Generation Interconnection
In–Service Inspections and Construction Standards

A generation facility ("Facility" or "Interconnection Customer") interconnected to the Dominion Energy South Carolina system impacts the safety and reliability of the electric system. In addition, power quality issues due to improper construction can be difficult to identify and remedy. As such, Dominion Energy South Carolina reserves the right to inspect primary voltage (> 1 kV) customer facilities. Dominion Energy South Carolina uses a Distribution Construction Standards Manual as a design standard for distribution voltage level interconnections. The National Electric Safety Code ("NESC"), Occupational Health and Safety Administration ("OSHA") regulations, and specifications from equipment manufacturers guide these standards. Dominion Energy South Carolina will provide copies of pertinent standards to aid designers of generating facilities with medium voltage equipment.

Dominion Energy South Carolina provides standards for transmission level interconnection facilities in Dominion Energy South Carolina's Customer Substation Guidelines and its Solar Supplement. Requirements for distribution level interconnection facilities are provided at Attachment 4 to this document. The Facility will ensure that its infrastructure has been built in compliance with those standards, IEEE standards, the National Electric Code, good engineering practice, and the installation guidelines from equipment manufacturers.

Prior to requesting in-service inspections, the Facility is responsible for making available to Dominion Energy South Carolina:

1. Operating manuals for each type and/or sized inverter utilized,
2. Most up-to-date single line diagrams of high and medium voltage systems,
3. Relay and inverter settings,
4. Technical resources capable of operating the Facility and medium-voltage switching qualified personnel that can operate the Facility's interconnection facilities.

In-Service Process

Provided below is a generic schedule for the entire in-service process. The in-service process consists of two distinct Dominion Energy South Carolina inspections: the initial in-service inspection and the final testing inspection. More details for each of those inspections will follow this section. All inspections will occur during Dominion Energy South Carolina's normal business hours (exceptions on a case by case basis):

Pre-Inspection: The following must be accomplished prior to requesting the initial in-service inspection:

- Per the interconnection agreement, Interconnection Customer must notify Dominion Energy South Carolina of its testing and inspection dates of its Facility and Interconnection Facilities. The Interconnection Customer's testing and inspections must occur on a Business Day unless otherwise agreed to by Dominion Energy South Carolina. Dominion Energy South Carolina may choose to observe this testing and it does not supplant the in-service inspection or the final testing inspection.
- Relay and inverter settings must be coordinated with and approved by Dominion Energy South Carolina Relay & SCADA Engineering group.

  NOTE: Dominion Energy South Carolina must be given a minimum of 10 business days to approve the settings.
- Establish a retail account for the solar farm through the DESC Power Marketing group.
- Necessary local inspections are complete and local permits secured. Dominion Energy South Carolina must receive the release directly from the local authority having jurisdiction through the established process and not from the Interconnection Customer.

Step 1 – Interconnection Customer completes interconnection facilities. Per the interconnection agreement, Interconnection Customer must notify Dominion Energy South Carolina that they have completed all requirements for parallel operations. As such, Interconnection Customer must provide a written report to Dominion Energy South Carolina that summarizes the commissioning steps taken to date, but at a minimum should include the following:

- An indication that cold commissioning of the major components of the facility has been successfully completed;
- Interconnection Facilities are complete and ready to be energized;
- The AC portion of the collector system, down to the mid-voltage transformers (if applicable) and inverters, has been completed and are ready to be energized;
- All AC cabling and terminations have tested successfully.
- For transmission interconnections, the main transformer has tested successfully.
  - Include a copy of the transformer test report with this submittal.

- Operating requirements identified in the interconnection agreement have been met.

Step 2 – Dominion Energy South Carolina acknowledges the report and will schedule inspection of customer facilities to occur within 10 business days from date of receipt of the report.

Step 3 – Dominion Energy South Carolina will inspect customer facilities and verify the facility was constructed in accordance with the approved single-line diagram and other provisions, as applicable, and complete the inspection report included herein (Attachment 2). After successful completion, the Facility will be allowed to temporarily parallel Dominion Energy South Carolina's system for additional pre-operational testing. The output of the Facility during this testing period shall not exceed a pre-approved limit provided by Dominion Energy South Carolina, typically the rated output of one inverter.

Step 4 – Interconnection Customer will complete any necessary pre-operational testing and commissioning. Once completed, the Interconnection Customer must then submit a written request for final testing by affirming:

- All inverter commissioning has been completed,
- Power limiting labels are applied (if required),
- The primary frequency response capability of the Facility has been tested and confirmed during commissioning.
- The site is ready for final testing.

Step 5 – Dominion Energy South Carolina will acknowledge the request and schedule the final testing within 10 business days.

Step 6 – Dominion Energy South Carolina will conduct the final testing and, upon successful completion of the testing, complete the inspection report included herein (Attachment 3).

Step 7 – Dominion Energy South Carolina provides written permission to operate in parallel with Utility's system.

Step 8 – Within 30 days of final testing, customer must submit the following:

- As-built Single Line Diagram
- As-left Inverter Settings
- As-left Recloser Settings
- Evidence that liability insurance is in effect per Section 8.1 of the interconnection agreement.

Initial In-Service Inspection

Prior to in–service, Dominion Energy South Carolina or its designee will perform an inspection of the Facility to ensure compliance with standards, installation guidelines, and regulations as appropriate. The in-service date is identified for each project as a milestone in the associated interconnection agreement and is the point in time when interconnection facilities are energized and left in-service for testing purposes. This inspection will include, but is not limited to, the following:

- Verification that the project was built as submitted in the interconnection process,
- For distribution interconnected facilities, an isolation device is lockable and accessible to both parties per Dominion Energy South Carolina Standards (Dominion Energy South Carolina will provide a unique Dominion Energy South Carolina lock for this device),
- Isolation device has a visible open point,
- Verification that relay settings will coordinate with settings provided by Dominion Energy South Carolina in Attachment 1 to this document.

Common construction quality problems noted in the industry include, but are not limited to:

- insufficient clearances for overhead mid-voltage equipment,
- poles set to improper depths,
- conductor not pulled in with proper tension,
- gang operated switches improperly installed and tested resulting in malfunction,
- undersized ground wires,
- grounds bonded in the wrong locations,
- poor quality or improperly installed cable terminations,
- failure to use appropriate inhibitor in connections,
- failure to use lock washers,
- lack of animal guards,
- failure to install adequate number of properly rated surge arresters (e.g., overhead dips and in pad mounted transformers).

If the equipment installed, or its configuration, deviate from the single-line diagram(s) provided during the interconnection process and is deemed material, the Dominion Energy South Carolina inspection team will not complete the in-service inspection or other tests, and the Facility will not be granted permission to interconnect to Dominion Energy South Carolina's system. The Facility is responsible for seeking pre-approval of any changes in design and must submit any changes to Dominion Energy South Carolina in advance of the energization of interconnection facilities.

After the initial inspection has been completed, Dominion Energy South Carolina, or its designee, will provide to the Facility an inspection report (Attachment 2). The Facility will be responsible for addressing any findings as specified in the interconnection agreement. The Interconnection Customer is responsible for Dominion Energy South Carolina's cost to provide the in-service inspection and other commissioning activities.

Final Testing

After successful completion of the initial in-service inspection, the Interconnection Customer's Interconnection Facilities will be energized and the Interconnection Customer may complete any necessary pre-operational testing of the Facility. The output of the Facility will be limited, typically to an amount equal to the output of one inverter. Once the Interconnection Customer has completed pre-operational testing, Dominion Energy South Carolina will conduct anti-islanding tests for all facilities greater than 250 kW. Distribution level, utility-scale Facilities will also be tested for loss-of-phase functionality at both low-loads and moderate-to-full loads.

The preferred method for performing these tests is to introduce an interruption to utility service impacting the entire facility. Testing of this nature may introduce complications for facilities that interconnect to the load-side of a distribution transformer. In these instances, the interruption to utility service may take place at another location, provided the customer, at their expense, installs the necessary equipment to break individual phases between the point of interconnection and the inverters.

> **NOTE: In instances where final testing interrupts customer loads, the customer is responsible for reviewing the protection systems for its Facilities. Dominion Energy South Carolina is not responsible for losses associated with customer outages or damaged equipment.**

On the day of final testing, Dominion Energy South Carolina will first verify inverter settings are as approved by the Relay and SCADA Engineering group. Additionally, if not previously verified, Dominion Energy South Carolina will verify presence of any required power limiting nameplates. Once those verifications have taken place, Dominion Energy South Carolina will conduct the anti-islanding and loss-of-phase testing. When the inverters ramp back up after the anti-islanding test, Dominion Energy South Carolina will verify the required operating ramp rate to be <10 MW per minute.

Detailed Testing Procedure

The Interconnection Customer must outline to Dominion Energy South Carolina how the protections schemes should operate due to loss of utility power and how the facility should be re-energized after an outage. For example, after a facility disconnects itself from the grip, will it automatically reconnect after the return of utility power, or will a manual reclose be required?

1. **Loss-of-Phase Low-Load Test (Distribution Interconnections Only)**

   1.1. Customer loads up all available inverters such that Facility is at approximately 5% total output (test setting for small inverters will be handled on a case by case basis).

   1.2. Stage one person at electronic recloser or AC disconnect device.

   1.3. DESC personnel opens one phase of interconnection facilities.

   1.4. Verify Facility removes itself from service within 2 seconds.

   1.5. DESC re-energizes the Facility. Time inverters to confirm they return to service no sooner than 5 minutes after return of stable utility service.

   1.6. The test may be repeated for additional phases.

2. **Three-Phase Test**

   2.1. If all loss-of-phase tests are successfully passed, stage one person at the electronic recloser or AC disconnect device.

   2.2. DESC personnel will open the DESC isolating device to simulate complete loss of utility.

   2.3. Verify Facility operates as expected, including isolation from the DESC system within 2 seconds.

   2.4. DESC re-energizes the Facility. If applicable, the Interconnection Customer will take steps to re-energize the Facility. Time inverters to confirm they return to service no sooner than 5 minutes after return of stable utility service.

   2.5. When inverters ramp back up, DESC personnel will verify the Generating Facility meets the Operating Ramp Rate guideline of 10 MW/min or less.

3. **Any other tests deemed necessary by Dominion Energy South Carolina based on the operational characteristics of the Facility.**

After the final testing has been completed, Dominion Energy South Carolina, or its designee, will provide to the Facility a testing report (Attachment 3). The Facility will be responsible for addressing any findings. The Interconnection Customer is responsible for DESC's cost to provide the in-service inspections.

Revision History

Revision	Date	Developed\Revised by	Comments\Details of Revision
0	July 25, 2016	Electric Transmission Support, Distribution Planning, Renewables, Distribution MES	Original version developed
1	April 18, 2017	Electric Transmission Support	Updated inspection process
2	August 7, 2018	Electric Transmission Support	Updated formatting
3	April 12, 2019	Jay Cole	Updated inspection process; Updated Attachment 1 and added transmission relay standards; Took anti-island testing out of App. 2 and into new App. 3
4	August 12, 2019	Jay Cole	Added language addressing frequency response during commissioning; Added language about checking operating ramp rate during final testing; Removed three-phase low-load test.
5	October 9, 2019	Jay Cole	Clarified SLD need on p.1; Added Pre-Inspection requirement of establishing a commercial account; Added step to test procedure to verify Operating Ramp Rate of GF.

Attachment 1

Typical Protection Settings

A. Transmission Interconnections (33 kV and above)

1. The interconnection will require protective relaying capable of providing protection per applicable industry standards, including IEEE 1547 and PRC-024.
2. Below are the voltage and frequency settings used on Dominion Energy South Carolina's primary isolation device. It is the Interconnection Customer's responsibility to ensure that their equipment settings will coordinate with these settings. A tiered approach is recommended: inverters should respond first, then customer's protection device, and finally the Dominion Energy South Carolina isolation device. There should be enough coordination to allow for relay response time plus breaker operate time.
    a. Underfrequency (81U)
        - 57.8 Hz @ Time delay of 126 cycles (2.1 seconds)
        - 57.0 Hz @ Time delay of 12 cycles (.2 seconds)
    b. Overfrequency (81O)
        - 61.0 Hz @ Time delay of 7,200 cycles (120 seconds)
        - 62.0 Hz @ Time delay of 12 cycles (.2 seconds)
    c. Undervoltage (27)
        - 88% of nominal @ Time delay of 192 cycles (3.2 seconds)
        - 50% of nominal @ Time delay of 45 cycles (0.75 seconds)
    d. Overvoltage (59)
        - 110% of nominal @ Time delay of 132 cycles (2.2 seconds)
        - 120% of nominal @ Time delay of 45 cycles (0.75 seconds)
3. The Facility must have anti-islanding protection.
4. It is the customer's responsibility to protect their generation from utility circuit breaker reclosing operations.
5. Reverse Power relaying where applicable.

B. Distribution Interconnections (23.9 kV and below)

1. The interconnection will require protective relaying capable of providing protection per IEEE 1547.
2. Below are the voltage and frequency settings used on Dominion Energy South Carolina's recloser. It is the customer's responsibility to ensure that the settings will coordinate with their equipment. A tiered approach is recommended: inverters should respond first, then customer's recloser, and finally the Dominion Energy South Carolina recloser. There should be enough coordination to allow for relay response time plus recloser operate time.
    a. Underfrequency (81U)
        - 58.5 Hz @ Time delay of 10,920 cycles (182 seconds)
        - 56.5 Hz @ Time delay of 22 cycles (0.37 seconds)
    b. Overfrequency (81O)
        - 61.2 Hz @ Time delay of 10,920 cycles (182 seconds)
        - 62 Hz @ Time delay of 22 cycles (0.37 seconds)
    c. Undervoltage (27)
        - 70% of nominal @ Time delay of 900 cycles (15 seconds)
        - 45% of nominal @ Time delay of 22 cycles (0.37 seconds)
    d. Overvoltage (59)
        - 110% of nominal @ Time delay of 72 cycles (1.2 seconds)
        - 120% of nominal @ Time delay of 22 cycles (0.37 seconds)
3. Reverse Power (where required)
    a. 100kW -- Time delay of 3 seconds
4. The generator must have anti-islanding protection.
5. It is the customer's responsibility to protect their generation from utility circuit breaker reclosing operations.

Attachment 2

Generator Interconnection

In-Service Inspection

Generator Interconnection In-Service Inspection

General Inspection Information
Date: __ __ / __ __ / __ __ __ __
Time: __ __ : __ __ AM / PM
Inspector name(s):

Site Information
Site Name:
Site Address:
Interconnection Type: DISTRIBUTION or TRANSMISSION **Interconnection Voltage:** _____ kV
Number of Inverters: _____ (*attach photos of nameplate*)
Firmware Version: attach photos
Transformer Size(s): Main - _____ kVA (*attach photos of nameplate*) Inverters - _____ kVA (*attach photos of nameplate*)
Transformer Connection Type(s): Main - _____ (*e.g. Delta-Wye*) Inverters - _____
Transformer Impedances (attach photos): Main - _____ % 1 - _____ %; 2 - _____ %; 3 - _____ %; 4 - _____ %; 5 - _____ %; 6 - _____ %; 7 - _____ %; 8 - _____ %; 9 - _____ %; 10 - _____ %; 11 - _____ %; 12 - _____ %; 13 - _____ %; 14 - _____ %; 15 - _____ %; 16 - _____ %; 17 - _____ %; 18 - _____ %; 19 - _____ %; 20 - _____ %; 21 - _____ %; 22 - _____ %; 23 - _____ %; 24 - _____ %; 25 - _____ %; 26 - _____ %; 27 - _____ %; 28 - _____ %; 29 - _____ %; 30 - _____ %

Inspection Checklist				
	Inspection Item	**Result**		**Comments**
1	Single-line diagram matches as-built condition of Facility?	Yes	No	
2	Isolation device is lockable and accessible to both parties per Dominion Energy South Carolina Standards?	Yes	No	
3	Isolation device has a visible open point?	Yes	No	

Record anything unusual about the site and installation:

Does the Site Pass the In-Service Inspection?

☐ **PASS**

PASS = All "Yes" checked and nothing unusual is noted. Facility is allowed to operate temporarily in parallel at a limited output.

☐ **NOT PASS**

NOT PASS = Any item checked "No" or something unusual is noted. Deficiencies must be corrected in order for Interconnection Customer to connect to the Dominion Energy South Carolina system.

In-Service Inspection Report Certification

Solar Farm Representative

Signature: _____

Print Name: _____

Inspector

Signature: _____

Print Name: _____

Attachment 3

Anti-Islanding
and Loss-of-Phase Testing

Anti-Islanding and Loss-of-Phase Testing

General Inspection Information
Date: __ __ / __ __ / __ __ __ __
Time: __ __ : __ __ AM / PM
Weather Conditions:
Inspector name(s):

Site Information
Site Name:
Site Address:
Interconnection Type: DISTRIBUTION or TRANSMISSION **Interconnection Voltage:** _____ kV
Site Capacity: _____ MW Number of Inverters In Service: _____
Inverter Settings Confirmed: YES or NO (attach check sheet)
Generator Test Output: _____ MW / _____ MVA **Current Output:** _____ % **(min. 25%)**

Notes: _____

Low-Load Test (site at 5-10% output)				DISTRIBUTION PROJECTS ONLY
	Inspection Item	**Result**		**Comments**
1	**Phase A test was successful?** (customer recloser opened and all inverters dropped out and did so within the specified time)	Yes	No	
2	**Phase B test was successful?** (customer recloser opened and all inverters dropped out and did so within the specified time)	Yes	No	
3	**Phase C test was successful?** (customer recloser opened and all inverters dropped out and did so within the specified time)	Yes	No	
4	Transfer Trip test (if applicable)	Yes	No	

Additional information about the testing (if applicable):

_____

_____

_____

Three-Phase Test (Maximum Capacity)				
	Inspection Item	**Result**		**Comments**
1	**Three phase test was successful?** (customer recloser opened and all inverters dropped out and did so within the specified time)	Yes	No	

Additional information about the testing (if applicable):

_____

_____

_____

Other Tests (Attach report and results of any other tests conducted)

Does the site pass Anti-Islanding Test(s)?

☐ **PASS**

PASS = All "Yes" checked and nothing unusual is noted. Interconnection Customer is allowed to operate in parallel at full output.

☐ **NOT PASS**

NOT PASS = Any item checked "No" or something unusual is noted. Deficiencies must be corrected to operate at full output on the Dominion Energy South Carolina system.

Anti-Islanding Test Report Certification

Solar Farm Representative

Signature: _____

Print Name: _____

Inspector

Signature: _____

Print Name: _____