metering shall be compensated for losses to the Point of Interconnection (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 Interconnection Customer's generator step-up transformer(s) or facility main step-up transformer and/or station service power transformers.

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

Dominion Energy Revenue Metering Requirements for Generation Facilities Connected 69 kV and Higher:

The Interconnection Customer shall install, own, operate, test, and maintain the revenue metering equipment at the Interconnection Customer’s expense. A redundant revenue meter and real-time Supervisory Control and Data Acquisition (SCADA) data is also required. The SCADA data consists of analog MW and MVAR at all generation, load, and transmission line terminals; analog kV at all buses 69 kV and greater; circuit breaker open/close status for all breakers; other device status points (for example, automatic reclosing on/off). It is preferred that the redundant meter have a different method of
telecommunications than the primary meter. Dominion Energy will provide revenue metering for station service power supply at a generation facility if the supply is from the Dominion Energy distribution system.

**Dominion Energy Revenue Metering Requirements for Generation Facilities Connected Below 69 kV:**

Dominion Energy shall install own, operate, test and maintain the revenue metering at the Interconnection Customer’s expense. A redundant revenue meter is also required. It is preferred that the redundant meter have a different method of telecommunications than the primary meter.

**Dominion Energy Revenue Metering Requirements for Behind-The-Meter Generation Facilities Participating in the PJM or Wholesale Energy Markets:**

Dominion Energy shall own, operate, test, and maintain the revenue metering equipment at the POI, except as otherwise specified by the applicable retail tariff or interconnection service agreement. The physical arrangements of such facilities are often complex. As such, Dominion Energy will make a case-specific review of each installation and will determine the revenue metering required. Any additional metering equipment or metering data that one or more of the Parties may require for the generation equipment is the responsibility of the Interconnection Customer.

**Specific Revenue Metering Requirements for Existing Non-Utility Generator Facilities That Are Ending Power Purchase Agreements with Dominion Energy:**

For an existing non-utility generator (NUG) that is ending its power purchase agreements with Dominion Energy and will sell its power in the PJM energy market, Dominion Energy shall continue to own, operate, test, and maintain the existing revenue metering equipment at the Interconnection Customer’s expense, except as otherwise specified by the applicable tariff or service agreement. The customer is responsible for all PJM meter data reporting requirements; DVP will not report the generation on behalf of the NUG to PJM. The Interconnection Customer’s RTU shall provide Dominion Energy access to the operational and revenue metering data specified in Telecommunication Section.

**Transmission Owner Facilities**

For the interconnection facilities of Transmission Owners, except as may be otherwise provided for in applicable tariffs or agreements, or as may be otherwise agreed by Dominion Energy and the Interconnection Customer, the Interconnection Customer shall install, own, operate, test, and maintain the revenue metering equipment at its facility. 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 at the point(s) where the Interconnection Customer's facility connects to the Dominion Energy Transmission System. The exact location of the revenue metering CTs and VTs shall be as determined by agreement between Dominion Energy and the Interconnection Customer.

- The Interconnection Customer shall provide a primary and redundant revenue meters and along with SCADA data. It is preferred that the redundant meter have a different method of telecommunications than the primary meter.
End-User Facilities

Except as may be otherwise provided for in applicable tariffs or agreements, or as may be otherwise agreed by Dominion Energy and the Interconnection Customer, the provisions of this section apply to all end user revenue metering whether installed by Dominion Energy or the interconnected end user.

For the interconnected facilities of end users, the revenue metering shall be installed on either the primary side or the secondary side of the Interconnection Customer’s step-down transformer in accordance with the applicable interconnection agreements. Dominion Energy will use its best engineering judgment to determine the appropriate location for the revenue metering equipment if the interconnection agreement provides Dominion Energy the option to choose either the primary side or the secondary side.

If the revenue metering is installed on the primary side of the Interconnection Customer’s step-down transformer, the Dominion Energy CTs and VTs shall be located on the high side of the Interconnection Customer’s step-down transformer. When revenue metering is installed by the Interconnection Customer, the proposed metering installation design must be reviewed and accepted by Dominion Energy prior to installation.

If the revenue metering is installed on the secondary side of the Interconnection Customer’s step-down transformer, it shall be compensated for losses in the transformer. The revenue metering shall also be compensated for losses in any significant length of conductors between the metering point, the step-down transformer and the POI.

If Interconnection Customer revenue metering is compensated, the Interconnection Customer shall provide Dominion Energy with the following information:

- Certified manufacturer test data for the step-down transformer including nameplate ratings, no-load losses, load losses, exciting current, and impedance.
- Primary side voltage tap setting planned for the step-down transformer if equipped with a no-load tap changer. The transformer test data specified above shall be provided for all available taps.
- Information regarding the conductors on the primary side of the Interconnection Customer’s step-down transformer, if applicable, and the secondary side including conductor type, number of conductors per phase, length, resistance and reactance (in Ohms per conductor per 1000 feet or per mile).
- If Dominion Energy specifies compensated revenue metering on the secondary side of a step-down transformer, the Interconnection Customer may install the CTs and VTs in any one of the following configurations after Dominion Energy review and acceptance of the proposed design:
  - An outdoor overhead metering structure with a visible break switches or disconnects on both the incoming and load sides.
  - Pad mounted metering enclosure with dead-front disconnecting elbows on both the incoming and load sides.
  - Switchgear metering compartment with a visible break switch or disconnect on both the incoming and load sides. The compartment must be sealable with doors on the front and back. The CTs and VTs can be picked up from the closest Dominion Energy office to the interconnecting site. The Interconnection Customer...
must provide Dominion Energy with detailed metering compartment drawings (front, side, and rear views) that show the orientation of the CTs on the bus work and indicate electrical clearances. There must be adequate working clearances around the CT and VT secondary terminal boxes for Dominion Energy meter personnel to install the secondary wires.

For end-user Interconnection Customer’s facility with behind-the-meter generation, Dominion Energy may require the Interconnection Customer to install, own, operate, test, and maintain additional revenue metering at the output of the generation equipment, which shall meet any requirement specified in the applicable tariffs or interconnection agreements. If Interconnection Customer owned metering is installed, the Interconnection Customer shall also provide Dominion Energy with the generation revenue metering data if required.

When the end user has non-conforming load, a primary revenue meter along with SCADA data is required. Non-conforming load is load of more than 50 MW that exhibits one of more of the following characteristics:

- Expected load swings of approximately 50 MW or more and ramp rates of approximately 10 MW or more per minute
- Loads with expected daily reactive power ramp rates of 50 MVAR or more per minute
- Loads that may create voltage flicker exceeding the limits set out in the Institute of Electrical and Electronics Engineers (IEEE) Standard 1453
- Loads that may create harmonic current distortions exceeding the limits set out in IEEE Standard 519

Telecommunications

In recognition that the coordination of the system operations by the Parties may be facilitated by the sharing of power flow and other real-time information from meters and other equipment at the Interconnection Points, the Parties may agree to cooperate on the installation and operation of data acquisition system (“DAS”) equipment including, but not limited to, remote terminal units (“RTU”), meters, MW/MVAR and Volt transducers, telecommunication devices, lease lines, and any related equipment at points which shall from time to time be mutually agreed upon.

If a backup telemetry system or data is required by one Party for their own use, the requesting Party shall be responsible for installing and/or maintaining the field devices and associated telecommunication system at their cost.

The following real-time operational data shall be provided to all Parties as available: three phase bi-directional energy flows (e.g., MWh, MVARh), three phase instantaneous power flows (e.g. MW, MVAR), per phase RMS voltages, and per phase RMS currents with at least two decimal points resolution shall be provided. In addition to the real-time operational data, the status of all switching devices associated with the interconnection circuit(s) shall be provided. The real-time data requirements defined in the PJM manuals, including PJM Manual 01 – Control Center and Data Exchange Requirements and PJM Manual 03 – Transmission Operations, shall be provided to PJM to fulfill its roles as Reliability Coordinator (RC), Balancing Authority (BA), and Transmission Operator (TOP).
Metering, Data, and Communications requirements between a generation facility and PJM will be resolved in the kickoff meeting between the PJM client manager and the generation owner, as described in §4.2.2 of PJM Manual 14D – Generator Operational Requirements.

### 3.4.7. Grounding and safety issues

All electrical equipment, electrical components, fences, metal buildings, protective controls, and structures shall be properly grounded and bonded. A safe grounding design must accomplish two basic functions:

1. **Personnel safety**: Ensure that facility personnel, their contractors and the public are not exposed to harmful step-and-touch potentials.

2. **Current path to earth**: Provide a path for electric currents into the earth under normal and fault conditions. Under normal conditions currents will not exceed any operating and equipment limits. Under fault conditions the currents will not adversely affect the continuity of service.

Accordingly, each electrical facility must have a grounding system or grid that solidly grounds all metallic structures and equipment in accordance with standards outlined in the latest revisions of IEEE 80, IEEE Guide for Safety in AC Substation Grounding, and IEEE C2, National Electrical Safety Code (NESC).

Designs must ensure that step and touch potentials and transferred voltages are limited to safe levels. Furthermore, testing must be performed to verify the integrity of the installed grounding system and ensure safe step and touch potential parameters have been met in accordance with the latest revision of IEEE 80.

When various switching devices are opened on an energized circuit, its ground reference may be lost if all sources are not effectively grounded. This situation may cause over voltages that can affect personnel safety and damage equipment. This is especially true when one phase becomes short-circuited to ground. Therefore, the interconnected transmission power system is to be effectively grounded from all sources. This is defined as:

\[
\frac{X_o}{X_1} \leq 3 \\
\frac{R_o}{X_1} \leq 1
\]

This relationship assumes \(R_1/X_1 = 0\), which is a worst case condition.

Interconnected generators should provide for effective system grounding of the high-side transmission equipment by means of a grounded high-voltage generation step-up transformer.

Shield wires should be considered, where applicable, to protect conductors and equipment from lightning strikes. A recommendation for maximum resistance values for all new stand-alone (not connected to a ground grid) structures carrying shield wires are as follows: 25 Ohms for structures supporting facilities at or below 230kV, and 20 Ohms for structures supporting facilities from above 230kV to 500kV.

Safety is of utmost importance. Any work carried out within a facility shall be performed in accordance with all applicable laws, rules, and regulations and in compliance with Occupational Safety and Health Administration (OSHA), NESC, and Good Utility Practice. Automatic and manual disconnect devices are to be provided as a means of removing all
Facility Interconnection Requirements

| NERC ID: NCR01214 | REVISION #: 16.0 | EFFECTIVE DATE: 03/15/2019 | Page 20 of 53 |

sources of current to any particular element of the power system. Only trained operators are to perform switching functions within a facility under the direction of the responsible dispatcher or designated person as outlined in the NESC. The Interconnection Customer and Dominion Energy must agree to switching and Lock Out/Tag Out procedures that will be adhered to at all times for the safety of all personnel. Dominion Energy will follow its own standard operating practices and grounding procedures for safety of personnel.
3.4.8. Insulation and insulation coordination

Insulation coordination is defined by IEEE 62.22 as "the selection of insulation strength consistent with expected over-voltages to obtain an acceptable risk of failure". Insulation coordination must be designed properly both for personnel safety and in order to protect the electrical equipment from the harmful over-voltages resulting from faults, lightning or switching transients. An insulation design must accomplish two basic functions:

- **Electrical isolation**: Electrically isolate the maximum anticipated voltage of energized parts from supporting structures or ground.
- **Mechanical support**: Mechanically support energized parts as intended.

Surge arresters and static wires are used to safeguard the electric power equipment against harmful over-voltages. Basic Impulse Levels (BIL) for electrical equipment and high voltage substation buses shall meet or exceed Dominion Energy’s standard listed below.

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<tr>
<th>Nominal KV (phase to phase)</th>
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Equipment BIL shielding and surge protection shall be designed as determined by lightning and switching surge analysis to meet all applicable ANSI/IEEE standards and Dominion Energy transmission and substation engineering standards.

Dominion Energy Specifications for Transmission Line Insulators include:

- TE VEP 1115 – Porcelain and Glass Insulators
- TE VEP 1117 – Suspension Type Non Ceramic Insulators
- TE VEP 1118 – Non-Ceramic Post Type Insulators

ANSI/IEEE standards include, but are not limited to:

- ANSI C29 collection of standards – Insulators for Electric Power Lines

Interconnection facilities to be constructed in areas with salt spray contamination or other types of contamination shall be properly designed to meet or exceed the performance of facilities in a non-contaminated area. Typically this involves more insulation, higher leakage distances and/or non-standard insulating components and materials.

The following shall be submitted, as applicable, with the Customer Request Form (Exhibit B) for evaluation as part of the interconnection plan:

- Surge arrester ratings
- Basic switching surge levels
- Surge arrester, conductor spacing and gap application
- Substation and transmission line insulation strength
- Protection and/or shielding schemes
• Overhead static wire location
• Equipment BIL ratings
• Insulator BIL ratings

3.4.9. Voltage, Reactive Power, and power factor control

Generation Facilities

PJM is responsible for ensuring the stability and reliability of its electric transmission system. In turn, all generation Interconnection Customers are responsible for operating their units in a stable manner while those units are connected to Dominion Energy’s facilities. Generator excitation and prime mover controls are key elements in ensuring electric system stability and reliability. To meet its responsibility, PJM must have the ability to establish voltage and governor control requirements for all generators connected to its system, including units connected through Dominion Energy’s facilities. These requirements may vary depending on the location, size, and type of generation installed.

Generator Interconnection Customers are required, with oversight by PJM, to follow the current NERC and SERC standards and guides for generator operation, protection, and control.

• All synchronous generators connected to the interconnected transmission systems shall be operated with their excitation system in automatic voltage control mode unless approved otherwise by PJM. PJM and Dominion Energy shall be notified any time a generator control system is removed from service or its logic is modified. These control systems may include but are not limited to: voltage regulators, power system stabilizers, governor and prime mover controls.
• Generators shall maintain a network voltage or reactive power output as required by Dominion Energy, with governance by PJM, within the reactive capability of the units. Generator step-up and auxiliary transformer shall have their tap settings coordinated with electric system voltage requirements.
• Temporary excursions in voltage, frequency, and real and reactive power output that a generator shall be able to sustain shall be defined and coordinated on a regional basis.
• Voltage regulator controls and limit functions (such as over and under excitation and volts/hertz limiters) shall coordinate with the generator’s short duration capabilities and protective relays.
• Prime mover controls (governors) shall operate with appropriate speed/load characteristics to regulate frequency.

All interconnected generation must adhere to power factor requirements for new generator interconnection requests and increase to existing generators as documented in PJM Manual 14A – Generation and Transmission Interconnection Process, Section 5: Additional Generator Requirements. Asynchronous generators connected to the transmission systems shall be studied in the PJM System Impact Study to determine the reactive power compensation required. All interconnected generation must meet the following criteria:

Level 1 - Public Information
Facility Interconnection Requirements

NERC Standard/Requirement: FAC-001 (R1, R3)

All synchronous and asynchronous generators connected to the interconnected transmission systems shall maintain a power factor of at least 0.95 leading to 0.95 lagging measured at the Point of Interconnection.

All new intermittent, asynchronous generators interconnecting to the transmission system that cannot provide control of real power output (wind, solar) will be studied for reactive power capabilities in a manner that considers the variability of the entire intermittent generation fleet within the Dominion Energy footprint; Dominion Energy will provide input and support these studies if deemed necessary, following these requirements.

Voltages at the Point of Interconnection of any generating station should not vary more than 1.0% for expected changes in generation output caused by fluctuations in the prime mover output.

The System Impact Study for asynchronous, intermittent generation will consider the generator under study as well as variability of the entire intermittent generation fleet when determining if the voltage fluctuation criteria is met.

New variable generation resources that cannot meet the 1% voltage deviation criteria will provide dynamic reactive compensation as specified in the PJM System Impact Study, with Dominion Energy support and studies incorporated.

Specific requirements for voltage regulators, power system stabilizers, governor controls, and remote control and telemetry of such devices will be determined during the System Impact Study. The specific requirements for a generator will become part of the Interconnection Service Agreement. (PJM Manual 14A, Section 2: Generation and Transmission Interconnection Planning Process).

Transmission Facilities

The Transmission System must be capable of moving electric power from areas of generation to areas of load under a wide variety of expected system conditions. Adequate reactive power supplies are of paramount importance to the capability of the Transmission System to reliably support a wide variety of transfers. Transmission facilities must be designed to minimize excessively high voltages during light transmission loading conditions, yet have adequate reactive supplies to support system voltage during heavy transmission loading conditions.

End-User Facilities

The voltage variation limitations for interconnections with End-User facilities are as stated in the applicable tariff or agreement. End-User facilities connected directly to the Transmission System should plan and design their systems to operate at close to unity power factor to minimize the reactive power burden on the Transmission System.

3.4.10. Power quality impacts

Flicker Requirements

Flicker will be assessed at the Point of Common Coupling (PCC) using an instrument in compliance with IEC 1000-4-15, except that the weighting curve used to represent the response of the light bulb shall be based on the 120 volt lamp characteristics as recommended in UIE 96-10.

Level 1 - Public Information
The flicker measured at the PCC shall be 0.8 or less for the short-term flicker (Pst) and 0.6 or less for the long term Flicker (Plt). The Pst and Plt values measured shall not be exceeded more than 1% of the time based on a probability distribution calculated for a one-week period.

**Harmonic and Inter-Harmonic Requirements**

Harmonic levels will be assessed at the PCC with an instrument that can take individual samples of voltage and current waveforms and determine the probability distribution of the individual harmonic levels for both the current and the voltage. Harmonic distortion levels at the PCC should meet the requirements contained in the latest revision of IEEE Standard 519.

In addition, the individual inter-harmonic currents shall be limited to 25% of the values in IEEE Standard 519 and the THD (Total Harmonic Distortion) and TDD (Total Demand Distortion) calculation shall include the inter-harmonic components. The Inter-harmonics shall be calculated in 10 Hz increments. The current distortion levels specified in IEEE Standard 519 shall not be exceeded more than 5% of the time based on a probability distribution calculated for a one-week period.

### 3.4.11. Equipment Ratings

Electrical equipment and associated interconnected facilities shall be capable of safely interrupting the worst case short circuit faults calculated for the protection zone.

All current-carrying equipment and devices shall be designed to carry the maximum loads that are predicted and used in load flow analysis, tested against all applicable NERC standards, PJM Transmission Planning Criteria and Dominion Energy Electric Transmission Planning Criteria. Loads exceeding nameplate or normal design capacities are acceptable only when allowed by manufacturers’ design documentation or standard industry practice or by Dominion Energy’s Facility Rating Methodology (FRM).

Circuit breakers and disconnect switches shall be designed and tested according to the latest IEEE C37 collection of standards. Power transformer and Instrument transformers shall be designed and tested according to IEEE C57 standards. Rigid bus structures shall be designed to meet the latest revision to IEEE 605. Current carrying conductors and tubing shall be braced and supported for the expected worst case, short circuit currents, ice loading and wind loading. For overhead line facilities, ground clearance shall be maintained according to the latest IEEE C2, National Electrical Safety Code (NESC). All facilities at voltages greater than 230kV should be considered Extra High Voltage (EHV) and designed accordingly.

Equipment BILs, shielding, and surge protective device application must meet requirements as determined by the latest IEEE C62 standards. Dominion Energy will provide the BIL for the system in the interconnection area. Also, equipment must meet all applicable ANSI/IEEE standards and specifications communicated by PJM and Dominion Energy. Basic Impulse Levels (BIL) for electrical equipment and high voltage substation buses shall meet or exceed Dominion Energy’s standard listed below.

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3.4.12. Synchronizing of facilities

Synchronizing equipment consisting of potential devices and associated protective relay and controls is required on facilities where energy can be sourced on both sides of an interconnection circuit breaker. The Interconnection Customer shall not synchronize with the Transmission System prior to obtaining approval from Dominion Energy.

The following explains the various synchronizing options.

Generation Facilities

Live line, dead bus (LLDB) control is used in the interconnection circuit breaker reclosing scheme when generation facilities are connected to Dominion Energy. The circuit breaker cannot be closed unless the generation side has zero voltage. The interconnection circuit breaker should not be used to synchronize a generator to the Transmission System. Instead, the generation facilities should have their own synchronizing facilities. In the event a generation Interconnection Customer’s facility becomes disconnected from Dominion Energy’s system, it shall remain disconnected until system voltage and frequency are within an established range. In all scenarios, Dominion Energy shall retain operational control of the interconnection breaker.

Interconnected and Separate Systems for Generators

The Interconnection Customer may elect to run its generator in parallel (interconnected) with Dominion Energy or as a separate system with the capability of nonparallel load transfer between the two independent systems. The two methods of operation are outlined as follows:

Parallel system

A parallel system is one in which the Interconnection Customer’s generation equipment can be connected to Dominion Energy’s system resulting in a transfer of power between the two systems. A consequence of such parallel operation is that the parallel generator becomes an electrical part of the Dominion Energy system, which must be considered in the operation and protection of Dominion Energy’s facilities. The general and specific requirements for parallel generation installations are discussed in this document.

Synchronizing equipment consisting of potential transformers and associated protective relaying/controls is required on facilities where energy can be sourced on both sides of an interconnection circuit breaker. This equipment serves the following purposes:

- Verifies the voltages on both sides of a circuit breaker fall within set tolerances, which must meet Dominion Energy’s approval, as to the magnitude and phase angle established by system conditions
- Supervises the closing and automatic reclosing of the circuit breaker
- Prevents the closing of the circuit breaker when the two systems are out of sync

Voltage magnitudes, phase angles, and frequency constraints shall be determined on a case-by-case basis.

Level 1 - Public Information
Separate system with nonparallel load transfer capability

A separate system is one in which there is no possibility of delivering energy to the Dominion Energy system from the Interconnection Customer’s equipment. The Interconnection Customer may maintain the capability of transferring load between the two systems, but such transfer must be accomplished in an open-transition or nonparallel mode. This can be accomplished by either an electrically or mechanically interlocked switching arrangement that precludes both the switch connecting the load to Dominion Energy’s system and the switch connecting the load to the Interconnection Customer’s generation being in the closed position simultaneously. If the Interconnection Customer has a separate system, the Interconnection Customer shall not operate the generation until Dominion Energy has verified that the transfer scheme meets the nonparallel requirements. This verification will be accomplished by review and approval of drawings and equipment specifications by Dominion Energy and, if Dominion Energy so elects, by field inspection of the transfer scheme. Dominion Energy will not be responsible for approving the Interconnection Customer’s generation equipment and assumes no responsibility for its design or operation.
3.4.13. Maintenance coordination

Testing
Dominion Energy requires interconnecting entities with protection systems which coordinate with Dominion Energy’s transmission network protection systems to have a documented maintenance program for those systems in accordance with NERC PRC-005 requirements. Documentation of the maintenance program shall be supplied to Dominion Energy upon request. Additionally, the interconnecting entity, on maintenance intervals identified within their documented program and following any apparent malfunction of the protection equipment, shall perform and document both calibration and functional trip tests of its protection equipment as outlined within its maintenance program. Customer shall maintain evidence of such activities and make them available to Dominion Energy upon request.

Coordination
Dominion Energy may remove its lines and associated equipment from service for testing of relays and maintenance of lines or substations in accordance with its maintenance program. The Interconnection Customer, Dominion Energy and PJM will coordinate for these planned outages.

The interconnection parties agree to confer regularly to coordinate the planning, scheduling and performance of preventative and corrective maintenance on the Interconnection Customer’s facility, the Interconnection Facilities and associated facilities owned by Dominion Energy. The Interconnection Customer must coordinate its approach and schedule for maintenance and testing with Dominion Energy to ensure the reliability of the bulk electric system.

Generator Interconnection
On occasion, the generation Interconnection Customer may not be allowed to operate in parallel with the Dominion Energy transmission or distribution system. A generator Interconnection Customer with multiple interconnection points may be permitted to operate only in parallel with specific lines so Dominion Energy can perform “live line maintenance” on the facilities serving the generator Interconnection Customer. The generator Interconnection Customer, Dominion Energy and, as needed, PJM, will coordinate with these conditions and requests.
3.4.14. Operational issues (abnormal frequency and voltages)

PJM is the Transmission Operator for Dominion Energy’s Transmission System. The interconnection will be operated consistent with PJM requirements and procedures. Specific transmission conditions and procedures for operation of Transmission Facilities (defined by PJM) within PJM are found in Manual 3 – Transmission Operations on the PJM website (www.pjm.com).

Generator Interconnection

The transmission system is designed to automatically activate a load-shed program as required by PJM in the event of an under-frequency system disturbance. A generation Interconnection Customer shall implement under-frequency and over-frequency relay set points for the generation Interconnection Customer as required by PJM to ensure ‘ride through’ capability of the transmission system. The generation Interconnection Customer facility is to stay connected to and synchronized with the Transmission System during system disturbances within a range of under-frequency and over-frequency conditions, in accordance with Good Utility Practice. The response of a generation Interconnection Customer’s facility to frequency deviations of predetermined magnitudes; both under-frequency and over-frequency deviations are studied and coordinated with PJM in accordance with Good Utility Practice. Additional information is found in PJM Manual 14D – Generator Operational Requirements.

3.4.15. Inspection requirements for new or materially modified existing interconnections

Dominion Energy has established inspections as a component of its maintenance program for Dominion Energy owned assets. Dominion Energy may require right of access to the Interconnection Customer’s facility for purposes of conducting inspections: to include observing tests, visual inspections, and auditing maintenance and testing records.

Additionally, Dominion Energy may require right of access to conduct initial (pre-operational) inspection and/or require copies of pre-operational procedures and test reports.

Each party shall, at its own expense, have the right to observe the testing of any of the other party’s metering equipment whose performance may reasonably be expected to affect the accuracy of the observing party’s telemetry and revenue. If requested, each party shall notify the other in advance of metering or other equipment testing and maintenance, and may have a representative attend and be present during such testing.

If Dominion Energy identifies any deficiencies, defects, or inconsistencies of the Interconnection Customer’s facility that may adversely affect the reliability of the bulk power system and/or potentially constitute a compliance concern for Dominion Energy, then Dominion Energy shall provide notice to the Interconnection Customer outlining the concern and the suggested corrective action. Customer shall provide Dominion Energy with a corrective action plan resolving identified concern(s).

If Interconnection Customer observes any deficiencies, defects, or inconsistencies of its Interconnection facility that may adversely affect the reliability of the bulk power system and/or potentially constitute a compliance concern for Dominion Energy, then the Customer shall provide notice to Dominion Energy outlining the identified concern and the corrective actions that will be taken to resolve the concern.
3.4.16. Communications and procedures during normal and emergency operating conditions.

Complete, precise, and timely communication is an essential element for maintaining reliability and security of a power system. Under normal operating conditions, the major link of communication with various interconnects shall be by telephone lines. Dominion Energy and the Interconnection Customer shall maintain communications which shall include, but not be limited to exchanging up-to-date information regarding:

- contact information for maintenance personnel
- maintenance schedules
- meter tests
- relay tests
- system paralleling or separation
- scheduled or unscheduled shutdowns
- equipment clearances
- periodic load reports
- tagging of interconnection interrupting devices
- billing
- other routine communication

In case of emergency or abnormal operating conditions, various communication channels may be used depending on the interconnect category. Emergency telephone numbers should be agreed upon by both parties prior to the date of initial interconnection. Each interconnection party shall notify the other parties promptly when it becomes aware of an emergency condition that may reasonably be expected to affect operation of the Interconnection Customer’s facility, the Interconnection Facilities, the Dominion Energy Interconnection Facilities, or the Transmission System.

**Generation and Transmission Interconnection Customer Obligations**

Generation and transmission Interconnection Customers shall install and maintain satisfactory operating communications with PJM’s system dispatcher or its other designated representative and with Dominion Energy system dispatcher. Generation and transmission Interconnection Customers shall provide standard voice line, dedicated voice line, and facsimile communications at their facility control room through use of the public telephone system. Generation and transmission Interconnection Customers also shall provide and maintain backup communication links as specified by both PJM and Dominion Energy for use during abnormal conditions. Satellite phones compatible with PJM and Dominion Energy equipment should be available for emergency communications. Generation and transmission Interconnection Customers further shall provide the dedicated data circuit(s) necessary to provide Interconnection Customer data to PJM and Dominion Energy as necessary to conform to applicable technical requirements and standards.
4. **FAC-001 R4**

   FAC-001 R4 applies only to Generator Owner registration.

5. **TRANSMISSION LINE CONNECTIONS – GENERATION**

   Transmission facilities may be used for providing service to generation developers when the use of distribution feeders is not practicable. Generally, the use of transmission facilities should be considered for the following conditions:

   - All generating facilities over 20 MW
   - Locations remote from distribution facilities
   - Remote locations where distribution facilities are not adequate

   For interconnection to the 500kV network, the preferred minimum generation capability at a single point of connection is 500MW. The interconnection of generating plants on the 500kV network below this level will be permitted for cases where no other lower transmission voltage option is available.

   The descriptions and diagrams in this section are typical from an interconnection standpoint; they are subject to further modification as necessary to comply with Exhibit C-Electric Transmission Generator Interconnection Protection Requirements (Section 3 Interconnection Protection Requirements).
5.1. Single circuit interconnections to a transmission line

A transmission line tap as shown in Diagram 5.1 can generally be used to interconnect a proposed new generating facility of any size located within one mile, or a generating facility of 500 MW or less located at a distance greater than one mile to the Transmission System. With this arrangement, loss of generation does not interrupt flow on the Transmission System and loss of a transmission line does not result in loss of generation. However, final System Protection requirements along with interconnection substation requirements shall be based on the reliability impact conducted through the PJM Interconnection Queue process as defined in PJM Manual 14C – Generation & Transmission Interconnection Facility Construction. The customer should reserve property for construction of the Dominion Energy-owned interconnection station.

Diagram 5.1: Line Tap – Generation adjacent to transmission line

Company

Customer

Notes:
- Specific violation of the NERC standard outlined in Section C may require a four-breaker ring bus.
- See Section 5.5 for additional acceptable breaker configurations.
5.2. Transmission interconnections located remote from a transmission line

If the proposed Generating Facility is greater than 500 MW and located more than one mile from an existing transmission line then the proposed arrangement shown in Diagram 5.2.A or 5.2.B could be used. With this arrangement, loss of generation does not interrupt flow on the Transmission System and loss of a transmission line does not result in loss of generation. However, final System Protection requirements along with interconnection substation requirements shall be based on the reliability impact conducted through the PJM Interconnection Queue process as defined in PJM Manual 14C – Generation & Transmission Interconnection Facility Construction.

Diagram 5.2.A: Line Tap – Large generation located remote from transmission line
As an alternative to constructing a switching station at the tap point, the transmission line can be cut and looped in and out to a switching station located adjacent to the generating station as shown in Diagram 5.2.B. This arrangement can have its advantages since acquiring land and permitting a new station at the tap point would not be required. The customer should reserve property for construction of the Dominion Energy owned interconnection station.

Diagram 5.2.B: Looped Tap – Large generation located remote from transmission line

Notes:
- Specific violation of the NERC standard outlined in Section C may require a four-breaker ring bus.
- See Section 5.5 for acceptable arrangements for interconnection breaker.
5.3. Interconnection to radial transmission line or radial transmission tap

5.3.1. Connection to radial transmission lines

A proposed generating facility may be connected to a radial transmission line. A radial transmission line is defined as a single line that has one transmission source and does NOT tie to any other transmission network source (line or substation).

Diagram 5.3.1 – Connection to radial transmission line
5.3.2. Interconnection to radial transmission tap

A proposed generating facility may be connected to a transmission tap line portion of a network transmission line, as shown in diagrams 5.3.2.A and 5.3.2.B, subject to Exhibit C-Electric Transmission Generator Interconnection Protection Requirements (Section 3 Interconnection Protection Requirements)

Diagram 5.3.2.A – Connection to radial transmission tap line (single point)
5.4. **Substation interconnection requirements**

All generation interconnection substation designs will include all switches and devices required to permit maintenance of all breakers and transmission lines without the loss of the ability to use the generation capacity when required. Small units can be bussed together behind breakers unless reliability studies indicate issues.

5.5. **Transmission interconnection breakers**

If new transmission lines are required by the addition of generator capacity at a new or existing power station, the breaker arrangement at the existing substation will determine both the number of breakers and the breaker arrangement required for the interconnection. Line terminations that result in a four breaker or less ring bus are acceptable. If more than a four breaker ring bus is required, a breaker and a half arrangement would be used for reliability considerations.
5.6. Generation interconnection breakers

A customer owned interconnection breaker is required if the generating station is located remote from
the interconnection station (See Diagrams 5.2.A and 5.2.B). Small generating units totaling 500 MW or
less, or all units of a combined-cycle set can be bused together behind this breaker as shown in
Diagram 5.6.A or multiple breakers can be used as in Diagram 5.6.B.

Diagrams 5.6.A and 5.6.B – Multiple breakers

Diagram 5.6.A.          Diagram 5.6.B.

However, regardless of distance, final System Protection requirements along with interconnection
substation requirements shall be based on the reliability impact conducted through the PJM
Interconnection Queue process as defined in PJM Manual 14C – Generation & Transmission
Interconnection Facility Construction.
5.7. Interconnection Requirements for Distribution Connected Generation

The Distribution Connected Generation is defined as a generator who is requesting connection to distribution facilities serving retail customers (excluding the station service load for the respective generator).

Distribution connected generation resources where the aggregate nameplate rating of all the generating resources (dispersed generation resources) is greater than 100 MVA, will require a three breaker ring at the point of connection to the transmission system.

Diagram 5.7.A Distributed Generation greater than 100MVA

Distribution connected generation resources where the aggregate nameplate rating of all the generating resources (dispersed generation resources) is less than 100MVA can be connected behind a single interrupting device (circuit breaker or circuit switcher).

Diagram 5.7.B Distributed Generation less than 100MVA
6. LOAD CRITERIA – END USER

Transmission facilities may be used for providing service to commercial, industrial, municipal, cooperative and cogeneration customers when the use of distribution feeders is not practicable. Generally, the use of transmission facilities should be considered for the following conditions:

- All loads over 20 MW
- Locations remote from distribution facilities
- Remote locations where distribution facilities are not adequate
- Loads with nonstandard voltage requirements
- Loads having large surge requirements

The following are minimum load levels within the ten year planning horizon for the direct interconnection of loads to existing transmission lines:

- 500 kV – Reserved for bulk power transfers
- 230 kV – 30 MW
- 138 kV – 20 MW
- 115 kV – 20 MW

The interconnection of loads below these levels will be permitted after a thorough planning analysis concludes that the cost and reliability of distribution alternatives are clearly inferior to the overall cost and reliability of a transmission interconnection which includes, without limitation, considerations of any transmission reliability or operational concerns that may arise from adding the transmission interconnection. For consideration of an interconnection of loads below the specified levels, the requesting party shall prepare documentation explaining and supporting why distribution alternatives are inferior and must supply additional documentation which may require Dominion Energy to undertake its own analysis.

The feasibility of serving customers direct from the transmission along with determining the final recommended transmission interconnection facilities requires a comprehensive study and coordination. Factors to be considered prior to agreeing on a customer connection are as follows:

- Economics of distribution versus transmission alternates
- Customer parallel generation
- Transmission line tap or loop length
- Economics of radial line versus looping even when typical thresholds (e.g., length, load level) are not met
- Mitigation of economic risk in the event actual load varies materially from planned load
- Customer transformer characteristics
- Customer switching
- Effect on protective relaying at remote terminals
- Problems of large through power on looped lines
- Extent of customer facilities

In general, a tap line in excess of one mile shall require a terminal station. If the tap line is long enough to require a terminal substation, a three-breaker or four-breaker ring bus may be required. With these arrangements, loss of line to the customer does not interrupt flow on the Transmission System and loss of a
transmission line does not result in loss of service to the customer. The total projected load and MW-Mile\(^1\) exposure are also factors to be taken into consideration. The final number of breakers and breaker arrangement will however be based on the specific interconnection request and reliability impact on Transmission System.

The following typical diagrams indicate the facilities arrangement for normal service 100 kV and above.

**6.1. Tapping line for loads below 100 MW**

**Diagram 6.1.A: Tap line for less than 100MW, less than 1 mile**

A transmission line tap as shown in Diagram 6.1.A can generally be used to interconnect a proposed customer facility located within one mile or less to the nearest transmission line. With this arrangement, company will install necessary system protection equipment and associated components at the customer's facility. The final System Protection and interconnection substation requirements communicated to the customer shall be based on the site-specific detailed reliability impact as determined by Dominion Energy. See Section 6.3 for additional options.

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\(^1\) Total length of the line in miles times the total projected load in MW. See Transmission Planning Criteria, Section C.2.6 Radial transmission lines for details.
A transmission line tap as shown in Diagram 6.1.B can generally be used to interconnect a proposed customer facility located more than one mile from the nearest transmission line. A three-breaker or four-breaker ring bus may be required. With this arrangement, company will install all necessary equipment at the interconnection substation at or near the transmission line. The final System Protection and interconnection substation requirements communicated to the customer shall be based on the site-specific detailed reliability impact as determined by Dominion Energy.

Level 1 - Public Information
A transmission line tap as shown in Diagram 6.1.C can generally be used to interconnect a proposed customer facility of less than 100 MW and when it is more economical to build double circuit rather than a single line. The customer may reserve property for the Dominion Energy owned interconnection station if one is required.

The addition of breaker “C” may be required in order to limit the number of direct-connect loads (tapped facilities) to four, or as otherwise required based on detailed System Protection and interconnection substation assessments.
6.2. Tapping lines for loads 100 MW and greater

The addition of customer load in excess of 100 MW should be connected to the Company’s Transmission System as shown in Diagrams 6.2.A and 6.2.B below. If available 230kV is the preferred voltage level to connect loads greater than 100MW.

Diagram 6.2.A: Tapping line 100 MW load and greater, less than a mile

A 4-breaker ring bus arrangement as shown in Diagram 6.2.A can generally be used to interconnect a proposed customer facility of 100 MW and greater having two customer transformers, or to address a specific violation of the NERC standard outlined in Section C. For cases in which there is only one customer transformer, a 3-breaker ring bus may be acceptable. With either arrangement, loss of line to the customer does not interrupt flow on the Transmission System and loss of a transmission line does not result in loss of service to the customer. However, the final System Protection and interconnection substation requirements communicated to the customer shall be based on the site-specific detailed reliability impact as determined by Dominion Energy. The customer could reserve property for construction of the Dominion Energy-owned interconnection station if customer parcel is adjacent to or in very close proximity of transmission right of way.
Diagram 6.2.B: Tapping line 100 MW load and greater, more than a mile

As an alternative to constructing a switching station at the tap point, the transmission line can be cut and looped in and out to a switching station located adjacent to the customer station as shown in Diagram 6.2.B. This arrangement can have its advantages since acquiring land and permitting a new station at the tap point would not be required. The customer should reserve property for construction of the Dominion Energy owned interconnection station.

A 4-breaker ring bus arrangement as shown in Diagram 6.2.B can generally be used to interconnect a proposed customer facility of 100 MW and greater having two customer transformers, or to address a specific violation of the NERC standard outlined in Section C. For cases in which there is only one customer transformer, a 3-breaker ring bus may be acceptable. With either arrangement, loss of line to the customer does not interrupt flow on the Transmission System and loss of a transmission line does not result in loss of service to the customer.
6.3. Prohibited arrangements and allowable alternatives

The Company does not allow by-pass switches around primary interrupting devices on the customer's distribution transformer at the point of interconnection as shown in Diagram 6.3.A. The Company's current system protection principles require that each system element, (line, transformer, bus, etc) have primary relay protection in service at all times when the element is energized and placed in service. This ensures that all elements have adequate protection for safe and reliable operation of the Transmission System and are ready to remove the element from service should a fault occur. This is even more critical in cases like distribution tapped transformers where upstream line protection cannot provide backup coverage. The use of an air-break bypass switch would expose customer's personnel and equipment in an unprotected zone. This places risk to the Bulk Electric Systems integrity as well as impacting all other customers served by the same transmission line.

Diagram 6.3.A: Prohibited by-pass switch
Allowable Sample Alternatives: A parallel circuit switcher arrangement as shown in Diagram 6.3.B provides a fully redundant capability. Another approach is the fused bypass as depicted in Diagram 6.3.C. The exact design, system protection configuration and operating arrangement may be customized as necessary, subject to review and approval by both the Company and the Customer.

Diagram 6.3.B: Allowable sample alternative with interrupting devices

Diagram 6.3.C.: Allowable sample alternative with fused bypass
6.4. **Tapping Company's bus**

The requirements for direct interconnection to company's transmission bus will be determined on case by case basis.

Generally, the following are preferred minimum load levels within the ten year planning horizon for the direct interconnection of loads to the existing substation busses:

- 230 kV – 75 MW
- 138 kV – 50 MW
- 115 kV – 50 MW

In those cases where it may be practicable to tap an existing transmission substation bus to serve a customer, Diagram 6.4 indicates the typical facilities arrangement for normal service:

![Diagram 6.4: Tapping existing substation bus below 100 MW load](image-url)
7. APPLICABILITY
NERC Reliability Standard FAC-001 R1 and R3 apply to Virginia Electric and Power Company - (DP, , TO) as a registered TO with NERC.

8. DEFINITIONS
8.1. Definitions
Wherever used in this document with initial capitalization, the following terms shall have the meanings as specified below.

- **Capacity**—The seasonal maximum generating capability of the generation Interconnection Customer’s facility, measured in megawatts.
- **Distribution Facilities**—The facilities rated at less than 69 kV which are owned and operated by the Company and which are necessary to connect the Interconnection Customer’s facility to the Transmission System.
- **Emergency Condition(s)**—A condition or situation (i) that in the judgment of either party is imminently likely to endanger life or property; (ii) that in the sole judgment of The Company is imminently likely to affect adversely or impair the Transmission System or imminently will affect or impair the transmission systems of others to which the Transmission System is directly or indirectly connected; or (iii) that in the sole judgment of the generation Interconnection Customer is imminently likely to adversely affect or impair the facility. Such a condition or situation includes, but is not limited to, overloading, or potential overloading of, excessive voltage drop, or other unusual operating conditions on the Transmission System or the generation Interconnection Customer’s facility such that the output of the facility must be shut down or curtailed to avoid damaging the facility or the Transmission System.
- **Good Utility Practice**—Any of the practices, methods, and acts engaged in or approved by a significant portion of the electric utility industry during the relevant time period, or any of the practices, methods and acts that, in the exercise of reasonable judgment in light of the facts known at the time the decision is made, could have been expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety and expedition. Good Utility Practice is not intended to be limited to the optimum practice, method, or act to the exclusion of all others, but rather is intended to include acceptable practices, methods, or acts generally accepted in the region.
- **Governmental Authority**—Any federal, state, local or other governmental, regulatory or administrative agency, court, commission, department, board, or other governmental subdivision, legislature, rulemaking board, tribunal, arbitrating body, or other governmental authority.
- **Interconnection Facilities**—All structures, equipment, devices and apparatus owned or leased by, or under contract to each party presently in place or proposed to be installed, which are necessary to connect the Interconnection Customer’s facility(ies) to the Dominion Energy Transmission System.
- **Interconnection Customer**—A transmission, generation, or end user connected to, or seeking to connect to, the Dominion Energy Transmission System.
Facility Interconnection Requirements

NERC Standard/Requirement: FAC-001 (R1, R3)

NERC ID: NCR01214  REVISION #: 16.0  EFFECTIVE DATE: 03/15/2019  Page 49 of 53

- **Interconnection Point**—The point at which the Facilities are physically connected to the Transmission System (including any Distribution Facilities required to facilitate the interconnection).

- **Metering Equipment**—All metering equipment currently installed at the Interconnection Customer’s facility and/or any other metering equipment to be installed at the metering points designated in the Interconnection Facilities, including Revenue Meters.

- **RTO**—A Regional Transmission Organization or any successor thereof which becomes responsible for operating the Company Transmission System to which the Interconnection Customer’s facility is connected. PJM Interconnection, L.L.C. is Dominion Energy’s RTO.

- **Transmission Element**—Transmission elements are primary equipment (69kV and above) that constitutes, or interconnects with, the Dominion Energy Electric Transmission System. Examples include buses, lines, or transformers with lowside voltage 69kV or above, regardless of Bulk Electric System status.

- **Transmission System**—The facilities owned by Dominion Energy that are used to provide transmission service, including any Distribution Facilities required to provide Wholesale Distribution Service, under the PJM OATT.

- **Wholesale Distribution Service**—The provision of distribution service to wholesale customers, including generator Facilities, over Distribution Facilities as necessary to effectuate transmission service under the PJM OATT or Interconnection Service under this Agreement.

8.2. Abbreviations

Wherever used in this document with initial capitalization, the following terms shall have the meanings as specified below. Terms used in this document with initial capitalization not defined shall have the meanings specified in the PJM Open Access Transmission Tariff.

- **ANSI**—American National Standards Institute
- **IEEE**—Institute of Electrical and Electronic Engineers
- **NERC**—North American Electric Reliability Corporation
- **OATT**—PJM Open Access Transmission Tariff
- **PCC**—Point of Common Coupling
- **SERC**—SERC Reliability Corporation
## 9. REVISION HISTORY

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**Details for Revision 1.0**
- Revised to include information regarding Dominion’s generation interconnection procedures/process.

**Details for Revision 2.0**
- Revised to reflect transition from old NERC Planning Standards to NERC Reliability Standards, including changing the naming convention of all referenced standards throughout the document.

**Details for Revision 3.0**
Revised to reflect the following:
- Updates to NERC Reliability Standards
- Dominion’s PJM Membership
- References to new SERC regional studies processes

**Details for Revision 4.0**
Revised to reflect the following:
- PJM Generation Queue Changes Section 4
Facility Interconnection Requirements

NERC Standard/Requirement: FAC-001 (R1, R3)

NERC ID: NCR01214  REVISION #: 16.0  EFFECTIVE DATE: 03/15/2019  Page 51 of 53

- General Revisions all sections

Details for Revision 5.0
Revised the following:
- Section 2.12: Clarified content regarding synchronizing of facilities.
- Exhibit A: Changed loading criteria to not exceed emergency rating of transmission facility.
- Various errata changes.

Details for Revision 6.0
- Comprehensive overhaul to better align with the numerical flow of NERC Reliability Standard FAC-001.

Details for Revision 7.0
Revised to reflect the following:
- Annual review of Facility Connection Requirement document.
- Updated titles for approval process on page 1.
- Incorporated changes to reflect FERC approval of FAC-001-1 effective 11/25/2013.
- Section 3.1.5 – Removed “Coordination and Compatibility” and “Performance Tracking and Compliance”; Added “Protection System Misoperations”.
- Section 3.1.13 – Added “Testing” paragraph
- Various errata changes.

Details for Revision 8.0
Revised Exhibit A – Transmission Planning Criteria R8 as listed below:
- Expanded description for Section G.1. TAPPING LINE BELOW 100 MW LOAD to emphasize the requirement of a fused bypass arrangement.
- Recreated diagrams throughout for consistency of style.

Details for Revision 9.0
Revised Exhibit A – Transmission Planning Criteria as listed below:
- Added Section C.2.8 – End of life criteria
- Reformatted headers to improve PDF navigation via bookmarks

Details for Revision 10.0
Revised Facility Connection Requirement document to reflect the following:
- Minor clarifications and annual review.
- Section 1 Purpose and Introduction: Added statement regarding applicability of document.
- Section 3.1.9 Voltage, Reactive Power, and power factor control; Generation Facilities subsection:
- Revised first bullet regarding generator control systems.
- Added new series of bullets regarding interconnected generation criteria.

Level 1 - Public Information
• Revised Exhibit A – Transmission Planning Criteria (for details, see Revision History within Transmission Planning Criteria)

Details for Revision 11.0

• Revised Exhibit A – Transmission Planning Criteria (for details, see Revision History within Transmission Planning Criteria)

Details for Revision 12.0

• Made revisions to align with new version of the standard, FAC-001-2.
• Updated signature page to reflect personnel change.
• Relocated Section 3 content formerly associated with R3 in the prior version (FAC-001-1) to Section 3.3 Additional items per FAC-001 Application Guidelines and Technical Basis.
• Section 3.1 added bullet regarding distributed generation output for both conventional and alternative (solar, wind, etc.) sources
• Added sections 3.3.1 and 3.3.2 due to new information contained within Application Guidelines and Technical Basis of FAC-001-2.
• 3.3.5. Refined discussion of Protection System Design
• 3.3.6. Added reference to PJM Manual 01 – Control Center and Data Exchange Requirements
• Revised Exhibit A – Transmission Planning Criteria (for details, see Revision History within Transmission Planning Criteria)
• Integrated prior content from Transmission Planning Criteria, refined drawings and associated discussions:
  - § Section 5. TRANSMISSION LINE CONNECTIONS – GENERATION (previously Section F of Transmission Planning Criteria). Established minimum generation MW level for interconnection to the Transmission System.
  - § Section 6. LOAD CRITERIA – END USER (previously Section G of Transmission Planning Criteria)
• Added Exhibit C DVP Electric Transmission Generator Interconnection Protection Requirements.
• Altered capitalization throughout the document to ensure consistent application of defined terms.

Details for Revision 13.0

• Performed annual review of document and exhibits.
• Updated approval page per personnel change since prior version.
• Revised references for new Dominion Energy corporate identity.
• Removed references to registration as an "LSE" (deactivated through NERC December 2015)
• Added Section 5.6 Interconnection Requirements for Distribution Connected Generation.
• Section 3.3.6. Metering and telecommunications, subsection “Revenue Metering Data Communications”: added reference to Primestone billing data system.
• Revised Exhibit A – Dominion Energy Electric Transmission Planning Criteria (for details, see Revision History within Exhibit A)
Details for Revision 14.0

- Revised Exhibit A – Transmission Planning Criteria (for details, see Revision History within Transmission Planning Criteria)

Details for Revision 15.0

- Section 3.3: Added new section per new NERC FAC-001-3 standard; content within Section 3.3 of prior versions of this document is now in Section 3.4.
- Section 3.4.5 System protection and coordination (Protection system design) - added content re: Breaker Failure Protection.
- Section 5: Added reference to Exhibit C Protection Requirements; renumbered all sections and diagrams occurring after newly inserted section 5.3.
- Section 5.3: Added new section regarding generation connected to transmission tap lines.
- Section 8.1: Added definition for Transmission Element.
- Made all remaining revisions for Dominion Energy corporate identity, in text and in images (Rev 13 included initial related changes along with a clarifying statement in Section 1).
- Revised Exhibit C – Dominion Energy Electric Transmission Generator Interconnection Protection Requirements_Rev3 (for details, see Revision History within Exhibit C)

Details for Revision 16.0

- Revised Exhibit A – Transmission Planning Criteria (for details, see Revision History within Transmission Planning Criteria)
ELECTRIC TRANSMISSION PLANNING CRITERIA

Electric Transmission Planning Department
Version 16
Effective 3/15/2019

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Table of Contents

A. SCOPE AND OBJECTIVE .................................................................................................................. 4

B. NATIONAL AND REGIONAL CRITERIA AND GUIDES ................................................................. 4
   B.1. NERC planning standards ........................................................................................................... 4
   B.2. Regional reliability planning standards .................................................................................... 4
   B.3. PJM planning standards ............................................................................................................ 4

C. TRANSMISSION PLANNING, STEADY-STATE CRITERIA .................................................... 5
   C.1. Planning principles and standards ........................................................................................... 5
      C.1.1. Voltage limits at generating stations .............................................................................. 14
   C.2. Detailed steady-state criteria .................................................................................................. 14
      C.2.1. System load level .......................................................................................................... 14
         C.2.1.1. Peak period studies .......................................................................................... 14
         C.2.1.2. Off-peak period studies .................................................................................. 14
         C.2.1.3. Critical stress case development and studies ............................................... 14
      C.2.2. Power transfers ........................................................................................................... 15
      C.2.3. Equipment ratings ....................................................................................................... 15
      C.2.4. Circuit breaker interrupting capability ......................................................................... 16
      C.2.5. Reactive power planning ............................................................................................. 16
      C.2.6. Radial transmission lines ............................................................................................. 16
      C.2.7. Network transmission lines – Limitations on direct-connect loads ......................... 17
      C.2.8. Substation – Limitation on direct-connect loads ......................................................... 17
      C.2.9. End of life criteria ......................................................................................................... 17
   C.3. Selection of generation dispatch used in DEV Power Flow Studies .................................... 19

D. TRANSMISSION PLANNING, SYSTEM STABILITY CRITERIA ........................................ 20
   D.1. Introduction ............................................................................................................................ 20
   D.2. General criteria ....................................................................................................................... 20
   D.3. Study horizon ......................................................................................................................... 21
   D.4. Study cycle ............................................................................................................................. 22
   D.5. Dynamics data collection ...................................................................................................... 22
   D.6. Selection of a reference power flow case ............................................................................. 22
   D.7. Selection of generation dispatch .......................................................................................... 22
   D.8. Selection of contingencies .................................................................................................... 23
   D.9. What to look for in study results ........................................................................................... 23
   D.10. Implementation procedure ................................................................................................... 24
      D.10.1. For existing installations ........................................................................................... 24
D.10.2. For new installations or capacity additions ........................... 25
E.  NUCLEAR PLANT INTERFACE COORDINATION ........................... 25
   E.1. Introduction ................................................................. 25
   E.2. NRC regulations......................................................... 25
   E.3. Design requirements................................................... 26
   E.4. Underfrequency studies.............................................. 26
   E.5. Angular stability studies............................................. 27
   E.6. System analysis protocol............................................ 27
   E.7. Changes to the system............................................... 27
F.  REFERENCES ................................................................. 28
G.  ABBREVIATIONS & DEFINITIONS .......................................... 28
H.  REVISION HISTORY .......................................................... 29
A. **Scope and objective**

The function of the transmission system is to transport power from generating resources to distribution systems in order to serve the demand of the end-user customers. Reliable transmission system operation implies maintaining continuity of service at sufficient voltage levels without overloading equipment under a wide range of operating conditions.

Virginia Electric and Power Company is commonly referred to as Dominion Energy Virginia (DEV). For the purpose of this document, “DEV transmission system” refers to the transmission system owned by Dominion Energy Virginia. “Transmission system” refers to networked and radial facilities within the DEV system at voltage levels of 69, 115, 138, 230, and 500 kV. This document provides approved criteria upon which the needs for reinforcements and enhancements to the DEV transmission system are determined.

DEV’s transmission planning criteria ensures adherence to the transmission planning standards of the North American Electric Reliability Corporation (NERC) and those of the SERC Reliability Corporation (SERC), one of the eight regional reliability organizations (RRO) of NERC. Unless noted, the Criteria in this document apply to generation, transmission, and end user facilities.

B. **National and regional criteria and guides**

B.1. **NERC planning standards**

The North American Electric Reliability Corporation was established to promote the reliability of the bulk electric systems of North America. NERC coordinates reliability standards for the power systems of the United States, the bordering provinces of Canada, and a portion of Mexico. NERC has developed planning standards to ensure the reliable operation of the interconnected bulk electric systems. These standards can be found at the NERC homepage.

The DEV Transmission Planning Criteria provides a description of how DEV performs simulated testing of the interconnected transmission system to determine its ability to withstand probable and extreme contingencies.

B.2. **Regional reliability planning standards**

NERC consists of eight regional reliability organizations. DEV is a member of the SERC Reliability Corporation (SERC), one of the eight regional reliability organizations of NERC. DEV plans the bulk electric system (BES) in coordination with PJM, its Transmission Planner (TP), to meet the requirements of NERC and SERC.

B.3. **PJM planning standards**

The DEV transmission system is integrated into planning and operations of the PJM Interconnections, L.L.C. RTO (PJM). PJM manages a regional planning process for generation and transmission expansion to ensure the continued reliability of the electric system. PJM annually develops a Regional Transmission Expansion Plan (RTEP) to meet system enhancement requirements for firm transmission service, load growth, interconnection requests and other system enhancement drivers. The criteria PJM uses in developing the RTEP is set forth in PJM Manual 14B – PJM Region Transmission Planning Process.
C. Transmission planning, steady-state criteria

C.1. Planning principles and standards

The transmission system must perform reliably for a wide range of conditions. Because system operators can exercise only limited direct control, it is essential that studies be made in advance to identify the facilities necessary to assure a reliable transmission system in future years.

The voltages and equipment loadings on the transmission system should be within acceptable limits, both during normal operation and for an appropriate range of potential system faults and equipment outages. The more probable contingency conditions should not result in voltages or equipment loadings beyond emergency limits. These ‘emergency limits’ can vary based on equipment type and allowable time period.

Tables 1A and 1B specify outage events that are analyzed by DEV at the forecasted load levels to determine if any thermal or voltage violations exist. Thermal capability is given with equipment ratings in amps or MVA. Voltage limits are in reference to the nominal design voltage. Adherence to the criteria given in these tables ensures that DEV’s transmission system meets the applicable reliability requirements of NERC, SERC, and PJM.

System readjustment is allowed when attempting to reduce line loadings or improve voltage profile (only as allowed by NERC Criteria). System readjustments considered in planning analysis include:

- Generation re-dispatch (excludes nuclear generation)
- Phase angle regulator adjustment
- Load tap changer adjustment
- Capacitor bank switching
- Line switching
- Inductor switching

Loadings on DEV transmission facilities over their normal rating, following a contingency, must be adjusted back down to normal rating within the time frame of the appropriate term emergency rating. Any of the above listed system readjustments are allowable in this situation as DEV employs 8 hour short-term emergency ratings and 15 minute load dump ratings on transmission equipment, which allows sufficient time to implement any adjustments that reduce loadings to the normal rating.

Loadings on facilities over their short-term emergency ratings, following a contingency, must be adjusted back down to the short-term emergency rating within the time frame of the short term emergency rating using the system readjustments listed above.

---

1 For DEV, phase angle regulator adjustment is used to relieve loadings on the 115kV system in Yorktown and Chesapeake Energy areas. Phase shifting transformers control the division of real power among parallel paths. Chesapeake Energy Center and Yorktown Power Station have phase shifters between the 230 kV and 115 kV systems. The phase shifter transfers load from one voltage level to the other. Phase angle adjustment will be allowed within the parameters noted in PJM’s Manual 14B – PJM Region Transmission Planning Process (RTEP Reliability Planning section).
If the criteria described in this document cannot be met, mitigation plans are developed. A valid mitigation plan will bring the system into compliance through the most judicious use of a variety of feasible options. These include the development of an operator action plan in conjunction with the use of short term ratings, generation re-dispatch, phase angle regulator adjustments, bus-tie switching, Remedial Action Schemes, or the installation of a physical reinforcement.

A Remedial Action Scheme (RAS), as interpreted from the NERC Reliability Standards Glossary of Terms, is designed to detect abnormal system conditions and take automatic corrective action to provide acceptable transmission system performance. The RAS isolates equipment other than faulted elements and/or reconfigures equipment outside of a zone containing faulted elements. An RAS may be applied as required to address thermal, voltage, or stability issues in accordance with NERC Transmission Planning (TPL) Standards and is subject to the RAS requirements of NERC Protection and Control (PRC) Standards 012 through 017. An RAS does not include automatic restoration to service of un-faulted elements within a faulted zone, under frequency and under voltage load shedding schemes, conventional generator out of step tripping schemes, or remote backup tripping schemes. DEV reviews all existing RASs periodically and adjusts settings as deemed necessary. DEV primarily installs RASs as a temporary measure until a more robust solution can be completed to provide acceptable system performance. Operating steps implemented as part of a Remedial Action Scheme shall be considered, provided that the failure of such system does not result in cascading outages or overloads.

In addition to those events and circumstances included in Tables 1A and 1B, Table 1C defines more severe but less probable scenarios that should also be considered for analysis to evaluate resulting consequences. As permitted in the NERC Planning Standards, judgment shall dictate whether and to what extent a mitigation plan would be appropriate.
### Table 1A Steady-State Performance PLANNING Events and Dominion Energy CRITERIA

**HIGH VOLTAGE (HV): 230 kV, 138 kV, 115 kV & 69kV Facilities**

<table>
<thead>
<tr>
<th>Category</th>
<th>Initial Condition</th>
<th>Event</th>
<th>Fault Type</th>
<th>Interruption of Firm Transmission Service Allowed</th>
<th>Non-Consequential Load Loss Allowed</th>
<th>Thermal Limits</th>
<th>Low Voltage Limit **</th>
<th>High Voltage Limit **</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0 No Contingency</td>
<td>Normal System</td>
<td>None</td>
<td>N/A</td>
<td>No</td>
<td>No</td>
<td>94% N</td>
<td>95%</td>
<td>105%</td>
</tr>
<tr>
<td>P1 Single Contingency</td>
<td>Normal System</td>
<td>Loss of one of the following: 1. Generator 2. Transmission Circuit 3. Transformer 4. Shunt Device</td>
<td>3Ø</td>
<td>No</td>
<td>No</td>
<td>94% STE</td>
<td>93%</td>
<td>105%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Opening of a line section w/o a fault</td>
<td>N/A</td>
<td>No</td>
<td>No</td>
<td>94% STE</td>
<td>93%</td>
<td>105%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Bus Section Fault</td>
<td>SLG</td>
<td>Yes</td>
<td>Yes</td>
<td>Notes &quot;A&quot;, &quot;B&quot; &amp; &quot;C&quot;</td>
<td>90%</td>
<td>105%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Internal Breaker Fault (non-Bus-tie Breaker)</td>
<td>SLG</td>
<td>Yes</td>
<td>Yes</td>
<td>Notes &quot;A&quot;, &quot;B&quot; &amp; &quot;C&quot;</td>
<td>90%</td>
<td>105%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Internal Breaker Fault (Bus-tie Breaker)</td>
<td>SLG</td>
<td>Yes</td>
<td>Yes</td>
<td>Notes &quot;A&quot;, &quot;B&quot; &amp; &quot;C&quot;</td>
<td>90%</td>
<td>105%</td>
</tr>
<tr>
<td>P2 Multiple Contingency</td>
<td>Loss of generator unit followed by System adjustments</td>
<td>Loss of one of the following: 1. Generator 2. Transmission Circuit 3. Transformer 4. Shunt Device</td>
<td>3Ø</td>
<td>No</td>
<td>No</td>
<td>94% STE</td>
<td>93%</td>
<td>105%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Bus Section</td>
<td>SLG</td>
<td>Yes</td>
<td>Yes</td>
<td>Notes &quot;A&quot;, &quot;B&quot; &amp; &quot;C&quot;</td>
<td>90%</td>
<td>105%</td>
</tr>
<tr>
<td>P4 Multiple Contingency</td>
<td>Normal System</td>
<td>Delayed Fault Clearing due to the failure of a non-redundant relay protecting the Faulted element to operate as designed, for one of the following: 1. Generator 2. Transmission Circuit 3. Transformer 4. Shunt Device 5. Bus Section</td>
<td>SLG</td>
<td>Yes</td>
<td>Yes</td>
<td>Notes &quot;A&quot;, &quot;B&quot; &amp; &quot;C&quot;</td>
<td>90%</td>
<td>105%</td>
</tr>
</tbody>
</table>

*Table 1A continued on next page*
Table 1A Steady-State Performance PLANNING Events and Dominion Energy CRITERIA (continued)

<table>
<thead>
<tr>
<th>Category</th>
<th>Initial Condition</th>
<th>Event</th>
<th>Fault Type</th>
<th>Interruption of Firm Transmission Service Allowed</th>
<th>Non-Consequential Load Loss Allowed</th>
<th>Dominion Energy Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>P6</td>
<td>Normal System</td>
<td>Loss of any two adjacent (vertically or horizontally) circuits on common structure</td>
<td>SLG</td>
<td>Yes</td>
<td>Yes</td>
<td>Notes &quot;A&quot;, &quot;B&quot; &amp; &quot;C&quot;</td>
</tr>
<tr>
<td>P7</td>
<td>Normal System</td>
<td>Loss of one of the following followed by System adjustments: 1. Transmission Circuit 2. Transformer 3. Shunt Device</td>
<td>SLG</td>
<td>Yes</td>
<td>Yes</td>
<td>Notes &quot;A&quot;, &quot;B&quot; &amp; &quot;C&quot;</td>
</tr>
</tbody>
</table>

**Dominion Energy Notes for Table 1A**

See separate listing Table 1 (A & B) Footnotes for superscript numbered footnotes.

Note "A" - For thermal overloads greater than 100% of Load Dump (LD) rating, system reinforcements will be required.

Note "B" - For thermal overloads less than 100% of Load Dump (LD) rating but greater than 100% of Short Term Emergency (STE) rating, system reinforcements may NOT be required if system adjustments can reduce thermal overloads to less than 100% of Short Term Rating (STE).

Note "C" - For thermal overloads less than 100% of Load Dump (LD) rating but greater than 100% of Short Term Emergency (STE) rating, system reinforcements may NOT be required if the loss of consequential load up to 300MW achieves a return to less than the STE rating.

Note "D" - See Section C.2.1.3 – Critical stress case development and studies for details.

Note "E" - Areas of the system that become radial post-contingency will be included for monitoring of thermal and voltage violations for all load levels served by the radial.

** Percent of Nominal Voltage (Note: Voltage limits for North Anna and Surry Power Stations are governed by the requirements of their respective Nuclear Plant Interface Requirements (NPIR) with Dominion Energy Electric Transmission as noted in Section E.3).

N – Normal Rating

STE – Short Term Emergency

LD – Load Dump
### Table 1B Steady-State Performance PLANNING Events and Dominion Energy CRITERIA

**EXTRA HIGH VOLTAGE (EHV): 500kV Facilities**

<table>
<thead>
<tr>
<th>NERC TPL-001 Events (excludes DC)</th>
<th>Dominion Energy Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NERC Category</strong></td>
<td><strong>Initial Condition</strong></td>
</tr>
<tr>
<td>P0</td>
<td>No Contingency</td>
</tr>
<tr>
<td>P1</td>
<td>Single Contingency</td>
</tr>
<tr>
<td>P2</td>
<td>Single Contingency</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>Multiple Contingency [see Dominion Energy Note &quot;I&quot; &amp; &quot;J&quot;]</td>
</tr>
<tr>
<td>P4</td>
<td>Multiple Contingency (Fault plus stuck breaker) [see Dominion Energy Note &quot;J&quot;]</td>
</tr>
<tr>
<td>P5</td>
<td>Multiple Contingency (Fault plus relay failure to operate) [see Dominion Energy Note &quot;J&quot;]</td>
</tr>
</tbody>
</table>

*Table 1B continued on next page*
### Table 1B Steady-State Performance PLANNING Events and Dominion Energy CRITERIA (continued)

**EXTRA HIGH VOLTAGE (EHV): 500kV Facilities**

<table>
<thead>
<tr>
<th>NERC TPL-001 Events (excludes DC)</th>
<th>Dominion Energy Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>NERC Category</td>
<td>Initial Condition</td>
</tr>
<tr>
<td>----------------</td>
<td>-----------------</td>
</tr>
</tbody>
</table>
| P6 Multiple Contingency (Two overlapping singles) [see Dominion Energy Note "J"] | Loss of one of the following followed by System adjustments.  
1. Transmission Circuit  
2. Transformer  
3. Shunt Device | Loss of one of the following:  
1. Transmission Circuit  
2. Transformer  
3. Shunt Device | 3Ø | Yes | Yes | Notes "F", "G" & "H" | 100% | 108% |
| P7 Multiple Contingency (Common Structure) | Normal System | The loss of any two adjacent (vertically or horizontally) circuits on common structure | SLG | Yes | Yes | Notes "F", "G" & "H" | 100% | 108% |

**Dominion Energy Notes for Table 1B**

See separate listing Table 1 (A & B) Footnotes for superscript numbered footnotes.

Note "F" – For thermal overloads greater than 100% of Load Dump (LD) rating, system reinforcements will be required.

Note "G" - For thermal overloads less than 100% of Load Dump (LD) rating but greater than 100% of Short Term Emergency (STE) rating system reinforcements may NOT be required if system adjustments can reduce thermal overloads to less than 100% of Short Term Rating (STE).

Note "H" - For thermal overloads less than 100% of Load Dump (LD) rating but greater than 100% of Short Term Emergency (STE) rating, system reinforcements may NOT be required if the loss of consequential load up to 300MW achieves a return to less than the STE rating.

Note "I" - See Section C.2.1.3 – Critical stress case development and studies for details.

Note "J" - Areas of the system that become radial post-contingency will be included for monitoring of thermal and voltage violations for all load levels served by the radial.

** ** Percent of Nominal Voltage (Note: Voltage limits for North Anna and Surry Power Stations are governed by the requirements of their respective Nuclear Plant Interface Requirements (NPIR) with Dominion Energy Electric Transmission as noted in Section E.3).

N – Normal Rating

STE – Short Term Emergency

LD – Load Dump
# Table 1C Steady-State Performance EXTREME Events and Dominion Energy CRITERIA

<table>
<thead>
<tr>
<th>Category</th>
<th>Event Note &quot;K&quot;</th>
<th>Interruption of Firm Transmission Service Allowed</th>
<th>Non-Consequential Load Loss Allowed</th>
<th>Dominion Energy Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>N-2 Two Contingencies</td>
<td>Loss of a single generator, Transmission Circuit, shunt device, or transformer forced out of service followed by another single generator, Transmission Circuit, shunt device, or transformer forced out of service prior to System adjustments.</td>
<td>YES</td>
<td>YES</td>
<td>100% LD</td>
</tr>
<tr>
<td>LAE Local Area Events</td>
<td>a. Loss of a tower line with three or more circuits.11</td>
<td>YES</td>
<td>YES</td>
<td>100% LD Note &quot;L&quot;</td>
</tr>
<tr>
<td></td>
<td>b. Loss of all Transmission lines on a common Right-of-Way.12</td>
<td>YES</td>
<td>YES</td>
<td>100% LD Note &quot;M&quot;</td>
</tr>
<tr>
<td></td>
<td>c. Loss of a switching station or substation (loss of one voltage level plus transformers).</td>
<td>YES</td>
<td>YES</td>
<td>100% LD Note &quot;N&quot;</td>
</tr>
<tr>
<td></td>
<td>d. Loss of all generating units at a generating station.</td>
<td>YES</td>
<td>YES</td>
<td>100% LD Note &quot;O&quot;</td>
</tr>
<tr>
<td></td>
<td>e. Loss of a large Load or major Load center.</td>
<td>YES</td>
<td>YES</td>
<td>100% LD Note &quot;P&quot;</td>
</tr>
<tr>
<td>WAE Wide Area Events</td>
<td>a. Loss of two generating stations resulting from conditions such as:</td>
<td>YES</td>
<td>YES</td>
<td>100% LD for both HV and EHV</td>
</tr>
<tr>
<td></td>
<td>i. Loss of a large gas pipeline into a region or multiple regions that have significant gas-fired generation.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ii. Loss of the use of a large body of water as the cooling source for generation.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>iii. Wildfires.</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>iv. Severe weather, e.g., hurricanes, tornadoes, etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>v. A successful cyber attack.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>vi. Shutdown of a nuclear power plant(s) and related facilities for a day or more for common causes such as problems with similarly designed plants.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Other events based upon operating experience that may result in wide area disturbances.</td>
<td>YES</td>
<td>YES</td>
<td></td>
</tr>
</tbody>
</table>

** Percent of Nominal Voltage (Note: Voltage limits for North Anna and Surry Power Stations are governed by the requirements of their respective Nuclear Plant Interface Requirements (NPIR) with Dominion Energy Electric Transmission as noted in Section E.3).

N – Normal Rating, STE – Short Term Emergency, LD – Load Dump

**Dominion Energy Notes for Table 1C**

See separate listing Table 1 (A, B & C) Footnotes for superscript numbered footnotes.

Note "K" – For all extreme events evaluated:
- Simulate the removal of all elements that Protection Systems and automatic controls are expected to disconnect for each Contingency.
- Simulate Normal Clearing unless otherwise specified.

Note "L" – The loss of three or more transmission circuits on a common structure should not result in cascading outages beyond the load area.
immediately involved. The overall supply system to a major load area should be able to withstand the loss of all circuits on a common structure and still supply most of the load in the area with tolerable voltage (at least 90% of nominal). A major load area would be an area similar to the Norfolk/Virginia Beach area or the Northern Virginia area.

Note "M" – The loss of transmission circuits on a common right of way should not result in cascading outages beyond the load area immediately involved. The overall supply system to a major load area should be able to withstand the loss of all circuits on a common right of way and still supply most of the load in the area with tolerable voltage (at least 90% of nominal). A major load area would be an area similar to the Norfolk/Virginia Beach area or the Northern Virginia area.

Note "N" – The loss of a switching station or substation (one voltage level plus transformers) should not result in cascading outages or intolerably low voltages (less than 90% of nominal voltage) nor should any overhead transmission facility be loaded to more than its load dump rating during the period required to make prompt power supply adjustments to reduce overloads to less than its emergency rating (STE). The consequential load due to the loss in the affected station is not to exceed 300 MW.

Note "O" – The loss of all generation at a generating station should not result in cascading outages or intolerably low voltages (less than 90% of nominal voltage) nor should any overhead transmission facility be loaded to more than its load dump rating during the period required to make prompt power supply adjustments to reduce overloads to less than its emergency rating (STE).

Note "P" – The loss of a large load or major load center should not result in cascading outages or intolerably low voltages (less than 90% of nominal voltage) nor should any overhead transmission facility be loaded to more than its load dump rating during the period required to make prompt power supply adjustments to reduce overloads to less than its emergency rating (STE).

Note "Q" - High Voltage (HV): 105%; Extra High Voltage (EHV): 108%
Table 1 (A, B & C) Footnotes [NERC Standard TPL-001-4]

1. If the event analyzed involves BES elements at multiple System voltage levels, the lowest System voltage level of the element(s) removed for the analyzed event determines the stated performance criteria regarding allowances for interruptions of Firm Transmission Service and Non-Consequential Load Loss.

2. Unless specified otherwise, simulate Normal Clearing of faults. Single line to ground (SLG) or three-phase (3Ø) are the fault types that must be evaluated in Stability simulations for the event described. A 3Ø or a double line to ground fault study indicating the criteria are being met is sufficient evidence that a SLG condition would also meet the criteria.

3. Bulk Electric System (BES) level references include extra-high voltage (EHV) Facilities defined as greater than 300kV and high voltage (HV) Facilities defined as the 300kV and lower voltage Systems. The designation of EHV and HV is used to distinguish between stated performance criteria allowances for interruption of Firm Transmission Service and Non-Consequential Load Loss.

4. Curtailment of Conditional Firm Transmission Service is allowed when the conditions and/or events being studied formed the basis for the Conditional Firm Transmission Service.

5. For non-generator step up transformer outage events, the reference voltage, as used in footnote 1, applies to the low-side winding (excluding tertiary windings). For generator and Generator Step Up transformer outage events, the reference voltage apply to the BES connected voltage (high-side of the Generator Step Up transformer). Requirements which are applicable to transformers also apply to variable frequency transformers and phase shifting transformers.

6. Requirements which are applicable to shunt devices also apply to FACTS devices that are connected to ground.

7. Opening one end of a line section without a fault on a normally networked Transmission circuit such that the line is possibly serving Load radial from a single source point.

8. An internal breaker fault means a breaker failing internally, thus creating a System fault which must be cleared by protection on both sides of the breaker.

9. An objective of the planning process should be to minimize the likelihood and magnitude of interruption of Firm Transmission Service following Contingency events. Curtailment of Firm Transmission Service is allowed both as a System adjustment (as identified in the column entitled 'Initial Condition') and a corrective action when achieved through the appropriate re-dispatch of resources obligated to re-dispatch, where it can be demonstrated that Facilities, internal and external to the Transmission Planner’s planning region, remain within applicable Facility Ratings and the re-dispatch does not result in any Non-Consequential Load Loss. Where limited options for re-dispatch exist, sensitivities associated with the availability of those resources should be considered.

10. A stuck breaker means that for a gang-operated breaker, all three phases of the breaker have remained closed. For an independent pole operated (IPO) or an independent pole tripping (IPT) breaker, only one pole is assumed to remain closed. A stuck breaker results in Delayed Fault Clearing.

11. Excludes circuits that share a common structure (Planning event P7, Extreme event steady state 2a) or common Right-of-Way (Extreme event, steady state 2b) for 1 mile or less.

12. An objective of the planning process is to minimize the likelihood and magnitude of Non-Consequential Load Loss following planning events. In limited circumstances, Non-Consequential Load Loss may be needed throughout the planning horizon to ensure that BES performance requirements are met. However, when Non-Consequential Load Loss is utilized under footnote 12 within the Near-Term Transmission Planning Horizon to address BES performance requirements, such interruption is limited to circumstances where the Non-Consequential Load Loss meets the conditions shown in Attachment 1. In no case can the planned Non-Consequential Load Loss under footnote 12 exceed 75 MW for US registered entities. The amount of planned Non-Consequential Load Loss for a non-US Registered Entity should be implemented in a manner that is consistent with, or under the direction of, the applicable governmental authority or its agency in the non-US jurisdiction.

13. Applies to the following relay functions or types: pilot (#85), distance (#21), differential (#87), current (#50, 51, and 67), voltage (#27 & 59), directional (#32, & 67), and tripping (#86, & 94).
C.1.1. Voltage limits at generating stations

Plant auxiliary power equipment requires adequate voltages in order to maintain reliable operation of online generators as well as to provide for reliable startup capability for offline generators. Minimum transmission voltage limits specific to generating stations, are used to ensure plant auxiliary equipment is provided with adequate voltages during both online and offline operation. These limits apply to all classes of generation except wind turbines, for which the system transmission voltage limits are adequate.

In cases where plant auxiliary power is supplied by power transformers not equipped with a load tap changer (LTC) or equivalent voltage control device, the voltage limits at the low side of the Generator Step-up Unit (GSU) are established as 0.95 per unit (minimum) and 1.05 per unit (maximum) unless otherwise specified by the generator owner.

C.2. Detailed steady-state criteria

C.2.1. System load level

C.2.1.1. Peak period studies

The peak load period must be studied to determine future requirements for the transmission system. The basic references for system peak load to be used in studies for future years are the total corporate system load projection provided by the PJM Load Analysis. The actual peak load in any given future year is likely to be higher or lower than the forecast value. A '50/50' forecast provides a peak load projection with a 50% probability that the actual peak will be higher than the level forecasted in that year.

C.2.1.2. Off-peak period studies

Studies should also be conducted for the purpose of determining risks and consequences at light load or shoulder peak conditions, and for any other period for which system adequacy cannot be evaluated from peak period study results. For these off peak periods, it is assumed that the number of hours of occurrence is substantially higher than the number of hours at or near peak load levels. In addition, severe drought conditions effecting hydro generation plant availability and its impact on the transmission system are also studied.

C.2.1.3. Critical stress case development and studies

DEV studies the transmission system under both normal and critical system stress conditions. For NERC Category P3 Analysis, DEV will outage the most critical generator in the area being studied, and the resulting power flow case is considered a critical stress case. Under this critical stress case condition, the generator being studied is taken off-line and the remaining generators connected to the DEV System are proportionally increased to make-up for the
lost generation. If there are not enough generation resources available within the DEV system, or the use of DEV generation resources would not provide an adequate base case, then PJM generation resources should be utilized to make-up any generation deficiency. This resulting critical stress case is then analyzed for NERC Compliance based on the transmission contingency events listed in Table 1A and Table 1B Category P3(Multiple Contingency).

C.2.2. Power transfers

All studies should consider known firm power transfers affecting the DEV transmission system. This includes known firm transmission service reservations, including those with rollover rights, as well as parallel path power transfers through the system that may impact system reliability.

DEV is part of a larger regional power system that must be capable of withstanding certain levels of power transfers between or through sub areas of the region. PJM conducts load and generator deliverability tests for specific sub areas as part of the Regional Transmission Expansion Plan (RTEP) process to determine whether the system can accommodate these transfers. The DEV transmission system must meet this transfer Load and Generator Deliverability Requirement. A description of the deliverability testing procedures can be found in PJM Manual 14B – PJM Region Transmission Planning Process. SERC Reliability Corporation also performs transfer limit testing to trend the strength of the transmission system. The results of these studies may also indicate a need to increase transfer strength on the DEV system.

DEV routinely tests the capability of the transmission system to transfer reasonable amounts of power (approximately 2000 MW) in excess of firm purchases, sales and transfers, between and among the Company and the neighboring utilities. Such tests are conducted under two basic scenarios: (1) with all transmission facilities in service at or below the maximum continuous normal rating; and (2) with one transmission circuit or transformer out of service while maintaining the loading on all remaining transmission facilities at or below the maximum continuous emergency rating. Any new facilities connected to the transmission system shall not significantly decrement, the First Contingency Incremental Transfer Capability (FCITC) for transfers between utilities. A FCITC decrement in excess of 5% will be considered significant in most cases.

C.2.3. Equipment ratings

Allowable loadings for transmission facilities are maintained by DEV in an equipment ratings database. In most cases, equipment is given at least a normal rating and one emergency rating. Some equipment is given multiple emergency ratings. These ratings differ by allowable duration, and are referred to as short-term, long-term, and load dump.

The specific procedure used for determining equipment ratings is outlined in the DEV Transmission Facility Ratings Methodology technical reference document.
C.2.4. Circuit breaker interrupting capability

All Facilities must equal or exceed the fault duty capability necessary to meet system short circuit requirements as determined through short circuit analyses, and shall fully comply with the latest ANSI/IEEE C37 standards for circuit breakers, switch gear, substations, and fuses.

Under normal conditions, the current through a circuit breaker shall not exceed the maximum continuous ratings of that breaker. Further, a circuit breaker shall have sufficient capability to interrupt a close-in single phase fault or three phase-to-ground fault.

C.2.5. Reactive power planning

The objective of system reactive power planning is to efficiently coordinate the reactive requirements of the transmission and distribution systems to satisfy voltage criteria. Meeting this objective ensures voltage stability, provides generator auxiliary power systems on the distribution system with adequate voltage, and minimizes transmission losses and reactive interchange. System reactive requirements can be controlled by changing generation excitation, operating synchronous condensers, changing transformer tap positions, switching transmission and distribution level static capacitors, switching shunt reactors, and adjusting solid-state reactive compensation devices (SVCs, etc.).

The DEV system is planned so that transmission voltages will be maintained within an acceptable range for normal and emergency conditions as described in Tables 1A and 1B.

Low transmission voltage will lead to undesirable effects in both the transmission and distribution systems, such as higher losses, reduced insulation life, and reduced effectiveness of capacitors. These effects would also increase the difficulty in recovering from low transmission voltage situations. The outage events analyzed to assess voltage adequacy are the same as those listed in Tables 1A and 1B. Distribution facilities which are maintaining power factors at the Transmission Point of Interconnection (POI) that are less than PJM’s requirement (per Manual 14B – PJM Region Transmission Planning Process) and DEV’s requirement (97.3% lagging) may not be able to maintain satisfactory voltage to customers served from these distribution facilities when transmission system voltages are at or near the lower voltage limits of normal and emergency transmission system operations.

Conversely, high transmission voltages that exceed operating voltage schedules can stress generation, distribution, and transmission equipment and lead to premature fatigue or even failure.

C.2.6. Radial transmission lines

A Radial transmission line is defined as a single line that has one transmission source, serves load, and does NOT tie to any other transmission source (line or substation).
Unlike load served from a network transmission line having two sources where a
downed conductor or structure can be sectionalized for load to be served before repairs
are completed, load served from a single source radial transmission line cannot be
reenergized until all repairs to the line are completed. Accordingly, loading on single
source radial transmission lines will be limited to the following:

- 100 MW Maximum
- 700 MW-Mile Exposure (MW-Mile = Peak MW X Radial Line Length)

Once a radial loading limit exceeds any of these thresholds, an additional transmission
source is required. Acceptable transmission source includes but is not limited to the
following:

- Network from a separate transmission substation source (Preferred)
- Loop back to same transmission substation source
- Normally open network or loop transmission source

C.2.7. Network transmission lines – Limitations on direct-connect loads

A network transmission line is defined as one that connects two network transmission
sources (connect to other lines & substations) and a "Tap point" is defined as a direct
connection of a customer to a network transmission line without addition of any
transmission breaker or breakers to split the line. Network transmission lines facilitate
network flows and could serve directly connected (Tapped) loads. In the Dominion
Energy system, 500, 230, 138, 115 and 69kV lines are considered transmission, and all
with the exception of 500kV could be tapped to serve customer load.

In general, the number of direct-connect loads (tapped facilities) should be limited to
four (4); however, Good Utility Practice and sound engineering judgment must be
exercised in application of this criteria.

C.2.8. Substation – Limitation on direct-connect loads

The amount of direct-connect load at any substation will be limited to 300MW.

C.2.9. End of life criteria

Electric transmission infrastructure reaches its end of life as a result of many factors.
Some factors such as extreme weather and environmental conditions can shorten
infrastructure life, while others such as maintenance activities can lengthen its life. Once
end of life is recognized, in order to ensure continued reliability of the transmission grid,
a decision must be made regarding the best way to address this end-of-life asset.

For this criterion, "end of life" is defined as the point at which infrastructure is at risk of
failure, and continued maintenance and/or refurbishment of the infrastructure is no
longer a valid option to extend the life of the facilities consistent with Good Utility
Practice and Dominion Energy Transmission Planning Criteria. The infrastructure to be
evaluated under this end-of-life criteria are all transmission lines at 69 kV and above.
The decision point of this criterion is based on satisfying two metrics:

1) Facility is nearing, or has already passed, its end of life, and
2) Continued operation risks negatively impacting reliability of the transmission system.

For facilities that satisfy both of these metrics, this criterion mandates either replacing these facilities with in-kind infrastructure that meets current Dominion Energy standards or employing an alternative solution to ensure the Dominion Energy transmission system satisfies all applicable reliability criteria.

Dominion Energy will determine whether the two metrics are satisfied based on the following assessment:

1. End of Life

Factors that support a determination that a facility has reached its end of life include, but are not limited to,

- **Condition** of the facility, taking into consideration:
  - Industry recommendations on service life for the particular type of facility
  - The facility’s performance history
    - Documented evidence indicating that the facility has reached the end of its useful service life
  - The facility’s maintenance and expense history
- **Third-party assessment** - While not required, Dominion Energy has the option of seeking a third-party assessment of a facility to determine if industry specialists agree the facility has reached the end of its useful service life

2. Reliability and System Impact

The reliability impact of continued operation of a facility will be determined based on a planning power flow assessment and operational performance considerations. The end-of-life determination for a facility to be tested for reliability impact will be assessed by evaluating the impact on short and long term reliability with and without the facility in service in the power flow model. The existing system with the facility removed will become the base case system for which all reliability tests will be performed.

The primary four (4) reliability tests to be considered are:

1. NERC Reliability Standards
2. PJM Planning Criteria - As documented in PJM Manual 14B – PJM Region Transmission Planning Process
3. Dominion Energy Transmission Planning Criteria contained in this
document
4. Operational Performance – This test will be based on input from PJM and/or Dominion Energy System Operations as to the impact on reliably operating the system without the facility

Additional factors to be evaluated under system impact may include but not be limited to:

1. Market efficiency
2. Stage 1A ARR sufficiency
3. Public policy
4. SERC reliability criteria

Failure of any of these reliability tests, along with the end-of-life assessment discussed herein, will indicate a violation of the End-of-Life Criteria and necessitate replacement as mandated earlier in this document.

After the end of service life and reliability impact of a facility are evaluated and it has been determined that the facility violates the End-of-Life Criteria, a determination will be made as to whether replacement of the facility is the most effective solution for an identified reliability need, or whether an alternative solution should be employed. One or more of the following factors may be considered in determining whether to proceed with facility replacement or with an alternative solution:

- Planning analysis which may include power flow studies
- Operational performance
- System Reliability
- Effectiveness of the alternative as compared to the replacement facility
- Future load growth in the study area
- Future transmission projects or interconnects that impact the study area
- Constructability comparison
- Cost comparison

C.3. Selection of generation dispatch used in DEV Power Flow Studies

The PJM RTEP Power Flow case for the year under study is the starting point for DEV Power Flow Studies. The generation dispatch in the PJM RTEP case is developed based on PJM’s Study Methodologies as outlined in PJM’s Manual 14B. DEV may modify this generation dispatch to develop a Base Power Flow case which is used as the starting point of DEV’s Analysis to support PJM’s RTEP Study Process. These modifications may include the following:

- Generating Units which have significant environmental limitations which severely limit the units availability in real time operation may be modeled as
being off-line.

- Generating Units which have been identified in DEV’s IRP Filings in Virginia/North Carolina as being “Potential” Generation Retirements may be modeled as being off-line.

- Known outages of a generating unit which are consistent with NERC TPL-001 selection criteria may be modeled as being off-line.

The base power flow dispatch provided to DEV in a power flow case which is used to analyze the reliability impact (Feasibility Study/System Impact Study) of generators in the PJM Generation Queue is typically modified by DEV. Since the case provided to DEV typically has all queue generation located on the DEV System as being off-line, DEV will modify the generation dispatch for power flow studies. Specifically, will turn on all higher order queue generators then the queue request under study as the base case condition for the generator under study. To account for this additional generation, generators located on the PJM System are proportional re-dispatched to account for this additional generation.

D. Transmission planning, system stability criteria

D.1. Introduction

There are many different variables that affect the results of a stability study. These factors include:

- pre-fault and post-fault system configuration
- system load level and load characteristics
- generation dispatch patterns and unit dynamic characteristics
- type and locations of system disturbances
- total fault clearing time(s)
- the amount of flow interrupted as a result of switching out a faulted element
- level of detail and accuracy of available models/data
- proximity to other generating units

Many of these factors change in the operating arena on a continuous basis. Every effort should be made to evaluate the most severe, yet credible/probable combinations of line/faults/equipment failures in planning arena. If the system operating condition is known a couple of days in advance of any scheduled maintenance outage, a more accurate assessment/analysis can be performed which could be more restrictive or less restrictive than the ones studied in planning arena.

D.2. General criteria

The criteria for performing stability simulations near generating stations on the Dominion Energy Virginia (DEV) system supports PJM in its role as Transmission Planner (TP).

For breaker failure backup clearing, it will be assumed that only one pole fails to operate where
three separate mechanisms (independent poles) are available as in the case of all 500 kV
breakers on DEV system. Stability analysis is not required for units that are not part of the Bulk
Electric System (BES) as defined by NERC. In general, generators rated 20 MVA or less in size
and with aggregate plant capacity less than or equal to 75 MVA are not part of the BES. The
results of stability studies are generally valid for about 15 to 20 seconds following a
disturbance. Therefore, disturbance simulations will be carried out to 15 to 20 seconds. The
transformer taps are fixed at the pre-disturbance level throughout the simulations since the tap
movements take more than 30 seconds.

D.3. Study horizon

Generally, stability studies are performed for the near-term horizon (1-5 years) since the
required corrections, if and when warranted, are generally of the following types and can be
implemented in a relatively short period of time:

- Shorten the fault clearing time(s) by resetting breaker failure timer(s), replacing relays, or
  replacing circuit breakers
- Add dual primary protection schemes to mitigate delayed clearing
- Add or tune a power system stabilizer (PSS)
- Apply Remedial Action Scheme (RAS)
- Add out-of-step (OOS) protection
- Install series capacitors
- Establish operating restrictions for a contingency period of short duration covering forced
  or maintenance outages.

There are several other reasons stability studies concentrate in the near-term horizon. The
system representation (load, generation, etc.) in study base cases for a long-term horizon (6-10
years) is inherently uncertain from a dynamics perspective. Some of the future generation in
these cases may not materialize and hence may yield erroneous results indicating either
unnecessary improvements or a false sense of security. A large number of merchant plants
have been delayed or cancelled altogether in the past. The delays or cancellations of such
merchant plants require re-studies. The further one goes out in study time horizon, the
possible combinations of such uncertainties multiply. Since stability studies are very time
consuming, extensive long-term studies become impractical. SERC has recognized this and has
acknowledged in its supplement that stability studies for a longer-term planning horizon are
not required for full compliance except for new generation that falls into the long-term study
horizon.

For identified stability problems that cannot be remedied with the aforementioned solutions,
i.e. the probability of the operating condition and/or contingency occurring is deemed high,
new transmission infrastructure may be required to ensure stability for safe and reliable
operation of the electric grid. In cases where a near-term horizon stability study indicates a
potential correction that may require much longer lead time, such as requiring a new
transmission line, or if a Generation Interconnection request is for a long-term horizon, the
long-term stability study would then be performed.
D.4. Study cycle

It is not practical to perform dynamic simulations for all generating plants every year for all categories listed in Table 1 of the TPL Standards. Therefore, PJM will perform simulations to cover all generating plants over a three-year study cycle unless changing system conditions warrant a shorter interval. In case of a new generation addition or a capacity addition to an existing plant, it should be properly studied prior to its in-service date. Stability analysis in such cases will first be performed by PJM as the Generation Interconnection queue administrator. DEV will review the results of PJM stability analysis and perform any subsequent analysis, if and when deemed necessary.

D.5. Dynamics data collection


Dominion Energy Electric Transmission Planning is responsible for submitting dynamic data to PJM for Transmission Owner equipment with dynamic characteristics such as SVCs and STATCOMs.

D.6. Selection of a reference power flow case

Planning arena studies for stability analysis are performed using an estimated snap-shot of the expected system operating conditions for the study period selected. The power flow base cases that match dynamics data for the Eastern Interconnection are prepared by the Multi-regional Modeling Working Group (MMWG) for selected years on an annual basis. The dynamically reduced SERC cases are prepared using three of the MMWG cases, generally every other year. The internal DEV power flow base cases are updated on a regular basis to incorporate the most updated information on facility ratings/upgrades, load, etc.

It is a general practice to incorporate the DEV system representation from the most updated internal base case for the study year into one of the SERC reduced base cases depending on the study year. A validation review is then performed on the combined case to make sure that the stability case thus prepared initializes error free and a 30-second “Drift Run” is performed to insure that the steady-state stability is maintained. This is steady-state condition, NERC TPL-001, Category P0.

D.7. Selection of generation dispatch

The economic dispatch used in internal power flow base cases may not represent conditions which could pose a stability risk. Therefore, the power flow cases may be stressed to test the area or generation under study. For example, increased transfers near generating facilities can have an adverse impact on transient stability and therefore need to be accounted for when creating stressed yet credible system dispatches for the stability studies.

Unit dispatch for transient stability studies also differs from the conventional power flow analysis. Units in the study region are generally dispatched to maximum real power output (Pmax), and at leading power factor at the low side of the GSU provided that the equipment voltage limits are not violated. Specifically, units under study and electrically close that fall
within the study region\(^2\) should be dispatched to absorb approximately 50% of the minimum reactive capability (Q\(_{\text{min}}\)) without violating the terminal voltage limits (generally 0.95 pu).

**D.8. Selection of contingencies**

In general, contingency simulations are based on Table 1 of NERC Reliability Standard TPL-001-4. However, all contingencies may not be applicable in a given study due to either breaker arrangement or type of protection scheme employed. Also, if the stability is maintained for a more severe fault condition (e.g. three-phase or two-phase-to-ground), it is not necessary to simulate a fault of less severity (e.g. single-phase-to-ground). If identical equipment is removed from service due to a fault at various locations in a substation, leaving identical post-fault/post-switching system condition, it is not necessary to apply the fault at more than one of such locations. Much depends on the type of station equipment, station arrangement and type of protection schemes applied at a given location.

As for simulating transmission line faults, if there are only two lines from a plant, both should be tested using different power flow cases with different dispatch patterns (see Selection of Generation Dispatch above), faulting the line with highest flow in each case. For a multiple line station, the line carrying the highest power should be the first one to be selected and the remaining lines(s) should be selected based on system experience and sound engineering judgment. In case of any doubt, faults on all lines may need to be simulated. If stability is maintained for a more severe fault scenario (e.g. 3-phase fault), a less severe fault scenario (e.g. SLG) need not be simulated everything else remaining same.

If a line length is short, it may be necessary to check contingencies at the next station. For breaker-failure scenarios, contingencies are selected that would simulate the weakest system condition based on station breaker arrangement and system knowledge. If the failed breaker would trip a generating unit(s) due to breaker arrangement, that contingency may be omitted depending on the results of more severe contingencies.

The voltage stability analysis shall first be performed by power flow studies. Once potential voltage instability problem is identified in a power flow study (or observed in the field), a time-domain analysis shall then be performed for confirmation and mitigation of the problem.

**D.9. What to look for in study results**

Checks are performed to make sure all on-line units initialize properly without any error messages. A 30-second "drift run" should be performed prior to any stability analysis to ensure successful initialization. This corresponds to the steady-state condition defined as Category "P0" in Table 1 of NERC TPL-001.

Checks are performed to make sure the system is stable with acceptable voltages for selected contingencies, and the damping ratio is 3% or better for inter-area oscillations and 4% or better for local mode oscillations. Solutions identified in section D3 are considered for situations where transient voltage or oscillation damping is not met, or if transient stability is not maintained. If the inter-area oscillations have an unacceptable damping ratio and other entities’ units are found to be participating significantly, then it may require a joint study between the affected parties. Power system stabilizers are recommended, especially if

\(^2\) Engineering judgment must be applied in selecting the generators that electrically close to unit(s) under study.
oscillation damping criteria is marginally satisfied. N-1-1 contingencies with no redispatch are considered to ensure transient stability is maintained with positive damping. This provides a safety margin for any planned conditions and/or unexpected contingencies that could occur. If the oscillation damping is positive but does not meet the criteria above, operation restriction may be applied to ensure sufficient oscillation damping for both local and inter-area modes of oscillations. Generator out-of-step (OOS) protection is highly recommended on all BES generating units to ensure the protection and safety of the generator itself.

For system conditions and selected contingencies that results in generator transient instability, additional analysis is performed to quantify the risk of cascading events and potential for blackout conditions. Cascading failure analysis will consider a risk-based study of the loss of the generating unit based on expected protection and control as well as unexpected tripping. Depending on the size and expanse of the affected area, other solution options, operating restrictions, or transmission investments may be considered.

Since the transmission planning studies are performed for an estimated operating condition for a future date, the post disturbance thermal loading and voltage levels may vary widely when real disturbance occurs. This is because the load, generation dispatch and available reactive resources in real time may be quite different than the ones studied in planning arena. For this reason, the thermal limits and voltage conditions should be checked using the real-time contingency analysis tool.

D.10. Implementation procedure

Stability analysis may warrant corrections or additional requirements in order to meet the stability criteria listed in this document. The implementation procedure for such items depends on the type of corrections warranted and the nature of installation. The following is a general guideline for Transmission Planning to get such fixes implemented.

D.10.1. For existing installations

- Corrections related to transmission fault clearing times near generating stations that can be resolved by changes to existing relay set points shall be communicated to Electric Transmissions Circuit Calculations group for implementation. PJM should also be informed as to the results of this analysis.

- A Capital project shall be generated for corrections related to transmission fault clearing times near generation stations that require baseline improvements such as new or additional equipment. All Capital projects shall first be validated, approved and assigned cost and construction responsibility by the PJM Regional Transmission Expansion Planning (RTEP) process.

- Output restrictions and/or unit trip(s) for the next pending contingency condition identified by DEV in routine planning studies, will be communicated to the SOC. In turn, the SOC shall inform PJM for implementation as appropriate.

- In case of scheduled maintenance or construction outages, the results/recommendations shall be conveyed to the person through whom
the stability analysis request came to the stability engineers. For example, if a Project Manager requests such analysis to the load Planning Engineer, the stability engineer shall forward his analysis to the load Planning Engineer. If SOC requests such analysis, the results/recommendations shall be forwarded to SOC which in turn shall inform PJM for implementation as appropriate.

D.10.2. For new installations or capacity additions

New generating resources are studied as part of the PJM Generation Interconnection Queue process. PJM shall document the fault clearing time requirements and/or any additional protection requirements in its Impact Study report. PJM shall also communicate the requirements on the generation side to the GO requesting the Interconnection in PJM Queue. For the transmission related requirements, Dominion Energy shall communicate these to the Substation Engineering group for design and implementation.

E. Nuclear plant interface coordination

E.1. Introduction

Nuclear power plants have special needs for backup station service not found in other plants. In order to safely shut down a nuclear unit, the station service must have an adequate supply of power under tight voltage tolerances to the safety systems. Although nuclear plants have diesel generators as a backup supply, their preferred power source is the transmission grid. This allows multiple levels of redundancy which is the hallmark of the nuclear plant's endeavor to the highest level of safety.

E.2. NRC regulations

The Federal Nuclear Regulatory Commission (NRC) lays out certain regulations on the design and operation of Nuclear Plants. Appendix A of Regulation 10 CFR 50 "General Design Criteria for Nuclear Power Plants" states:

"Criterion 17--Electric power systems. An onsite electric power system and an offsite electric power system shall be provided to permit functioning of structures, systems, and components important to safety. The safety function for each system (assuming the other system is not functioning) shall be to provide sufficient capacity and capability to assure that (1) specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences and (2) the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents.

The onsite electric power supplies, including the batteries, and the onsite electric distribution system, shall have sufficient independence, redundancy, and testability to perform their safety functions assuming a single failure.

Electric power from the transmission network to the onsite electric distribution system shall be supplied by two physically independent circuits (not necessarily on separate
rights of way) designed and located so as to minimize to the extent practical the likelihood of their simultaneous failure under operating and postulated accident and environmental conditions. A switchyard common to both circuits is acceptable. Each of these circuits shall be designed to be available in sufficient time following a loss of all onsite alternating current power supplies and the other offsite electric power circuit, to assure that specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded. One of these circuits shall be designed to be available within a few seconds following a loss-of-coolant accident to assure that core cooling, containment integrity, and other vital safety functions are maintained.

Provisions shall be included to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit, the loss of power from the transmission network, or the loss of power from the onsite electric power supplies."

The above regulation General Design Criterion 17 is often abbreviated “GDC-17.”

E.3. Design requirements

PJM and Dominion Energy Electric Transmission Planning will design the system to meet the GDC-17 requirements. In order to provide adequate voltage to safety systems, the Nuclear group periodically provides Nuclear Plant Interface Requirements (NPIR) to Dominion Energy Electric Transmission. Dominion Energy transmission planners should consult the latest version of applicable Interface Agreements between Dominion Energy Electric Transmission and the nuclear plants for applicable normal and emergency voltage limits, voltage drops and contingency scenarios.

Because emergency systems require adequate voltage immediately following an event, transmission LTC’s should be locked post-contingency.

For violations of the NPIRs, the transmission planner will contact the GDC-17 coordinator for Electric Transmission Planning. PJM/Dominion Energy Electric Transmission Planning will notify Dominion Energy Nuclear of any NPIR criteria violations. Transmission study criteria violations based on standard PJM/Dominion Energy criteria testing will be handled by the procedures described in the PJM agreements and manuals. For study violations that are beyond applicable PJM criteria, Dominion Energy Nuclear will determine if any further action is required and respond to Dominion Energy Electric Transmission Planning. Dominion Energy Electric Transmission Planning will work with PJM to resolve concerns identified by Dominion Nuclear.

For contingencies more severe than those within the NPIRs, standard planning voltage range criteria will be applied.

E.4. Underfrequency studies

The underfrequency load shed program (UFLS) should be designed to coordinate with station underfrequency trip settings. The North Anna reactor coolant pump (RCP) is set to trip at 56.55 Hz with a time delay of 100 milliseconds. The Surry reactor coolant pump (RCP) is set to trip at 58.05 Hz with a time delay of 100 milliseconds.
E.5. Angular stability studies

Angular stability studies are performed on nuclear plants using the standard methodology used for any synchronous machine. The results of these studies should be forwarded to Nuclear Engineering.

E.6. System analysis protocol

The Nuclear Switchyard Interface Agreement System Analysis Protocol (CO-AGREE-000-IA1-4 or its successor) outlines the types and frequency of studies which may be performed in support of the nuclear plant. It also specifies the type of communications necessary and the frequency of the analysis. In order to show compliance with NERC Standard NUC-001-2 (or its successor), the GDC-17 coordinator shall retain evidence of communications with the appropriate nuclear contacts.

E.7. Changes to the system

The NERC standard NUC-001-2, R8 states that the “…Transmission Entities shall inform the Nuclear Plant Generator Operator of actual or proposed changes to electric system design, configuration, operations, limits, protection systems, or capabilities that may impact the ability of the electric system to meet the NPIRs.”
F. References

- NERC Planning Standard TPL-001
- Transmission System Performance SERC Supplement
- NERC Reliability Standard NUC-001
- Nuclear Switchyard Interface Agreement CO-AGREE-000-IA1
- Nuclear Switchyard Interface Agreement System Analysis Protocol CO-AGREE-000-IA1-4
- PJM Manual 39 – Nuclear Plant Interface Coordination
- Manual 14B – PJM Region Transmission Planning Process

G. Abbreviations & definitions

- **AAR** - Auction Revenue Rights (see PJM Manual 06 – Financial Transmission Rights for more details)
- **ANSI** - American National Standards Institute
- **ERAG** - Eastern Interconnection Reliability Assessment Group
- **FCITC** - First Contingency Incremental Transfer Capability
- **Good Utility Practice** - Any of the practices, methods, and acts engaged in or approved by a significant portion of the electric utility industry during the relevant time period, or any of the practices, methods and acts that, in the exercise of reasonable judgment in light of the facts known at the time the decision is made, could have been expected to accomplish the desired result at a reasonable cost consistent with good business practices, reliability, safety and expedition.
- **GSU** - Generator Step-up Transformer
- **IEEE** - Institute of Electrical and Electronic Engineers
- **MMWG** - Multi-Regional Modeling Working Group
- **NERC** - North American Electric Reliability Corporation
- **POI** - Point of Interconnection
- **RTO** - Regional Transmission Organization
- **PSS** - Power System Stabilizer
- **SERC** - SERC Reliability Corporation
H. Revision History

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*For these revisions, the planning guideline was an attachment within the DEV facilities connection requirements document. Associated comments for these revisions do not necessarily apply to the contents of the planning guideline specifically.

Details for Revision 1.0

- Revised to include information regarding Dominion’s generation interconnection procedures/process

Details for Revision 2.0

- Revised to reflect transition from old NERC Planning Standards to NERC Reliability Standards, including changing the naming convention of all referenced standards throughout the document.

Details for Revision 3.0

- Revised to reflect the following:
  - Updates to NERC Reliability Standards
  - Dominion’s PJM Membership
  - References to new SERC regional studies processes

Details for Revision 4.0

- Revised to reflect the following:
  - PJM Generation Queue Changes Section 4
  - General Revisions all sections
Details for Revision 5.0
• Revised the following:
  o Section 2.12: Clarified content regarding synchronizing of facilities.
  o Exhibit A: Changed loading criteria to not exceed emergency rating of transmission facility.
  o Various errata changes.

Details for Revision 6.0
• Overhaul and expansion of entire Planning Criteria.
• Document previously called "Transmission Planning Guidelines"

Details for Revision 7.0
• Updated to include future reference to TPL-001-4 (R1 and R7 NERC enforcement date of 01-01-2015)
• Updated titles for approval process
• Various errata changes

Details for Revision 8.0
• Expanded description for Section G.1. TAPPING LINE BELOW 100 MW LOAD to emphasize the requirement of a fused bypass arrangement.
• Recreated diagrams throughout for consistency of style.

Details for Revision 9.0
• Added section C.2.8 - End of life criteria
• Reformatted headers to improve PDF navigation via bookmarks

Details for Revision 10.0
• Clarifications and annual review.
• Reformatted approval area and moved to title page.
• Reformatted Revision History and moved to end of document (Section J).
• Modified throughout to reflect NERC Reliability Standard TPL-001-4, including replacement of Tables 1A and 1B and deletion of “Category D Multiple Testing Requirements” (previously Section C.2.7 in Revision 9.0 document).
• Section C.2.6 Radial lines: Expanded to introduce new criteria and metrics.
• Section C.2.7 Network transmission lines – Limitations on direct-connect loads: Inserted new section.
• Section D.4 Study cycle – Clarified that PJM (not DEV) performs simulations to cover all generating plants over a three-year study cycle (not five-year).
• Section G: Modified electrical arrangements and clarified lines of demarcation.

Details for Revision 11.0
• Section C1, Table 1A Notes – Added Note “C”
• Section C1, Table 1B Notes – Added Note “G”; re-numbered other notes to differentiate from Table 1A [Note G became Note I in v15]
• Section D7 Selection of generation dispatch – Rephrased the content to improve clarity.
Details for Revision 12.0

- Changed references of Special Protection System (SPS) to Remedial Action Scheme (RAS).
- Tables 1A and 1B: Removed references to DC line (does not apply to Dominion), and
- Table 1A, Note B and Table 1B, Note F: Clarified “may NOT be required if the loss of consequential and non-consequential load up to 300MW achieves a return to the STE rating.”
- Section E.3. Updated NPIR Limits.
- Former Section F (Transmission Line Connections – Generation) and former Section G (Load Criteria – End User) have been removed from this document and integrated into the Facility Interconnection Requirements as Sections 5 and 6.
- Section G Abbreviations & definitions: Added definition of “Good Utility Practice”.

Details for Revision 13.0

- Revised references for new Dominion Energy corporate identity.
- Section C.1. Added Table 1C Steady-State Performance EXTREME Events and Dominion Energy CRITERIA, and associated notes; refined notes for Tables 1A and 1B.
- Added Section C.2.8. Substation – Limitation on direct-connect loads.

Details for Revision 14.0

- Clarified that some notes to Tables A, B and C are “Dominion Energy” notes.
- Edited Dominion Energy Note “B” for Table 1A and Note “F” for Table 1B to remove phrase “and non-consequential” [load]. [Note F became Note H in v15]
- Edited Dominion Energy Note “C” for Table 1A and Note “G” for Table 1B to refer to new section C.2.1.3. [Note G became Note I in v15]
- Added Section C.2.1.3 - Critical stress case development and studies

Details for Revision 15.0

- Reviewed to ensure alignment with Facility Interconnection Requirements, v15, effective 1/1/2019.
- Tables 1A, 1B, 1C: Added new notes to Tables 1A and 1B, requiring re-labeling of notes in Tables 1A, 1B and 1C as follows:

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- Section C.1. Planning principles and standards - Simplified reference to Nuclear generation re-dispatch.
- Section C.2.9. End of life criteria - Edited discussion and list of factors considered.
- Section C.3. Selection of generation dispatch used in DEV Power Flow Studies - New section.
- Section E Nuclear plant interface coordination:
  - E.7. Changes to the system – Simplified content to contain only the NUC-001-2, R8 quotation.
Details for Revision 16.0

- Table 1A, Note B: Deleted specific reference to 230 kV (table applies to several voltages).
- Table 1B, Notes F & G: Removed specific references to 500 kV (500 kV is inherent to this table).
REQUEST/NOTIFICATION FOR
CHANGES IMPACTING DOMINION’S FACILITIES

Customer shall initiate requests to install, modify, or remove Dominion Facilities, or to modify the capacity or characteristics required at a Delivery Point, or to discontinue the delivery of electricity to a Delivery Point, in writing using the Request/Notification for Changes Impacting Dominion Facilities form included in this [form]. Customer shall also submit a Request Form when making changes to Customer’s Facilities that are reasonably anticipated to (i) lead to a modification to Dominion’s Facilities or (ii) impact the operation of Dominion’s Facilities.

The Request Form shall be submitted by Customer as soon as useful information is available. As additional or updated information becomes available, Customer shall make timely submission of a revised Request Form. For Request Forms submitted with notations of “(E)” or “TBD by [date]” as described below, the Parties shall determine a schedule for the provision of complete and final information.

1. Customer shall, in accordance with the following requirements, provide, on a timely basis, information that is complete and accurate. On every Request Form submitted, each blank (including items such as “Additional Comments” and “Other Milestones”) shall contain one of the following entries:

   1.1. The firm (e.g., final) information.
   1.2. If no information is appropriate for a given item, the entry “N/A.”
   1.3. An entry as further described below:

      1.3.1. In Sections II, III, and IV, an entry initially marked as “(E).” Such entries shall be revised with firm information as soon as it is available. If the “Requested Date to Energize” in Section IV is initially marked as (E), then the firm date ultimately supplied for “Requested Date to Energize” shall be on or after the estimated date unless an earlier firm date for “Requested Date to Energize” is mutually agreed-upon prior to submission of a revised request form.

      1.3.2. In Section III, an entry may be “TBD by [date].” Additionally, each of the Required Attachments of Section III shall be provided, or shall be substituted by a page bearing the attachment description and the date by which the attachment shall be provided.

2. Upon receiving a request, Dominion shall evaluate such request within its ordinary course of business and consistent with the PJM Requirements. The evaluation may include the investigation of alternate solutions to accommodating Customer’s needs. Customer to reasonably assist Dominion’s evaluation, including, without limitation, the provision of additional information and participation in a cooperative review and exploration of the request and its alternatives. Dominion shall not be required to complete such evaluation until a reasonable time after the Customer has supplied all information as firm information.

3. Upon concluding its evaluation, Dominion shall provide a written response approving the request, approving the request with modifications, or denying the request. Any
modification or denial shall not be unreasonable and shall be accompanied by the reasoning for such determination. In the event of approval or modified approval, the response shall describe, consistent with the Agreement, any required construction or modifications by the Parties, any estimated Project costs, cost responsibilities between the Parties, and other actions the Parties must take to implement the request in its approved form.
REQUEST/NOTIFICATION FOR
CHANGES IMPACTING DOMINION FACILITIES

SECTION I – GENERAL
Requestor Name: 
Requestor Address: 
Name of Contact Person: 
Contact’s Phone: - - ext. Contact’s Cell: - -
Contact’s Fax: - - Contact’s Email: 

Signature below authorizes Dominion to proceed with design, engineering, and estimation of Project cost as appropriate for Dominion to evaluate and respond to this request. This authorization is pursuant and subject to all terms and conditions of the Agreement of which this Appendix is a part.

Authorizing Signature: 
Printed Name: 
Title: 

SECTION II – DESCRIPTION OF REQUEST
Name of Delivery Point: 
Brief Description of Request: 
Brief Reasoning for Request: 
Delivery Point Location: 
Noteworthy Load Characteristics: 

B - 3
PRESENT DELIVERY POINT DATA:
Present Delivery Point Voltage: 
Present Maximum kVA Capacity of Delivery Point Facilities: 
Present Summer Peak kW Demand: Present Summer Peak kVAR Demand: 
Present Winter Peak kW Demand: Present Winter Peak kVAR Demand: 

ANTICIPATED NEW DELIVERY POINT FACILITIES DATA:
New Delivery Point Voltage: 
New Peak kVA Capacity of Delivery Point Facilities: 

Peak kW and rkVA During First Three Years Following Implementation and Highest Peak Within Ten Years:

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Delivery Point Facilities Route:
(attach detail if new line extension is involved)

Additional Comments:

SECTION III – CUSTOMER’S EQUIPMENT
Transformer Primary Voltage: Transformer Secondary Voltage: 
Transformer Nameplate Capacity: Temperature Rise: 
Transformer Taps: 
Connection (e.g. Wye-Wye): 
Transformer Impedance: 
Isolation Device Type and Rating: 
Protection Device Type and Rating: 

### SECTION IV – TIMING

Request included in Customer’s planning documents submitted to Dominion on:

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Electric Transmission
Generator Interconnection Protection Requirements

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Table of Contents

List of Figures ................................................................................................................................................ 5

Abbreviations ................................................................................................................................................ 6

Definitions ..................................................................................................................................................... 7

1 Purpose and Introduction .................................................................................................................................. 8

2 Wide Area Protection and Isolation .............................................................................................................. 9

   2.1 Line Transfer-Trip Requirements .................................................................................................. 9

   2.2 Anti-Islanding Requirements .................................................................................................... 9

3 Interconnection Protection Requirements ................................................................................................. 10

   3.1 Point of Interconnection Protection Requirements ...................................................................... 11

      3.1.1 Networked Transmission Line Interconnection ............................................................... 11

      3.1.2 Transmission Tap Line Interconnection ........................................................................... 12

      3.1.3 Radial Transmission Line Interconnection ....................................................................... 13

      3.1.4 Other Considerations………………………………………………………………………………………………….. 14

   3.2 Interconnection Generator Step-up Transformer Requirement ................................................ 15

   3.3 Instrument Transformer Requirements ...................................................................................... 15

   3.4 Transmission Elements Requirements ........................................................................................ 16

      3.4.1 Bus Protection .............................................................................................................. 16

      3.4.2 Short, Medium, and Long Transmission Line Protection................................................... 17

   3.5 Breaker Failure and Reclosing Equipment..................................................................................... 18

4 Impact of Networked Transmission Line Split on Line Terminal Protection ............................................ 19

   4.1 Short Transmission Line Protection .......................................................................................... 20

   4.2 Medium and Long Transmission Line Protection ........................................................................ 23

5 Power Quality Protection at Point of Common Coupling ........................................................................ 24

   5.1 Undervoltage (27) ..................................................................................................................... 24

   5.2 Overvoltage (59) ..................................................................................................................... 24
5.3 Under/Overfrequency (81/U, 81/O) ................................................................. 24
5.4 Reverse Power (32) ..................................................................................... 24
5.5 Power Factor ............................................................................................. 24
5.6 Imbalance .................................................................................................... 24
5.7 Waveform Distortion .................................................................................. 24
   5.7.1 Harmonics .......................................................................................... 24
5.8 Voltage Fluctuations .................................................................................. 25

6 Disturbance and Power Quality Monitoring ..................................................... 26
   6.1 Digital Fault Recorder Requirements ...................................................... 26
   6.2 Phasor Measurement Units/Synchrophasors Requirements ....................... 26
   6.3 Power Quality Monitoring ..................................................................... 26

7 Data Communications and Data Exchange Requirements ............................. 27
   7.1 Interconnection Switching Station Data Communication .......................... 27
   7.2 Interconnection Switching and Generation/Collector Station Data Exchange 27

8 Bibliography .................................................................................................. 28

9 Revision History ............................................................................................ 29
List of Figures and Tables

Figure 1: Complex (left) and Simplified (right) Customer Interconnection Generation Station ................. 11

Figure 2: Network Transmission Line Interconnection .................................................................................. 11

Figure 3: Typical Tap Line Customer Generation Interconnection Station (Generation Resource < 20 MW) ........................................................................................................................................... 12

Figure 4: Typical Tap Line Customer Generation Interconnection Station (Generation Resource > 20 MW) ........................................................................................................................................... 13

Table 1: Ring Bus Considerations .................................................................................................................. 14

Figure 5: Interconnection Zone of Protection Less Than 1000 Feet .............................................................. 16

Figure 6: Short Interconnection Zone of Protection ........................................................................................ 17

Figure 7: Breaker Failure and Reclosing Relays ............................................................................................. 18

Figure 8: Existing Transmission Line ........................................................................................................... 19

Figure 9: Transmission Line Split ................................................................................................................ 19

Figure 10: Short Line with Fiber ................................................................................................................... 20

Figure 11: Traditional Zone-of-Protection for a Short-Line ........................................................................... 21

Figure 12: Medium Line Requiring Carrier Blocking at Distribution Substation follows Short-Line Requirements ........................................................................................................................................... 22

Figure 13: Medium or Long Transmission Line Zone of Protection .............................................................. 23

Figure 14: Medium or Long Transmission Line Zone of Protection with Carrier Blocking Tap .................. 23
Abbreviations

CCVT (also CVT) – Coupling Capacitor Voltage Transformer (similar to Capacitor Voltage Transformer)

GSU – Generation Step-Up Transformer

MW – Megawatt(s)

N-1 – Single Contingency Outage (Normal minus One Transmission Element)

OPGW – Optical Ground Wire

PCC or POI – Point of Common Coupling or Point of Interconnection

PJM – Regional transmission organization of which Dominion Energy is a member (www.pjm.com)

SIR – Source Impedance Ratio
Definitions

Transmission Element – Transmission elements are primary equipment (69kV and above) that constitutes, or interconnects with, the Dominion Energy Electric Transmission System. Examples include buses, lines, or transformers with lowside voltage 69kV or above, regardless of Bulk Electric System status.

Breaker Failure Transfer Trip - Trips remote sources in the event of a breaker failure.

Customer Interconnected Generation Station or Customer Interconnected Collector Station – Customer owned substation containing line or collector line terminals, breakers, transformers, and protection, metering, and monitoring equipment

Dominion Energy Interconnected Switching Station – Dominion Energy owned substation containing line terminals, breakers, transformers, and protection, metering, and monitoring equipment. The Dominion Energy Interconnected Switching Station is included as a line terminal transmission substation.

Islanding Transfer Trip - Trips interconnection in the event a generating facility is operating disconnected from the transmission grid

Line Transfer Trip - Trips remote sources that are not capable of clearing a fault because current magnitude is below the protective relay scheme setpoints.

Networked Transmission Line – A transmission line that connects to two or more network transmission sources (lines and/or substations).

Radial Transmission Line - A radial transmission line is defined as a single line that has one transmission source and does NOT tie to any other transmission network source (line or substation).

Transmission Tap Line – A transmission tap line is defined as a radial line that connects to either a network or radial transmission line. Dominion Energy Facility Interconnection Requirements diagrams 5.3.2.A and 5.3.2.B provides examples.

N-1 – Contingency analysis for determining relay settings. This may be the lowest flow first contingency outage, or the highest flow first contingency outage depending on the relay element being analyzed.

Power Line Carrier (also Carrier; PLC) – Higher frequency signal coupled to the AC transmission system used to transmit one bit of information
1 Purpose and Introduction

Virginia Electric and Power Company is commonly referred to as Dominion Energy.

The purpose of the Dominion Energy Electric Transmission Generator Interconnection Protection Requirements document is to provide protection requirements and expectations to any individual or group seeking to connect electric power generation to Dominion Energy’s electric transmission system.

Two primary drivers for these protection requirements are safety of personnel and customers, and the reliability of the electric transmission system.

This document supplements Dominion Energy’s Facility Interconnection Requirements document.

†Protection settings are determined using N-1 contingency analysis where it is plausible generation may be offline during a line outage. Variable generation, including inverter-based wind and solar, will not be included as a valid contingency for protection analysis.
2 Wide Area Protection and Isolation

Boundary analysis and protection studies are required for identifying transfer-trip and anti-islanding requirements. Transfer-trip and anti-islanding requirements are dependent on system configuration.

2.1 Line Transfer-Trip Requirements

Weak, partial, or variable sources may not provide enough fault current for protective relaying to completely isolate faulted transmission elements\(^\d\). Dominion Energy will require installation of transfer-trip equipment on all lines contained within the identified transfer trip boundary. The transfer-trip boundary is expanded from the POI out to the nearest remote transmission terminal substation where three or more non-generation sources are encountered. The line connecting the interconnect station to the remote station is counted towards meeting the criteria. The line connecting to the substation, which satisfies the boundary requirement, also requires transfer-trip. All transmission elements within the transfer-trip boundary are subject to transfer-trip requirements. Additional transfer-trip equipment (such as transfer-trip electronics, including relays and accessories, wave traps, CCVTs, etc.) may be required due to the installation of the generation station. Transfer-trip equipment will also be used for breaker failure conditions outlined in Section 3.7.

2.2 Anti-Islanding Requirements

Dominion Energy will require application of its anti-islanding protection standard at all customer interconnected switching stations. Dominion Energy’s anti-islanding protection standard requires each breaker or terminal’s status within the anti-island boundary be sent to Dominion Energy’s interconnected switching station to determine whether the generation source is isolated from the rest of the electric transmission system. The purpose of the anti-islanding scheme is to prevent individual generation sources from exclusively energizing transmission elements within the islanding boundary and to prevent unsynchronized reclosing on the generator. The anti-islanding boundary is expanded from the POI out to the nearest terminal substations with three, or more, non-generation sources. The boundary substations may be included in the anti-islanding scheme depending on boundary substation configuration. The anti-islanding boundary may also be extended beyond three sources if one of the lines at the boundary exceeds its thermal limits due to unloading the generation, trips due to excessive loading, or trips due to a power swing in a power system simulation. All transmission elements within the anti-islanding boundary are subject to anti-islanding requirements. Anti-islanding schemes require separate relaying at each substation inside the anti-islanding boundary and a method to transmit breaker statuses between substations. Breaker or line terminal status will be transmitted via fiber, where available, or via power line carrier where existing fiber is unavailable and power line carrier is an acceptable transmission method (see Section 4.1 for more details).

\(^\d\) Protection settings are determined using N-1 contingency analysis where it is plausible generation may be offline during a line outage. Variable generation, including inverter-based wind and solar, will not be included as a valid contingency for protection analysis.
3 Interconnection Protection Requirements

Interconnection protection requirements include specifications for fault protection of the interconnection line, breaker failure and reclosing, generation step-up transformers, and instrument transformers. Determination of the necessary protection for the POI is dependent on the individual and aggregate total MW of the generation resource(s), length and configuration of the interconnection line, and technical limitations of existing facilities.

3.1 Point of Interconnection Protection Requirements

A customer-owned transformer-high-side breaker is required at the POI to separate the POI line zone of protection and the customer-owned transformer zone of protection. The customer-owned high-side breaker will be the disconnecting element should the generation source become islanded from the rest of the electric transmission system.

A high-side breaker in conjunction with a breaker ring station provides optimal isolation should a device fail to operate and initiate breaker failure (also see Section 3.7, Breaker Failure and Reclosing Requirements). To ensure reliability of the transmission system, this configuration, shown in Figure 1, is required for a POI at any network transmission line on Dominion Energy’s transmission system. A high-side breaker in conjunction with a breaker ring station is also required for a POI to a radial tap line on a network line of the transmission system for an individual generation resource or the aggregate total of generation resources that is greater than 20 MW.

For simplicity, the customer interconnection generation station will be represented as a simplified single source as shown in Figure 1.
3.1.1 Networked Transmission Line Interconnection

The Dominion Energy Interconnection Switching Station shall be a three or four breaker ring, or comparable layout as outlined in Section 5 of the main document [1] for generation resources of any MW size that connect to a network transmission line. A breaker station ring ensures separation in zones of protection between the Dominion Energy electric transmission system and the customer interconnected generation station. The three breaker ring provides increased reliability as two paths are available to export power from the generation source to the electric transmission system. The breaker ring station also creates two independent zones of protection for adjacent transmission lines allowing the generator to stay online for any single momentary or sustained line outage. See Figure 2.
3.1.2 Transmission Tap Line Interconnection

The Dominion Energy Interconnection Switching Station may be a single breaker when the total aggregate generation resource connected to the tap line is less than or equal to 20 MW and connecting to a line segment that is tapped off of a networked transmission line (Figure 3). A breaker ring substation will be required for an individual generation resource or the aggregate total of generation resources from all sources on the tap line greater than 20 MW (Figure 4).

There may be instances when the generation resource(s) connected to a tap line will desensitize the network relays and not allow proper protection. Additionally, design constraints (e.g., limitations on power line carrier or transfer trip communications channels) may prove unresolvable without system upgrades including line reconductoring, expanding communication channels, building a breaker ring station, or interfacing to the transmission system through a more distant POI. A detailed protection study will be required to determine if a breaker ring station or other upgrades are required regardless of the generation resource’s size.

Figure 3: Typical Tap Line Customer Generation Interconnection Station (Generation Resource < 20 MW)
3.1.3 **Radial Transmission Line Interconnection**

The Dominion Energy Interconnection Switching Station may be a single breaker. However, generation resource POIs on radial transmission lines in Dominion Energy’s transmission system must be considered on a case-by-case basis to evaluate potential reduction of relay sensitivity due to fault current contributions from the generation sources. If existing line relays cannot adequately protect against fault conditions with the addition of the generation resource, additional upgrades may be required.
3.1.4 Other Considerations

A generation resource may choose to have a breaker ring substation installed at the tap point to provide a more reliable interconnection regardless of POI, see Table 1 for further detail.

Table 1: Ring Bus Considerations

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<thead>
<tr>
<th></th>
<th>Ring Bus connection</th>
<th>Single Breaker connection on tap line or radial line</th>
</tr>
</thead>
</table>
| **Advantages**                    | • Increased Reliability: The generation resource will have two outlets to delivery power. An outage on the networked line will only remove one side of the ring and still allow generation.  
• More uptime for the generation resource that leads to higher revenue.  
• Initial cost savings for no utility owned breaker at POI. | • Possible decrease of initial capital cost for not building line back to networked transmission line. |
| **Disadvantages**                 | • Possible increase of initial capital cost for building line back to networked transmission line. | • Decreased Reliability: The generation resource will only have one outlet to delivery power. An outage on the tap line will remove the generation resource from service and not allow generation.  
• Less uptime for the generation resource that leads to lower revenue.  
• Additional cost for utility owned breaker at POI. |
3.2 Interconnection Generator Step-up Transformer Requirements

The customer interconnected generation step-up transformer (GSU) is required to provide a source of zero sequence current to the transmission system aiding in ground fault detection. The Utility side of the GSU shall be effectively grounded to prevent an excessive increase in voltage during single phase to ground faults. A GSU that can pass, but is not a source of, zero sequence current is only appropriate if a ground source is present on the medium voltage terminal, and will require evaluation prior to permission being granted. The interconnected GSU shall be protected using dual high-speed current differentials.

The following transformer configurations are commonly used to meet the above requirements:

- Utility side – grounded wye, generator side – delta (typical for synchronous generation)
- Utility side – grounded wye, generator side – grounded wye, delta on the tertiary (typical for inverted-based generation)

While utility side delta – generator side grounded wye transformers are appropriate for applications in a fully radial system where energy always flows from transmission-level voltages to distribution-level voltages, this design blinds high-side residual and/or ground devices to potential problems behind the transformer. For applications in systems with the ability to produce network flows, ground sources are required.

3.3 Instrument Transformer Requirements

Independent three-phase capacitor coupled voltage transformer (CCVT) and current transformers (CT) connections are required for protective relaying purposes at the point of interconnection. Accuracy class “0.3WXYZ,ZZ” CCVTs will be required for all power quality applications at the Dominion Energy Interconnection Switching Station. If the interconnected transmission element is longer than 1000 feet (short, medium, or long length transmission line), two CCVTs may be used within the zone of protection at Dominion Energy Interconnection Switching Station (1) and Dominion Energy Interconnection Switching Station (2) shown in Figure . The additional CCVT at Dominion Energy Interconnection Switching Station (2) may be accuracy class “1.2RWXYZ,ZZ” for backup impedance protect
3.4 *Transmission Elements Requirements*

Protection of a transmission element is determined based on element type (ex. Bus, Line, Transformer). In many cases, distance is the determining factor for protection system applications. Protection systems classified as dual primary are required for all transmission elements connected to Dominion Energy’s transmission grid [2]. Schemes will require two independent high speed, phase and ground fault protection systems designated system one and system two. Together these systems provide a redundant set of all normal primary and backup functions.

3.4.1 *Bus Protection*

Bus and line segments less than 1000 feet will be protected using dual high impedance bus differential relays. Fiber will be required between the interconnect station and generation station per data communications requirements in Section 7.2. At distances over 1000 feet (Figure ) requirements of short transmission lines (Section 4.1) will be applied.

![Diagram of Interconnection Zone of Protection Less Than 1000 Feet](image-url)
3.4.2 Short, Medium, and Long Transmission Line Protection

All transmission lines and line segments greater than 1000 feet will be protected using dual line current differential relays as shown in Figure. In all cases, dedicated fiber will be required between both Dominion Energy Interconnection Switching Stations (1) and (2). An additional Dominion Energy owned control house, adhering to Dominion Energy standards, will be required to house all associated protection and control equipment at Dominion Energy Interconnection Switching Station (2).

![Diagram of Short Interconnection Zone of Protection](image)

Figure 6: Short Interconnection Zone of Protection

The faint dotted CCVT at Dominion Energy Interconnection Switching Station (2) would be required if the interconnecting customer wants back-up impedance relaying enabled on the Dominion Energy owned line differential relay.
3.5 **Breaker Failure and Reclosing Equipment**

Separate breaker failure and reclosing relays (Figure 7) will be installed on all transmission breakers (the customer-owned high-side generation step-up transformer (GSU) breaker will only require breaker failure). All breaker failure relays will be required to send transfer trip to remote stations. A reclosing sync-check will be performed prior to the breaker closing for all time delayed reclosing attempts.

![Figure 7: Breaker Failure and Reclosing Relays](image-url)
4 Impact of Networked Transmission Line Split on Line Terminal Protection

In many cases, interconnection switching stations are built near an existing transmission line (Figure 8) resulting in the existing transmission line being split into two shorter transmission lines (Figure 9). The two shorter transmission lines may require protection modifications due to power line carrier or relaying constraints (ex. a medium length line now becomes two short length lines).

![Figure 8: Existing Transmission Line](#)

![Figure 9: Transmission Line Split](#)
4.1 Short Transmission Line Protection

Short transmission lines and line segments less than five (5) miles will be protected using dual line current differential relays. Line current differential relays require dedicated fiber be available between line and tap terminals. Relaying constraints permit the allowance of one tapped distribution substation within the line differential as shown in 10.

When a direct fiber connection is not available between the interconnect station (Dominion Energy Interconnection Switching Station), remote terminal station (Dominion Energy Existing Substation), and tapped distribution station, modifications to the lines, structures, towers, conduits, terminating and other equipment may be required to accommodate a direct fiber connection between the interconnect substation, existing remote substation, and tapped distribution substation. Shown on the next page in Figure 11, the five mile requirement is normally between line terminal stations.

If the distance between line terminal stations is greater than five miles and impedance relays would require carrier blocking be installed at a tapped distribution substation due to transformer penetration, then the five mile requirement is between the line terminal substation and the tapped distribution substation shown on the next page in Figure 12. In summary, the five mile requirement is between a location with a power line carrier transmitter and a location with a power line carrier receiver.
Power line carrier will **not** be used on transmission lines less than 5 miles long to maintain a high level of protection system dependability. Power line carrier systems coupled to short transmission lines have low signal attenuation causing several problems. Most prominently, low signal attenuation results in high voltage standing wave ratios and can cause carrier beating between opposite terminal power line carrier equipment [3] [4]. Carrier beating results in the power line carrier strength oscillating between zero and two times rated power resulting in power line carrier equipment being damaged, shutting down entirely, or misoperating.

Short lines are also problematic for impedance relaying. Transmission lines with a source impedance ratio (SIR) of 4.0 or greater are considered electrically short [5]. Source impedance ratio is the ratio of thevenin equivalent source impedance to line impedance. Short lines protected by impedance relays are subject to transient overreach due to suppressed voltage measured at the relay, and transient instrument and relay errors [6].

![Figure 11: Traditional Zone-of-Protection for a Short-Line](image-url)
Figure 12: Medium Line Requiring Carrier Blocking at Distribution Substation follows Short-Line Requirements
4.2 Medium and Long Transmission Line Protection

Medium and long transmission lines, greater than five (5) miles, will be protected using dual impedance relays. At Dominion Energy, impedance relays utilize directional comparison blocking (DCB) over power line carrier, or alternate communication method, to isolate faults within the line zone of protection.

![Diagram of Medium or Long Transmission Line Zone of Protection](image)

Figure 13: Medium or Long Transmission Line Zone of Protection

![Diagram of Medium or Long Transmission Line Zone of Protection with Carrier Blocking Tap](image)

Figure 14: Medium or Long Transmission Line Zone of Protection with Carrier Blocking Tap
5  Power Quality Protection at Point of Common Coupling

Power quality relaying capable of tripping will be required at all generator interconnections for criteria listed in IEEE Standard 1159 [7] and other applicable standards. Power quality concerns associated with solar photovoltaic are reiterated in IEEE Standard 929 [8]. Protective relays can make erroneous directional determinations due to waveform distortion and other power quality issues [9]. All power quality protective elements will measure individual phase quantities. Quantities include but are not limited to:

5.1 Undervoltage (27)
An undervoltage is an RMS decrease in AC voltage.

5.2 Overvoltage (59)
An overvoltage is an RMS increase in AC voltage.

5.3 Under/Overfrequency (81/U, 81/O)
Frequency deviations above or below nominal frequency.

5.4 Reverse Power (32)
Reverse power protection may be implemented as a supervisory function or to ensure contracted power agreements are not exceeded.

5.5 Power Factor
Power factor requirements will be based on contracted power factor agreement.

5.6 Imbalance
Imbalance will be measured through differing phase quantities of voltage or current.

5.7 Waveform Distortion
Waveform distortion is defined as steady-state deviation from an ideal power frequency sinusoid characterized by the spectral content of the deviation. Five primary types of waveform distortion are DC offset, harmonics, inter-harmonics, notching, and noise.

5.7.1 Harmonics
Voltage or current harmonics may be calculated in terms of total harmonic distortion (THD) or total demand distortion (TDD) as outlined in IEEE Standard 519 [10].
5.8 Voltage Fluctuations

Voltage fluctuations are defined as a varying voltage between 0.95 and 1.05 per-unit. Voltage flicker, an undesirable result of voltage fluctuations, may be measured or monitored using methods outlined in IEEE Standard 1453 [11], which is an adoption of IEC 61000-4-15.
6 Disturbance and Power Quality Monitoring

Disturbance and power quality monitoring equipment is independent of any protective equipment used for tripping outlined in Section 2 through Section 5 and must be time synched to UTC with a Satellite clock.

6.1 Digital Fault Recorder Requirements

A digital fault recorder (DFR) is required at all interconnected transmission substations. This device will provide high integrity triggered oscillography (minimum 4800 Hz sampling), triggered long-term RMS plus phase data (minimum 960 Hz sampling) and continuous oscillography data (minimum 720 Hz sampling) for the purpose of disturbance location and analysis. The device must also serve as a sequence of events recorder (minimum 1 millisecond resolution) logging all circuit breaker activity. Digital fault recorder data will be the primary means for fault and event analysis. Data must adhere to the IEEE Standard for Common Format for Transient Data Exchange (COMTRADE), revision C37.111-1999 [12] or later and IEEE Standard for Common Format for Naming Time Sequence Data Files (COMNAME), revision C37.232-2011 [13] or later.

6.2 Phasor Measurement Units/Synchrophasors Requirements

Phasor measurement units are required at all interconnection substations to provide real time synchrophasor data to Dominion Energy’s synchrophasor system. PJM Manual 14D specifies all generation greater than 100 MW must provide synchrophasor data to PJM’s synchrophasor system as well.

6.3 Power Quality Monitoring

Power quality monitoring is independent of power quality protection and may trigger on several layers of set points. Data collected from power quality monitors will strictly be used for engineering analysis.
7  Data Communications and Data Exchange Requirements
A robust data communications system is integral to providing information for system operations, engineering, fault analysis, and restoration.

7.1  Interconnection Switching Station Data Communication
All interconnected switching stations will be required to have T1 or better digital communication service. This service will transmit all required metering, protection, and monitoring information from the applicable station to centrally located operational, engineering, and data servers.

7.2  Interconnection Switching and Generation/Collector Station Data Exchange
A data communication link between the interconnection switching station and the interconnection generation station will be required to provide an exchange of operational and engineering data. The communication medium will be a fiber bundle in an enclosed conduit, or optical ground wire (OPGW).

Information provided by generation collector station will include, but is not limited to:

- **WIND**: turbine generation (kW), wind speed, wind direction, turbines generating, turbines available, total turbines, air pressure (millibars), air density (kg/m^3), high-wind cutoff, slew rate (MW/second)
- **SOLAR**: panel generation (kW), solar concentration (irradiance), panels producing, panels available, total panels
- **BOTH WIND AND SOLAR**: ambient temperature, breaker status, MW setpoint, var setpoint, voltage setpoint, power factor setpoint, AGC control (on/off), regulation (up/down), ramp rate (up/down)

This additional information will be used to identify and improve reliability initiatives related to disturbances.
8 Bibliography

[1] "Facility Interconnection Requirements," Section 5


9 Revision History

<table>
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<tr>
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<td>12/11/2018</td>
<td>3.0</td>
<td>See Details for Revision 3.0</td>
<td>Douglas Ladd</td>
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<td>Christopher Mertz</td>
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**Details for Revision 1.0**
- Updated short-line requirement drawings to show fiber into relaying at tapped distribution station
- Modified wording to exclude customer-owned GSU breaker from reclosing requirement

**Details for Revision 2.0**
- Revised references for new Dominion Energy corporate identity.
- Added additional definitions and minor sentence changes
- Updated reference 6

**Details for Revision 3.0**
- Added clarification for interconnections on network tap lines and radial lines.
- Expanded on Section 3.4
- Rearranged layout of several sections to improve flow of material