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Transmission Systems
Facility Connection Requirements**

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**Duke Energy Carolinas
Transmission Systems
Facility Connection Requirements**

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Procedure Changes and Updates

If a procedure change is necessary, a new revision will be approved and issued with steps revised to address the required changes.

IF an immediate process change is required **AND** revisions to the Procedure can **NOT** be completed quickly enough, **THEN** perform the following:

- Notify Transmission to issue a Work Directive to dictate the interim process.
- Use the Work Directive as a modifier to this procedure.
- Update the procedure as time permits.

The following table documents the version history for this procedure:

Revision Number	Date	Description of Change
0	---	Approved by SERC Reliability Corporation (SERC)
1	8/5/01	Include specific generator reactive support requirements in section IV.D.6.c
2	9/10/03	Clarify load connection requirements in section III.C.2. Clarify joint study requirements in section III.B and IV.B. Add statement that future project data changes may require additional study of impact.
3	8/25/06	Reformatting only of fonts and alignment. No technical changes.
4	10/1/06	Added section III .D. 1. i and associated definitions
5	12/1/06	Revised sections III.D.1.d and IV.D.1.e requirements for voltage flicker per IEEE Standard 1453-2004.
6	6/20/08	Section III E-4 "Protective System Coordination", additional clarifying language.
7	10/1/17	Extensive revisions following multi-departmental review. Reformatting and grammar edits by Technical Writer. No technical changes
8	10/15/18	Clarify voltage information for 161 kV and add language on metering requirements for new projects.
9	6/12/19	Updated source of facility ratings information. Clarified wording of reactive requirements for reactive resources. Clarified responsibility for access road to Connection Point.
10	3/26/20	Update references to the Energy Control Center and clarify requirements regarding PMU and SCADA requirements.
11	11/14/20	Section 4.2.4.1 change to ensure BAL-005 compliance and section 4.2.4.2 change to clarify requirements regarding telecommunications required to support SCADA and repair a hyperlink.
000	2/1/2022	Updated to latest version of Transmission Level Procedure Template Initial publication into Enterprise Fusion.
001	3/2/2022	Control Element Revision to remove Proprietary Business watermark only from footer and update revision number/date - no other content changes.

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1.0 Introduction

1.1 Purpose

The purpose of this document is to establish the minimum requirements for all facilities connecting to Duke Energy Carolinas, LLC's ("Duke Energy Carolinas") transmission system. The location of the connection and its impacts on the transmission system or other interconnected utility systems determine the specific requirements. These technical requirements are designed to ensure the safe operation and reliability of the **Duke Energy Carolinas Transmission System**. This document can be used to interpret some of the provisions of existing contracts, for example, where Prudent Utility Practice applies. This document can also be used in developing contracts, operating agreements, etc. to specify requirements of individual projects connecting to the **Duke Energy Carolinas Transmission System**. These requirements will be adhered to for all connections, including those owned by Duke Energy Carolinas.

The **North American Electric Reliability Corporation (NERC)** has issued a number of standards and operating policies for owners and operators of transmission systems. One such **NERC** Standard, FAC-001 – Facility Interconnection Requirements, states that Transmission Owners and applicable Generator Owners must document and make facility interconnection requirements available so that entities seeking to interconnect will have the necessary information. This document is written to comply with **NERC** FAC-001. This document also ensures comparability in the requirements imposed upon the various entities seeking to connect to the **Duke Energy Carolinas Transmission System**. It facilitates uniform and compatible equipment specifications, design, engineering, installation and operating practices to promote the safety and reliability of service.

Throughout this document, the term **Project** refers to the connection facilities and all equipment associated with a new **Interconnection** with the **Duke Energy Carolinas Transmission System**. The **Project Sponsor** is the entity that owns or develops the new **Interconnection** with the **Duke Energy Carolinas Transmission System**. The entity that operates the **Interconnection** is referred to as the **Project Operator**.

Technical requirements are addressed, but contractual matters such as costs, ownership, leasing options, scheduling and billing are not the focus of this document. In general, the **Project Sponsor** assumes the cost of all design, construction, inspection, analysis, maintenance, operations, monitoring, and all associated facilities needed to satisfy the technical requirements identified for integration of the **Project** into the **Duke Energy Carolinas Transmission System**. Enforcement of these requirements will be covered in the contracts, operating agreements, or other legal documents applicable to the specific **Project**.

This document is not intended as a design specification or an instruction manual. Technical requirements stated herein are intended to be consistent with **NERC** and **NERC's** Regional Entities' (such as **SERC Reliability Corporation (SERC)**) planning and operating policies, principles, practices, and standards. Compliance with **NERC** standards is expected and nothing in this document relieves the **Project Sponsor** of the industry expectation to meet them. The information presented in this document is subject to change

When a **Project Sponsor** submits a proposal for a new **Project**, Duke Energy Carolinas will evaluate the proposal on a case-by-case basis and specific connection requirements will be provided accordingly. Physical laws that govern the behavior of electric systems do not recognize boundaries of electric facility ownership. Thus, to properly design a connection, the electric systems must be studied and analyzed without regard to ownership. Duke Energy Carolinas will study the proposed connection to its system using existing and forecasted system data and data supplied by the **Project Sponsor**. In these studies, Duke Energy Carolinas considers all the requirements stated in the **NERC** standards in addition to following prudent and reasonable electric utility practices. Duke Energy Carolinas will perform connection studies and develop requirements for review with the **Project Sponsor**.

1.2 Scope

Duke Energy Carolinas has prepared this document to identify technical, operational and coordination requirements for load delivery, generation facility, and transmission system **Interconnections** to the **Duke Energy Carolinas Transmission System** which consists of 44 kV through 500 kV transmission lines and stations. These requirements apply to all entities seeking facility connections to the **Duke Energy**

Carolinas Transmission System including Duke Energy Carolinas itself and any of its affiliates. New facility connections and modifications to the **Duke Energy Carolinas Transmission System** are subject to these requirements. The **Project** must not degrade the safe operation, integrity, or reliability of the **Duke Energy Carolinas Transmission System**.

In addition to the requirements contained in this document, **Projects** must also comply with applicable industry standards, utility planning criteria and applicable local laws, ordinances, rules and state and federal statutes and regulations. [Section 2, References](#) in this document lists several but not all applicable standards, criteria, regulations and codes. The **Project** shall be in compliance with the codes, standards, criteria and regulations listed in Section 2 and others that are applicable.

Project Sponsors and **Project Operators** shall comply with **NERC** Reliability Standards and Operating Policies. The **Project Sponsor** is responsible for the planning, design, construction, reliability, protection, and safe operation of facilities not owned by Duke Energy Carolinas. The design and operation of the **Project** is subject to applicable local, state and federal statutes and regulations.

Duke Energy Carolinas, following discussions with the **Project Sponsor** and other relevant parties, shall make the sole and final determination as to whether the **Duke Energy Carolinas Transmission System** is properly protected from any problems that the **Project** might cause before a connection is closed. The **Project Sponsor** is responsible for the safety, protection, and reliability on the **Project** side of the **Connection Point** (refer to Duke Energy Carolinas North Carolina Service Regulations and Duke Energy Carolinas South Carolina Service Regulations).

This document is divided into two major sections: [4 - Facility Connection Requirements -Generation and Transmission Facilities](#) and [5 - Facility Connection Requirements - Load Delivery Facilities](#). Important terms used in this document are explained in [Section 3 - Definitions](#).

Generation Facility protection system requirements may apply when a **Project** has a generation capacity that is determined to be significant with respect to valley load (i.e. at or near annual minimum load) when evaluated at the point of delivery or when the impact on system protection is otherwise determined to be significant. Duke Energy Carolinas may perform a site-specific evaluation to determine if a **Project** is a load facility or generation facility considering the complexity and variability of individual site designs. However, the following general guidance is provided as an example. With respect to protection, the site may be considered a load delivery if the ratio of valley load to generation capacity is maintained at 3 to 1 or greater with any single load outage contingency in place.

The **Project Sponsor** seeking a facilities connection to the **Duke Energy Carolinas Transmission System** will reimburse Duke Energy Carolinas for the actual costs to perform studies and reviews associated with the request. Costs associated with verifying that all technical requirements in this document are properly addressed will also be included.

The **Project Sponsor**, for itself, its successors, assigns and subcontractors will be required to pay, indemnify and save Duke Energy Carolinas, its successors and assigns, harmless from and against any and all court costs and litigation expenses, including legal fees incurred or related to the defense of any action asserted by any person or persons for bodily injuries, death or property damage arising or in any manner growing out of the use and reliance upon the information provided by Duke Energy Carolinas. Reliance upon the information in this document shall not relieve the **Project Sponsor** from the responsibility for the protection and safety of the general public. The use and reliance upon the information contained in this document shall in no way relieve the **Project Sponsor** from the responsibility to meet NEC and NESC requirements governing their design, construction, operation and materials.

Guidance for the calculation of power station ground potential rise (GPR) and longitudinal induction (LI) voltages is provided, as well as guidance for their appropriate reduction from worst-case values, for use in metallic telecommunication protection design.

2.0 References

- ANSI C12.11-2006 (R2014) – Instrument Transformers for Revenue Metering 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV)
- Duke Energy Corporation Health and Safety Handbook (Available upon request)
- Duke Energy Corporation Work Methods (Available upon request)
- Duke Energy Carolinas Emergency Guidelines for Capacity Shortages (Available upon request)
- Duke Energy Carolinas Transmission Planning Guidelines (Available upon request)
- IEEE SA - 80-2013 - IEEE Guide for Safety in AC Substation Grounding
- IEEE SA - 81-2012 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System
- IEEE 367-2012 Recommended Practice for Determining the Electric Power Station Ground Potential Rise and Induced Voltage from a Power Fault
- IEEE SA - 421.4-2014 - IEEE Guide for the Preparation of Excitation System Specifications
- IEEE SA - 487-2015 - IEEE Standard for the Electrical Protection of Communications Facilities Serving Electric Supply Locations -- General Considerations
- IEEE SA - 837-2014 - IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding
- IEEE SA - 1453-2015 - IEEE Recommended Practice for the Analysis of Fluctuating Installations on Power Systems
- IEEE STD C37, Standards Downloads & Executable Files
- IEEE SA - C37.95-2014 - IEEE Guide for Protective Relaying of Utility-Consumer Interconnections
- IEEE SA - C57.13-2016 - IEEE Standard Requirements for Instrument Transformers
- IEEE SA - C37.102-2006 - IEEE Guide for AC Generator Protection
- IEEE SA - C57.116-2014 - IEEE Guide for Transformers Directly Connected to Generators
- IEEE SA - C62.92.4-2014 - IEEE Guide for the Application of Neutral Grounding in Electrical Utility Systems--Part IV: Distribution
- IEEE SA - P1547 - Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces
- National Electrical Code (NEC)
- National Electrical Safety Code (NESC)
- National Institute of Standards and Technology (NIST)
- North American Electric Reliability Corporation (NERC) Reliability Standards
- NERC Standard PRC-001 - System Protection Coordination
- NERC Standard PRC-019 - Coordination of Generating Unit or Plant Capabilities, Voltage Regulating Controls, and Protection
- NERC Standard PRC-024 - Generator Frequency and Voltage Protective Relay Settings
- NERC PRC-025, Generator Relay Loadability
- NERC MOD-026, Verification of Models and Data for Generator Excitation Control System or Plant Volt/Var Control Functions

- NERC MOD-027 NERC MOD-026, Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions\
- NERC MOD-032, Data for Power System Modeling and Analysis
- 2015 International Building Code (IBC)
- UL 1741, Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use with Distributed Energy Resources

3.0 Definitions

For the purposes of this document the following definitions apply:

Term	Definition
Absolute Voltage Limits	The upper and lower voltage operating limits of each bus on the system. The Absolute Voltage Limits are expressed as a percent of Duke Energy Carolina’s nominal voltage. The system is managed such that all voltages should be maintained within the appropriate absolute voltage bounds for all conditions
Alternate Station Service	A backup source of power, used only in emergency situations or during maintenance when primary Station Service is not available
Black Start	The condition where one unit of generation of the Project starts up under local power, in isolation from the Duke Energy Carolinas Transmission System
Bulk System	The portion of the Duke Energy Carolinas Transmission System used for transferring large amounts of power and includes all 500 kV lines, 500 kV substations, 500/230 kV transformers, and 230 kV lines
Connection Point	The physical location on the power system of the change of ownership between Duke Energy Carolinas and the Project
Connection Review	An internal review of a Project request to connect to the transmission system. This activity includes a review of the requested Connection Point, requested in-service date and Project schedule.
Contingency Voltage Drop	The decrease in voltage due to a single contingency
Customer Equivalent Incapacitating Disturbances	For a normalized customer load, a power problem equivalent in effect and severity to a sustained outage, and not limited to equipment malfunctions (e.g. severe “flicker” disturbs humans, not machines). Typical examples are Sustained Outages, Momentary Interruptions, and severe voltage sags. These disturbances must be shown to cause the customers a problem. Duke Energy Carolinas’ Transmission Asset Management use a methodology to normalize customers of unequal size. Customers are converted to “Customer Equivalents”. For example, for large customers, divide the peak KWD by 5 KW.
Design Review	A series of activities and meetings to review and approve the Project design before construction begins
Design Review Meeting	Meeting between representatives of Duke Energy Carolinas and the Project to review results of the Design Review
Duke Energy Carolinas Transmission System	The integrated electrical transmission facilities owned by Duke Energy Carolinas including 500 kV, 230 kV, 161 kV, 100 kV, 66 kV, and 44 kV lines and stations
Effectively Grounded	A system that provides an $X_0/X_1 < 3$ & $R_0/X_1 < 1$ where X_0 and R_0 are zero sequence reactance and resistance, and X_1 is positive sequence reactance
Energy Control Center (ECC)	The Duke Energy Carolinas facility responsible for generator dispatch and Balancing Authority Area monitoring, and responsible for transmission system switching and operations
Equivalent Fault	A fault of sufficient magnitude and duration to trip a utility owned line or circuit protective device, whether such a protective device exists or not

Term	Definition
Facilities Study	A study performed by Duke Energy Carolinas to determine an initial estimate of the costs and schedule associated with any upgrades required to reliably integrate the Project into the Duke Energy Carolinas Transmission System
Facilities Study Review Meeting	A meeting with Project Sponsor to review results of the Facilities Study
Feasibility Study	A study performed by Duke Energy Carolinas to assess the feasibility of a proposed facility connection to the Duke Energy Carolinas Transmission System
Feasibility Study Review Meeting	Meeting between representatives of Duke Energy Carolinas and the Project to discuss results of the Feasibility Study
Incapacitating Disturbance	For a customer, a power problem equivalent in effect and severity to a sustained outage, and not limited to equipment malfunctions (e.g. severe “flicker” disturbs humans, not machines). Typical examples are Sustained Outages, Momentary Interruptions, and severe voltage sags. These disturbances must be shown to cause the customers a problem
Infeed	Contribution from a positive or zero sequence source, a transformer or generator, to a fault
Initial Scoping Meeting	The initial meeting between Duke Energy Carolinas and the Project Sponsor to review the request, the supplied data and the requested point of connection
Interconnection	Tie point between two transmission systems
Interconnecting Utility	The utility that owns the transmission or distribution system that connects the Project to the Duke Energy Carolinas Transmission System at the Connection Point
Momentary Average Interruption Frequency Index (MAIFI)	refers to the average number of Momentary Interruptions per year per customer
Momentary Interruptions	Outages or zero voltage conditions, lasting 1 minute or less
New Delivery Point Data (NDPD) Form,	Duke Energy Carolinas form (available on request) to be completed by Project Sponsor defining new load delivery characteristics.
North American Electric Reliability Corporation (NERC)	The North American Electric Reliability Corporation (NERC) is certified as the Electric Reliability Organization (ERO) in the United States, pursuant to Section 215 of the Federal Power Act.
Operating Communications Meeting	Meeting with representatives of Duke Energy Carolinas and the Project to review and discuss operating communication protocols and requirements.
Planning Standards	Duke Energy Carolinas Planning Guidelines document, which is part of its annual FERC 715 filing, and the NERC Reliability Standards
Pre-Design Review Meeting	Meeting with representatives from Duke Energy Carolinas and the Project to review and discuss items to be included in the Design Review .
Pre-op Testing, Inspections and Calibrations Meeting	Meeting with representatives from Duke Energy Carolinas and the Project to review and discuss testing, inspections and calibrations required prior to startup of the facility.
Project	The load delivery, Interconnection , or generation facility and all equipment associated with integration of the Project up to the Connection Point with the Duke Energy Carolinas Transmission System .

Term	Definition
Project Initiation Meeting	The initial meeting within Duke Energy to review the load delivery interconnection request, the supplied data and the requested point of connection.
Project Operator	The company that operates a load delivery, Interconnection , or generation facility
Project Sponsor	A company that owns and/or develops a new load delivery, Interconnection or generation facility
Protection Station	Any facility that satisfies the requirements necessary to provide complete protection for the transmission system from the Project
Prudent Electric Utility Practices or Prudent Utility Practice	The generally accepted design, practices, methods, and operation of a power system, to achieve safety, dependability, efficiency, and economy, and to meet utility and industry codes, standards, and regulations
Regional System	The portion of the Duke Energy Carolinas Transmission System used for load deliveries and smaller generator interconnections, and includes all 44 kV, 66 kV, 100 kV, 115 kV and 161 kV lines and substations
Reliability and Integrity	Reliability is defined as the ability to meet the electricity needs of end-use customers, even when unexpected equipment failures or other conditions reduce the amount of available power supply. Integrity is the state of a system where it is performing its intended functions without being degraded or impaired by changes or disruptions in its internal or external environments. Integrity is the state of a system where it is performing its intended functions without being degraded or impaired by changes or disruptions in its internal or external environments.
SAIFI	The average number of sustained interruptions per customer per year
SCADA (Supervisory Control and Data Acquisition)	A system of remote control and telemetry used to monitor and control the transmission system
SERC Reliability Corporation (SERC) Reliability	SERC Reliability Corporation (SERC) is one of eight regional entities, designated by the North American Electric Reliability Corporation (NERC) to monitor and enforce reliability standards.
Station Service	The electric supply for the ancillary equipment used to operate a generating station or substation
Sustained Outages	Outages, zero voltage, lasting for more than 1 minute
System Impact Study	Studies performed by Duke Energy Carolinas to assess the impact of the Project on the reliability of the Duke Energy Carolinas Transmission System
System Impact Study Review Meeting	A meeting with Project Sponsor to review results of the System Impact Study
Voltage Regulation	The difference between expected maximum and minimum voltages at any particular delivery point. The Voltage Regulation limits are expressed as a percent of the nominal voltage and are defined for both normal and contingency conditions. Voltage Regulation for delivery point voltages should not exceed the guidelines

4.0 Facility Connection Requirements – Generation and Transmission Facilities

4.1 New Facility or Modifications to an Existing Facility Requests

Project Sponsors shall contact Duke Energy Carolinas as early as possible in the planning process for any new or modified utility **Interconnections** or generation connections to the **Duke Energy Carolinas Transmission System**. The **Project Sponsor** should supply information about the location, voltage, and other pertinent connection requirements as stated in the interconnection request. Certain areas within the **Duke Energy Carolinas Transmission System** can accept only limited amounts of additional generation without costly reinforcements. Duke Energy Carolinas may have to add to or modify its transmission system substantially before connecting a new **Project**. A **Connection Review** will be performed to determine the required connection facilities and system modifications to accommodate the **Project**. This review may address the transmission system capability, transient stability, voltage stability, losses, **Voltage Regulation**, harmonics, voltage flicker, electromagnetic transients, ferro resonance, metering requirements, protective relaying, substation grounding, and fault duties. If necessary, a joint study with neighboring Transmission Owners may be performed to assess the impact of the **Project**. The data that the **Project Sponsor** is required to provide to enable the completion of these studies is listed in Section 4.1.1 [Project Sponsor Supplied Information](#). Proposals for **Interconnection** with other transmission systems will require a **Connection Review**. The new **Interconnection** would require the development of a new, or modification of an existing interchange or **Interconnection** agreement.

4.1.1 Project Sponsor Supplied Information

Any **Project Sponsor** desiring a new connection or modification of an existing connection must provide the data in [Appendix A - Generation and Transmission Facility Data](#) of this document. If any data previously supplied pursuant to these connection requirements changes, the **Project Sponsors** or **Project Operator** will notify Duke Energy Carolinas in writing without delay. Data changes may require additional studies to examine the impact. This notification must include the time and date at which the change became, or is expected to become, effective and if the change is only temporary, an estimate of the time and date at which the data will revert to the previously supplied values.

A request for a change in the point of connection to the **Duke Energy Carolinas Transmission System** or level of generation must be submitted as a new request. A new completion date will be negotiated with the **Project Sponsor** or **Project Operator** when **Project** data is significantly changed.

4.1.2 Connection Point Considerations

Projects may be connected to the **Duke Energy Carolinas Transmission System** by tapping an existing transmission line(s) or by connecting directly into an existing transmission station. In rare cases, a new transmission switching station might be built in the middle of an existing transmission line. The 500 kV and 230 kV transmission systems are typically reserved for the bulk transport of large amounts of electricity.

Point of connection options are dependent upon several factors, including location of the desired **Connection Point** relative to existing Duke Energy Carolinas transmission facilities, the size of the **Project's** generation, present transmission line loading, and other requirements of the **Project**.

Integration of **Projects** into power systems usually falls into one of the following three categories:

- a) Connection into an existing 44 kV to 500 kV substation
- b) Connection on the low-voltage side (typically 4 kV to 24 kV) of a new or existing customer service transformer that was originally designed to serve load
- c) Connection at 44 kV to 500 kV to a transmission line by building a new switching station in the vicinity of the **Project**

4.1.3 Connection Review

An internal review is performed to review the data supplied in the Application, evaluate the requested **Connection Point** and identify feasible options that meet the request and requirements of the new **Interconnection**. Requested in-service date and **Project** schedule are discussed as part of the **Connection Review**. An agenda is developed for the **Initial Scoping Meeting** with the **Project Sponsor**.

4.1.4 Initial Scoping Meeting

An **Initial Scoping Meeting** is conducted with representatives from Duke Energy Carolinas and the **Project Sponsor** to review the request and supplied data. Results of the **Connection Review** are discussed along with **Project** in-service date and major **Project** milestones. Next step - Feasibility or System Impact Study - is discussed. Prior to or following this meeting, the **Project Sponsor** must provide a one-line diagram of the new facility along with the new **Interconnection Point** on the **Duke Energy Carolinas Transmission System**.

4.2 Technical Requirements

Existing electrical equipment, such as transformers, power circuit breakers, disconnect switches, and line conductors were originally designed based on the duties and capacity limits expected in response to system additions identified in long-range plans. However, with the connection of a new generating resource, some equipment may become overloaded and need to be replaced.

Duke Energy Carolinas operates and maintains its transmission system to provide reliable customer service at all times. **Project** integration requires that the equipment at the **Connection Point** not restrict timely outage coordination, automatic switching or equipment maintenance scheduling. Preserving reliable service to all Duke Energy Carolinas customers is essential and may require additional switchgear, equipment redundancy, or bypass capabilities at the **Connection Point** for acceptable operation of the system. Section 4.2 contains the various technical requirements that must be met for new generation connections to the **Duke Energy Carolinas Transmission System**.

4.2.1 System Review

Following the **Connection Review** and **Initial Scoping Meeting**, studies are performed to determine if the new generation connection is feasible and what impacts the new connection may have on the interconnected transmission systems. Data supplied by the **Project Sponsor** is incorporated into power flow models and Duke Energy Carolinas will perform power flow simulations to determine the impact of the **Project** on the transmission system. **Project Sponsor** provided GSU tap settings will be used in these studies. Any issues found with the proposed tap settings will be reviewed with the **Project Sponsor**. The **Project Sponsor** must provide the expected source and sink of energy related to the **Project**. The primary intent is to determine if the **Project** causes any violations of the Duke Energy Carolinas Transmission Planning Guidelines which is part of Duke's annual FERC 715 filing, or the **North American Electric Reliability Corporation (NERC)** Reliability Standards (**Planning Standards**). The various studies are summarized below.

4.2.1.1 Feasibility Study

Note: The **Project Sponsor** can elect to skip the **Feasibility Study** and proceed with a **System Impact Study**. A **Feasibility Study** is performed to look at thermal loadings and voltage levels anticipated after connection of the new generation. Specifically, a reactive study is performed to evaluate the reactive power output over the continuous MW output of the new generation. Generator step-up (GSU) Transformers tap settings are determined as well as any impacts on adjacent area voltages and reactive power flow. Next a thermal study is performed to determine if integration of the **Project** into the **Duke Energy Carolinas Transmission System** violates any of the Planning Guidelines. The Thermal Study will reveal any transmission upgrades required by the **Project**. These upgrades along with the new generation provided by the **Project** are incorporated into the system model and a fault duty study is conducted. The fault duty study will determine if any short circuit capabilities of current carrying elements are exceeded and what additional system upgrades will be required to accommodate the new generation. If requested by the **Project Sponsor**, an Energy Resource Interconnection Service (ERIS) study is performed. The **Project Sponsor** will be provided a complete **Feasibility Study** report following completion of these system review studies. If

appropriate, a **Feasibility Study Review Meeting** will be held with all responsible parties to review results of the Feasibility Studies and determine next steps.

4.2.1.2 System Impact Study

If a **Feasibility Study** is performed and the **Project** continues, or the **Project Sponsor** elects to move directly into the **System Impact Study**, the **System Impact Study** is performed using results of the **Feasibility Study, if available**, and adding a system stability study. Appropriate studies are performed to review thermal loadings, voltage levels and system fault duties that are anticipated after connection of the new generation to the transmission system. An affected system study by neighboring utilities may be necessary. Duke Energy Carolinas will coordinate generation interconnection studies with any affected systems and appropriate personnel of those affected systems will be included in all meetings. The **Project Sponsor** will cooperate with Duke Energy Carolinas in all matters related to the conduct of studies and the determination of modifications to affected systems. Results from the **Feasibility and System Impact Studies** are placed in individual reports that are provided to the Project Sponsor. These reports identify any transmission constraints and network upgrades that will be required to accommodate the new generation at the requested **Connection Point**. The **Project Sponsor** will be provided a complete **System Impact Study** report following completion of these system review studies. If appropriate, a **System Impact Study Review Meeting** will be held with all responsible parties to review results of these studies and determine next steps.

4.2.1.3 System Protection Review

The requested connection configuration that was reviewed as part of the **Connection Review** is then reviewed to determine protective requirements for the **Project**. This review will require an impedance model (short-circuit data) at the **Connection Point** in order to determine any protective changes to the transmission system, protective requirements for the new generation and any special protective needs for the **Project**. Any specific protection requirements determined at this point are added to those identified in the **Facilities Study**.

4.2.1.4 Power Quality and Reliability

Due to the sensitivity of many industrial and commercial loads such as adjustable speed drives and computer-controlled processes, reliability is no longer only defined by the frequency and duration of sustained interruptions. There are many power quality variations other than sustained interruptions that may constitute inadequate service for the proper operation of customer equipment. These variations include but are not limited to voltage imbalance, voltage flicker, harmonic distortion, transient overvoltage, temporary overvoltage, temporary undervoltage and steady-state **Voltage Regulation**. In order to meet the requirements of its many customers, Duke Energy Carolinas may require studies to be performed, as necessary, to determine the power quality and reliability impacts the **Project** may have on the transmission system at the point of connection. The intent of these studies is to ensure that the connection of the **Project** does not compromise the **Reliability and Integrity** of the **Duke Energy Carolinas Transmission System**. Limits for these variations and disturbances are stated in [Section 4.3 Performance Requirements](#).

4.2.1.5 Facilities Study

If the System Impact Study indicates that additions or upgrades to the **Duke Energy Carolinas Transmission System** are needed to meet the request of the **Project Sponsor**, a Facilities Study will be performed by Duke Energy Carolinas. This study will provide an estimate of the costs of:

- a) Direct Assignment Facilities to be charged to the **Project Sponsor**
- b) **Project Sponsor** appropriate share of the costs of any network upgrades
- c) Estimate of the time to complete construction and initiate requested service

Also included in the Facilities Study will be any operating and control requirements and metering and communications requirements (see sections 4.2.3 and 4.2.4) necessary to support the new generation. The **Project Sponsor** will be provided an Initial **Facilities Study** Draft report containing costs and schedule for all transmission system modifications and any operating, control, metering, and communications requirements. A **Facilities Study Review Meeting** will be held with all responsible parties to review results of these studies and determine next steps. Following the meeting, the report will be revised as appropriate to become the Final Facilities Study report. Following acceptance of the final **Facilities Study** report, the **Project Sponsor** executes the Large Generator Interconnection Agreement (LGIA). Duke Energy Carolinas will then assign a Project Manager to the **Project**. After that time all communications and information will flow through and by the Project Manager.

4.2.2 Facility Design and Equipment Specifications and Ratings

Circuit breakers, disconnect switches, buses and all current carrying equipment connected to transmission facilities shall be capable of carrying both normal and emergency load currents without damage. The design and ratings of all **Project** equipment connected to the transmission system shall not restrict the capability of any transmission circuits, reduce facility ratings of any Duke Energy equipment nor become a limiting factor in the ability to transfer power throughout the **Duke Energy Carolinas Transmission System**. All equipment ratings shall be determined according to the Duke Energy Carolinas Electrical Facilities Rating Methodology document. Duke Energy Carolinas operates and maintains its system to provide reliable service to all customers at all times. **Project** integration requires that the equipment at the **Interconnection** Facility not restrict timely outage coordination, automatic switching, or equipment maintenance scheduling. Preserving reliable service to all Duke Energy Carolinas customers is essential and may require additional switchgear, equipment redundancy, or bypass capabilities at the **Interconnection** Facility for acceptable and reliable operation of the system. The effects resulting from wind and ice storms, floods, lightning, altitude, temperature extremes, and earthquakes must be considered in the design and operation of the **Project**. The **Project Sponsor** is responsible for determining that the appropriate standards are met, including, but not limited to, the Uniform Building Code (UBC) and the National Electrical Safety Code (NESC). Depending on **Project** location, size, type, and importance, Duke Energy Carolinas may request that additional capabilities be designed into the **Project**.

4.2.2.1 Isolation Requirements

At the **Connection Point** with the **Duke Energy Carolinas Transmission System**, a disconnect switch shall be provided for the purpose of physically and visibly isolating the **Project** from the **Duke Energy Carolinas Transmission System**. With the consent of Duke Energy Carolinas and the **Project Sponsor**, the disconnect switch may be installed at another location, other than the **Connection Point**, provided that the purpose described herein is satisfied. The device must adhere to the following design requirements:

- a) Accessible by Duke Energy Carolinas personnel and under the jurisdiction of Energy **Control Center (ECC)**
- b) Lockable in the open position by Duke Energy Carolinas personnel if gang-operated
- c) Suitable for safe operation under the conditions of use
- d) Not to be operated without advance notice to either party, unless an emergency condition requires that the device be opened to isolate the **Project**

Consideration shall be given as to the design and capacity of the switch on a case-by-case basis. The switch is required for safety and may not be required to interrupt load or energizing (charging) current. However, a suitable switch for the safety requirements listed above may also be used for other operational purposes.

The **Project Sponsor** is also responsible for ensuring that proper current-interrupting equipment is installed at the facility. This equipment will be installed for the purposes of protecting the **Project** from faults or other undesirable conditions on the transmission system, and to protect the transmission system from faults internal to the **Project**.

4.2.2.2 Breaker Duty

All circuit breakers and other fault-interrupting devices shall be capable of safely interrupting fault currents for any fault that they may be required to interrupt. Application shall be in accordance with IEEE C37 Standards. These requirements apply to the generation site, the interconnecting substation, the **Connection Point** as well as other locations on the **Duke Energy Carolinas Transmission System**. Minimum fault-interrupting requirements are supplied by Duke Energy Carolinas as part of the Facilities study, and are based on the greater of the fault duties at the time of the connection request or those projected in long-range plans. System stability considerations may require very fast opening and/or reclosing times. The total automatic reclosing times would be the summation of the breaker interrupt and close time plus intentionally added delay to allow for deionization and subsequent extinction of the fault arc, referred to as the dead timer delay, and the specific protective relay requirements. Table 1 specifies the typical operating times required of circuit breakers on the **Duke Energy Carolinas Transmission System**. These times also apply to equipment at the generation site and the **Connection Point**.

Table 1. Circuit Breaker Operating Times

Voltage Class (kV)	Rated Interrupting Time (Cycles)	Dead Timer Delay (Cycles)
500	2	30
230	3	25
161 and below	3	18
138 and below	5	18

Depending on the application, the use of other fault-interrupting devices such as circuit switchers may be allowed. Trip times of these devices are generally slower, and current interrupting capabilities are often lower than those of circuit breakers. Often circuit switchers are utilized to isolate generator step-up transformers from the transmission breakers. The dead timer delay on circuit switchers is typically 15 seconds and consequently these devices usually are not reclosed.

4.2.2.3 Specification and Coordination of the Protection Station

The **Protection Station** is any facility that satisfies the requirements necessary to provide complete protection for the transmission system from the **Project**. The objectives of these requirements include but are not limited to the following:

- a) Maintain safety of the general public and Duke Energy Carolinas personnel
- b) Maintain dynamic stability
- c) Prevent or minimize equipment damage
- d) Minimize system voltage disturbances
- e) Minimize adverse operating conditions on the **Duke Energy Carolinas Transmission System** and customers

To achieve these objectives, certain protective equipment (relays, circuit breakers, etc.) must be installed. These devices ensure that faults or other abnormalities initiate prompt and appropriate disconnection of the **Project** from the **Duke Energy Carolinas Transmission System**. Protective equipment requirements depend on a variety of considerations. Significant issues that could affect these requirements include:

- a) The connection configuration of the **Project**
- b) The location of the **Connection Point** on the power system
- c) The level of existing service and protection to adjacent facilities (including those of other Duke Energy Carolinas customers and/or those of other utilities)

In addition, certain modifications and/or additions to the **Duke Energy Carolinas Transmission System** may be required for connection of the **Project**. Each individual connection will require a protection system consistent with these requirements. Duke Energy Carolinas will work with the **Project Sponsor** to achieve an installation that meets requirements of both the **Project Sponsor** and Duke Energy Carolinas. The **Project Sponsor** shall provide **Project** protection system design data as requested and shall address any aspects of the design that Duke Energy Carolinas finds unacceptable.

Duke Energy Carolinas will not assume any responsibility for protection of the **Project**. **Project Sponsors** are solely responsible for protecting their equipment in such a manner that faults, imbalances, or other disturbances on the **Duke Energy Carolinas Transmission System** do not cause damage to the **Project** facilities. The **Project Sponsor** is also expected to provide proper protective systems to ensure **Project** equipment does not adversely impact the **Duke Energy Carolinas Transmission System**. The **Project Sponsor** should follow applicable industry guides and standards such as those listed in [Section 2: References](#). Duke Energy Carolinas may elect to require compliance with guidelines and/or standards, or portions thereof, specific to the **Project**.

4.2.2.4 Protection Criteria

The information in this section is provided to identify general protection practices as applied to the Duke Energy Carolinas transmission lines and connections. The overall protection system, including the **Protection Station** and **Project** protection, must be designed such that the **Project** generating equipment or **Connection Point** is automatically isolated for the following situations:

- a) Faults within the **Project**
- b) Faults within **Duke Energy Carolinas Transmission System** zones of protection determined to be significantly impacted by the **Project**
- c) Conditions that indicate abnormal operation, including unintentional islanding of the **Project**

The protection schemes necessary to integrate the **Project** must be consistent with the following practices.

- a) A generator may interconnect to an existing transmission line only if the line protection can be coordinated without compromising reliability, system stability, or quality of service to Duke Energy Carolinas customers
- b) Protective equipment (relays, breakers, etc.) is required at the **Connection Point** or the Duke Energy Carolinas' interconnecting substation to isolate Duke Energy Carolinas equipment from the **Project** during faults or other system abnormalities. Duke Energy Carolinas reserves the right to require Duke Energy Carolinas-owned protective equipment to be installed adjacent to the **Connection Point**.
- c) The **Project** shall be synchronized to the power system. A synchronizing function must supervise all closures of the breaker connecting the generator to the power system
- d) Any breaker dedicated for the sole purpose of isolating the interconnecting power system or generator shall open all three phases simultaneously
- e) Where applicable, breaker automatic reclose supervision is required at the interconnecting substation and/or electrically adjacent stations; e.g., hot bus/dead line check, synchronization check, etc.
- f) Total fault-clearing times, including those of breaker failure schemes, must not exceed transmission system stability limits and must be provided for Duke Energy Carolinas review. Breaker-operating times, relay models, and relevant relay settings must be identified specifically
- g) Redundancy, pilot protection, communications paths, breaker failure scheme, backup relaying, automatic reclosing, and other requirements will be determined on a **Project**-specific basis. Duke Energy Carolinas reserves the right to modify automatic reclosing in the future

Duke Energy Carolinas reserves the right to specify interconnecting transformer connections. For example, small to medium distributed energy resource Interconnections may be required to have a delta connection on the utility side while larger generation may be required to have a grounded wye connection on the utility side. The **Project Sponsor** shall provide interconnecting transformer and/or neutral grounding device specifications for the **Project** and shall address any aspects of the specification that Duke Energy Carolinas finds unacceptable.

4.2.2.5 Connecting to an Existing Customer Service Substation

Many generation projects are proposed for integration into utility power systems through a transformer and facilities designed only to serve loads; for example, connection at a voltage of 24 kV or below. Existing facilities may have protection only on the high-voltage side of the transformer. The existing protection at these installations was applied under the assumption that there was not a source from the proposed **Project** side to feed faults on the transmission system. Responsible and thorough protective relaying strategies are necessary when generation is connected to these sites. Therefore, changes to existing protection and reclosing schemes may not be limited to those at the **Connection Point**.

4.2.2.6 Phase Sequence Orientation

Much of Duke Energy Carolinas uses a phase rotation of ABC (phase "A" voltage leads phase "B" voltage by 120 degrees and phase "B" voltage leads phase "C" voltage by 120 degrees). It is important that the **Project Sponsor** understand this phase sequence and coordinate with Duke Energy Carolinas before connection is made to ensure intended phase rotation is achieved. Duke Energy Carolinas can typically provide the phase sequence desired by the **Project Sponsor** at 100 kV, however there may be limitations in a given **Project**. Duke Energy cannot guarantee a requested phase sequence connection until each connection request is reviewed in detail. Duke Energy Carolinas will not typically "roll phases" at the **Connection Point** for a **Project** unless Duke Energy Carolinas did not provide adequate or accurate information regarding the phase sequence to be provided at the **Connection Point**.

4.2.2.7 Equipment Grounding

Each interconnecting substation or generation site must have a ground grid that solidly grounds all metallic structures, and fencing along with other non-energized metallic equipment. This grid shall limit the Ground Potential Rise (GPR) to such voltage and current levels that will not endanger the safety of people or damage equipment which are in, or immediately adjacent to, the station under normal and fault conditions.

If the **Project** is physically close to a Duke Energy Carolinas substation, it is required that the two ground grids be connected. However, the **Project** and substation fences should not be connected except via an isolated fence section with a minimum length of 10 feet. The interconnecting cables must have sufficient capacity to handle fault currents and control ground grid voltage rises. Duke Energy Carolinas must approve any physical connection to a Duke Energy Carolinas substation ground grid. If the ground grids must be isolated for operational reasons, there must be no metallic ground connections between the two substation ground grids and Duke Energy Carolinas shall approve the required minimum separation of the facilities.

As a note of caution, cable shields, cable sheaths, **Station Service** ground sheaths, fiber optic tracer wires, metallic cable trays and overhead transmission shield wires can all inadvertently connect ground grids. Fiber-optic cables with non-metallic sheaths are an excellent choice for telecommunications and control between two substations to maintain isolated ground grids. In the case where the **Project** is physically close to another substation, but the ground grids are isolated, the **Project Sponsor** must demonstrate that the ground grids are properly isolated and in compliance with all applicable codes and standards. Duke Energy Carolinas prefers to connect static wires on incoming transmission lines to the station ground grid. If the **Project Sponsor** prefers not to connect static wires on incoming transmission lines to the station ground grid, the **Project Sponsor** must notify Duke Energy Carolinas in writing and demonstrate that relay performance, lightning protection, and personnel safety are not compromised by isolating the static wires from the station ground grid.

The **Project** ground grid should be designed to IEEE SA - 80-2013 - IEEE Guide for Safety in AC Substation Grounding, and should be measured in accordance with IEEE SA - 81-2012 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System. **Project** grounding requirements shall also comply with the National Electrical Safety Code and the following:

IEEE SA - 837-2014 - IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding

IEEE SA - 487-2015 - IEEE Standard for the Electrical Protection of Communications Facilities Serving Electric Supply Locations -- General Considerations

IEEE STD 367, IEEE Recommended Practice for Determining the Electric Power Station Ground Potential Rise and Induced Voltage from a Power Fault.

4.2.2.8 Insulation and Insulation Coordination

Insulation and insulation coordination requirements are applicable to all generation, transmission and **Interconnection** facilities. Proper insulation coordination is necessary to ensure electrical system reliability and personnel safety. Power system equipment is designed to withstand voltage stresses associated with expected operation. System studies include the evaluation of the impact of the **Project** on equipment insulation coordination. Duke Energy Carolinas will identify equipment additions or specifications that are required to maintain an acceptable level of system availability, reliability, equipment insulation margins and safety. Basic Insulation Level (BILs) and arrester ratings are shown in **Table 2**.

Table 2 Substation Basic Insulation Levels and Arrester Ratings

Nominal System Voltage - kV	Substation Bus BIL kV	Transformer BIL kV	Bank Arrester kV	Line Arrester kV
525	1800	1675	420	420
230	900	900	192	192
161	650	650	132	132
138	550	550	108	108
115	550	450	108	108
100	475	450	96	88
66	350	350	72	70
44	250	250	48	48

Voltage stresses such as lightning surges, switching surges, temporary overvoltage, and normal 60 Hz voltages may affect equipment duty. Remedies depend on the equipment capability and the type and magnitude of the stress. In general, stations shall be protected against lightning and switching surges. Typically this includes, station shielding against direct lightning strokes, surge arresters on all wound devices, and shielding on the incoming lines. Below are the requirements that must be met to connect to the **Duke Energy Carolinas Transmission System**.

4.2.2.8.1 Lightning Surges

Lightning is the single largest cause of transmission line events in the Duke Energy Carolinas service area and must be considered during the design and installations of transmission lines and substations. Lightning related causes are not exempt from the Performance Requirements section. Although it is not always cost effective to design and build a power system to withstand every possible lightning stroke, it has been demonstrated that with proper design and installation procedures, the effects of lightning can be mitigated to achieve a reliability level equal to or exceeding the requirements of the **Project** performance criteria section. Techniques used to help control lightning related events on transmission lines include proper use of shield wires, insulation levels, low resistance grounding, and surge arresters. Techniques used to help control lightning related outages in substations include substation shielding, proper arrester applications, and shielding of incoming transmission lines.

If the **Project** proposes to tap a Duke Energy Carolinas transmission line that is shielded, the new tap line must also be properly shielded for at least one mile from the **Duke Energy Carolinas Transmission System**. If any stations are within one mile of the **Duke Energy Carolinas Transmission System**, these also must be properly shielded from direct lightning strokes. The **Project Sponsor** must be able to demonstrate proposed designs for any transmission lines and substations will perform within the limits for service interruptions as stated in the Performance Requirements section.

For transmission line design, an industry recognized lightning performance estimating algorithm may be used to demonstrate acceptable performance of the design. The **Project Sponsor** must make reasonable assumptions based on the geographic area in which the transmission line will be installed, including ground flash density and grounding conditions. The **Project Sponsor** must be able to provide an alternative plan if the ground conditions required for acceptable performance are not achieved during construction of the transmission line.

For substation design, the **Project Sponsor** must be able to demonstrate their proposed designs will operate within the Performance Requirements. The shielding designs and arrester applications shall adhere to applicable IEEE standards. In addition, any normally open points that are subject to voltage “doubling” of incoming lightning surges must be protected accordingly so the Performance Requirements are met.

4.2.2.8.2 Switching Surges

At voltages below 500 kV, modifications to protect the **Duke Energy Carolinas Transmission System** against switching surges generated by the **Project** are not anticipated although the **Connection Review** will identify the actual needs. At 500 kV, Duke Energy Carolinas may require that arresters be added at the line terminations of the substations or that pre-insertion resistors or inductors are included in **Project** breakers, if switching surge studies predict overvoltages that may cause a flashover at the **Project's** facilities.

4.2.2.8.3 Temporary Overvoltages

Temporary overvoltages can last from seconds to minutes and are not characterized as surges. These overvoltages are usually present during faults and other abnormal system conditions. The **Duke Energy Carolinas Transmission System** is typically considered to be **Effectively Grounded** at 100 kV and higher voltages. However, the 44 kV system is not **Effectively Grounded** in all locations. These systems may be impedance grounded and can have line-to-ground voltages approaching 1.73 times normal line-to-ground voltage during fault conditions on unfaulted phases. It is not acceptable for the **Project** to supply any ground source for the transmission system unless specifically approved and coordinated with Duke Energy Carolinas.

When generation is connected to the low voltage side of a delta-grounded wye (D-YG) transformer, remote end breaker operations initiated by the detection of faults on the high-voltage side can cause overvoltages that can affect personnel safety and damage equipment. In these instances, Duke Energy Carolinas will require the **Project** to rapidly separate the generator from the step-up transformer by tripping a breaker using either remote relay detection with pilot scheme (transfer trip) or local relay detection of the overvoltage condition.

A system study may be performed for each **Project** based on the point on the **Duke Energy Carolinas Transmission System** that is being connected. The **Project Sponsor** will be supplied the system characteristics needed to calculate the temporary overvoltages that need to be considered. Gapless metal-oxide surge arresters are especially sensitive to system temporary overvoltages and Duke Energy Carolinas may review the specification of arresters used on 44 kV systems to ensure proper application.

4.2.2.8.4 Normal Operating Voltages

Duke Energy Carolinas Transmission System voltages are normally operated within the limits specified in [Section 4.3, Performance Requirements](#) of this document. Insulation coordination usually does not need to consider this operating range once lightning and switching surge requirements are met; however, in highly contaminated areas, special consideration and additional insulation requirements may be required for proper insulation coordination. The **Project Sponsor** is responsible for determining whether special insulation requirements are needed for its system.

4.2.2.8.5 Station Service

Appropriate providers of **Station Service** and **Alternate Station Service** are ultimately determined during the **Project** planning process, including **Project** one-line diagram development and review. Generally, the utility with a distribution service in the vicinity will be the preferred provider of primary **Station Service** unless:

- a) The utility is unable to serve the load
- b) Costs to connect the local utility are prohibitive

The **Project Sponsor** is responsible for metering for **Station Service** and **Alternate Station Service**, as specified by the Metering Requirements (4.2.4.1) section of this document.

4.2.3 Operating and Control Requirements

Duke Energy Carolinas will conduct an internal review to determine additional facility design and operational factors affecting the operations and control of the new generation or interconnecting facilities based on the point of **Interconnection** with the **Duke Energy Carolinas Transmission System**. This review may generate additional design and operating requirements. These requirements will be communicated to the **Project Sponsor** through the Facilities Study report or separate document.

4.2.3.1 Voltage Level, MW and MVAR Capacity at the Point Of Connection

All new generation and interconnecting transmission facilities must be designed and operated to meet the voltage level, MW and MVAR capacity as agreed to in the interconnection request. The following items will be evaluated for applicability in each case:

- a) Load following capability
- b) Automatic Generation Control (AGC)
- c) Reactive power output
- d) Minimum operating capability
- e) Remote control functions
- f) Coordination of generation control settings per **North American Electric Reliability Corporation (NERC)** Standards PRC-019, MOD-026 and MOD-027
- g) Subsynchronous torsional interactions or resonances - Generators in close proximity to series-compensated lines or FACTS devices may experience undesirable or damaging subsynchronous currents
- h) **Black Start** capability

Black Start is the condition where one unit of generation of the **Project** starts up under local power, in isolation from the **Duke Energy Carolinas Transmission System**. **Black Start** capability is needed in the rare event of a system restoration emergency. Depending on the size and location of the **Project**, this service may be needed from that **Project**. It is generally not needed for small generators or for **Projects** in close proximity to other major generation. If the **Project** is supplying **Black Start** capability to the **Duke Energy Carolinas Transmission System**, then it will be a participant in the Duke Energy Emergency Guidelines for Capacity Shortages. In the event of a local or wide-spread blackout, those guidelines should be followed to aid in the restoration of the system. If for any event, generation is not running and the **Project** becomes completely de-energized, the **Project Operator** should advise the **Duke Energy Carolinas Transmission System Energy Control Center (ECC)** System Operator of its status and await further System Operator instruction.

Some issues Duke Energy Carolinas considers when determining whether to request the capability of the **Project** to provide **Black Start** capability include the following:

- Proximity to other generation
- Location of the **Project** on the transmission system

- Cost of on-site start-up
- Periodic testing to ensure personnel training and capability
- Dynamic stability and use of power stabilizers

Generation excitation systems are critical to the overall system performance. Therefore, Duke Energy Carolinas shall have control over and final approval of the settings for these systems (gains, time constants, limiters, etc.). Duke Energy Carolinas reserves the right to specify these settings initially or revise the settings at any time during the life of the generator as warranted by system conditions.

New or replacement voltage regulators may be required to have a load compensation circuit. Based on system conditions, it may become necessary to add load compensation to existing systems. In applications where needed, load compensation is used to control voltage at a point beyond the generator terminals (line-drop or transformer-drop compensator). The compensator is typically set to account for 50% to 80% of the transformer impedance. Generators whose terminals are tied directly together (cross-compound, hydro, etc.) require operation in a droop compensation mode to ensure stability. Droop compensation effectively regulates the voltage at a point behind the generator terminals (within the generator). In general, no two generators should be set to regulate the same point on the electric system.

A Power System Stabilizer (PSS) uses auxiliary stabilizing signals to control the excitation system to improve power system dynamic performance. For generators that have a PSS, Duke Energy Carolinas will determine if the PSS needs to be put into service and will work with the generator operator to calculate appropriate settings. Based on system conditions, it may become necessary to add the PSS prior to start-up or the installation of new or replacement systems.

IEEE SA - 421.4-2014 - IEEE Guide for the Preparation of Excitation System Specifications should be consulted in designing the excitation system. Additional requirements or a change in technical specification may be identified as a result of system studies:

- Review of the generator D Curve - Internal plant design shall not limit continuous reactive capability
- **Project** shall not negatively impact voltage and reactive power flow requirements on adjacent transmission systems

Operational requirements for voltage level, MW and MVAR capacity at the point of connection that shall be addressed include:

- a) Operation at 60 Hz nominal
- b) Mode of frequency control
- c) Operation of generators during frequency decline conditions per **North American Electric Reliability Corporation (NERC) Standard PRC-024 - Generator Frequency and Voltage Protective Relay Settings**
- d) Coordination between generator controls and underfrequency load-shedding programs
- e) Speed droop settings
- f) Responsibility for coordination with the appropriate operating entity
- g) Testing to verify reactive support capability per **North American Electric Reliability Corporation (NERC) Standard PRC-025, Generator Relay Loadability**

4.2.3.2 Voltage, Reactive Power and Power Factor Control

All new generation and interconnecting transmission facilities must be designed and operated to meet the voltage, reactive power and power factor control requirements as agreed to in the interconnection agreement. The following items will be evaluated for applicability in each case:

- a) Internal facility design shall not restrict any mode of **Project** operation within the transmission system allowable voltage range and regulation.

- b) Transmission interconnected equipment shall have tap ranges and self-regulation necessary to operate within the transmission system's voltage range and regulation.
- c) Voltage regulator load compensation may be required to control voltage beyond generator terminals.
- d) Voltage regulator droop compensation may be required for generators whose terminals are direct-connected.

Operational requirements for voltage, reactive power and power factor control that shall be addressed include:

- a) Generation operation within acceptable voltage range and regulation as specified by Duke Energy Carolinas
- b) Allowable operating modes for excitation system/voltage regulator (i.e. manual or automatic)
- c) Generator voltage schedules will be provided periodically, and the new generation is expected to operate to them
- d) Coordination with any reactive compensation device(s) is required
- e) Coordination of excitation system settings with Duke Energy Carolinas

4.2.3.3 Unusual Operating Conditions

There may be additional design and operational requirements for dealing with unusual operational issues such as abnormal frequency and voltages. Such requirements that should be addressed by the Project Sponsor include:

- a) Consideration of abnormal voltage conditions
- b) Consideration of abnormal frequency conditions
- c) Consideration of generators connected through a tapped transmission line i.e. islanding
- d) Relay coordination to maintain stability
- e) Load shedding implementation

Operational requirements that should be addressed for dealing with unusual operating issues such as abnormal frequency and voltages may include:

- a) Provisions for abnormal voltage conditions
- b) Provisions for abnormal frequency conditions
- c) Provisions for load shedding
- d) Any special procedures for coordination

4.2.4 Metering and Telecommunications Requirements

All **Projects** that are connected to the **Duke Energy Carolinas Transmission System** will require revenue-accuracy metering equipment (i.e. metering enclosure with meter and associated equipment, instrument transformers, and certain interface enclosures with associated isolation devices). In addition, Duke Energy Carolinas specified communications and Supervisory Control and Data Acquisition equipment must be installed at the **Connection Point** of the **Project** or in an agreed upon location. The **Projector Sponsor** is responsible for the costs, installation, calibration, and maintenance associated with metering and telecommunications equipment between the **Project** and Duke Energy Carolinas. In some cases, Duke Energy Carolinas may install some or all of the metering equipment. Either way, the **Project Sponsor** is responsible for all costs associated with the equipment, installation, and commissioning of the metering equipment. This section states the minimum requirements for metering and telecommunication equipment associated with a generation connection or transmission **Interconnection** to the **Duke Energy Carolinas Transmission System**. Additional site-specific equipment may be required.

4.2.4.1 Metering Requirements

It is the responsibility of the Project Sponsor to make appropriate arrangements with DEC, as the Balancing Authority, for the following: a) ensuring that their new or materially modified Facilities are within the BA metered boundaries, which also serves to facilitate the process of the coordination between the two entities that will be required under numerous other standards upon the start of operation; b) proper coordination with DEC so that DEC, as Balancing Authority, can ensure that any associated Tie-Line, Pseudo-Tie, and Dynamic Schedule with an Adjacent Balancing Authority is equipped with a common source to provide information to both Balancing Authorities for the scan rate values used in the calculation of Reporting ACE per the requirements of NERC Reliability Standard BAL-005, R7.1.

Metering equipment should be installed, if possible, at the **Connection Point**. If not installed at the **Connection Point**, the power transformer and line losses will need to be compensated. A solid-state meter shall be used to measure the real and reactive power interchange between the **Duke Energy Carolinas Transmission System** and the **Project**. Three-element, three-phase, four-wire meters shall be utilized on wye connected power systems. Two-element, three-phase, three-wire meters shall be utilized on delta connected power systems.

Typical metering data requirements include:

- a) kW
- b) kWh
- c) kVAR-hour, leading and lagging
- d) kV-hour
- e) Voltage (to monitor voltage schedule compliance)

Additional design and testing requirements that shall be addressed include:

1. Bi-directionality - A bi-directional watt/var-hour meter shall be utilized to measure the power flow in and out of the **Duke Energy Carolinas Transmission System**.
2. Metering-bypass - For metering equipment located in the **Project** substation, the installation of a metering bypass is suggested, but not required. For the replacement of failed or malfunctioning equipment a metering bypass is necessary to maintain power flow to the **Project**. If a metering bypass is not installed, an outage will be required to replace the failed or malfunctioning equipment.
3. Metering accuracy - Meters shall be calibrated to 0.2% accuracy at unity power factor for full load and 0.3% at unity power factor for light load. These meters shall be calibrated to 0.5% accuracy for 0.5 power factor at full load. Metering accuracy limits are stated in **Table 3**.

Table 3 – Meter Accuracy Limits

Function	Accuracy %	Load	Power Factor
Watt-hour	+/- 0.2	Full	1.0
	+/- 0.3	Light	1.0
	+/- 0.5	Full	0.5
Var-hour	+/- 0.5	Full	1.0

Notes:

- a) Watt-hour and var-hour functions should be tested in both directions of energy flow (In and Out).
- b) When compensating for transformer or line loss, utilize stated limits above or 5% of desired compensation, whichever is greater.

- c) The meter shall be tested with compensation applied to obtain a true test of the installation.

Test Points	Volts	Amps	Power Factor
Full Load	120	5	1.0
Full Load	120	5	0.5
Light Load	120	0.5	1.0

4. Provisions for maintenance and calibration - Metering facilities shall be tested, and calibrated if necessary, every two years. More frequent test intervals may be negotiated. All interested parties or their representatives may witness the calibration tests. Calibration records shall be made available to all interested parties. The accuracy of the standard utilized for calibration purposes shall be traceable to the [National Institute of Standards and Technology \(NIST\)](#).
5. Ancillary equipment specifications - Voltage transformers shall be 0.3% metering accuracy and current transformers shall be extended range 0.15% metering accuracy class for both magnitude and phase angle over the burden range of the installed metering circuit. Instrument transformer correction factors may be applied to the meter to adjust the meter for inaccuracies associated with the secondary burdens in the current transformer and voltage transformer circuits. In bi-directional situations where there are significant differences in the magnitude of capacity delivered to the **Duke Energy Carolinas Transmission System** compared to the load supplied by it; good engineering practices should be in place to accurately meter power flow in both directions. All instrument transformers shall comply with IEEE SA - C57.13-2016 - IEEE Standard Requirements for Instrument Transformers and ANSI C12.11-2006 (R2014) – Instrument Transformers for Revenue Metering 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV).
6. Loss compensation - If the metering is not located at the Connection Point, then Duke Energy Carolinas approved power transformer and line loss compensation values shall be applied to the meter to properly compensate for the losses in the power transformer and line.
7. Access to metering data - If access to the meter is required, proper security measures must be taken to ensure the integrity of the meter is not compromised. If data pulses are required from the revenue meter, then the appropriate interface box with associated equipment must be installed to properly protect the revenue meter. If an additional information meter is requested, good engineering practices must be adhered to when terminating the connections in the meter circuit to ensure the integrity of the revenue-accuracy metering circuit is intact. It must be determined which party has the responsibility to install the additional meter.
8. **Station Service Power** - Metering requirements for the **Station Service Power**, if any, will be determined on a case-by-case basis.

For metering equipment located in the **Project** substation, the installation of a metering bypass is suggested, but not required. For the replacement of failed or malfunctioning equipment a metering bypass is necessary to maintain power flow to the **Project**. If a metering bypass is not installed, an outage will be required to replace the failed or malfunctioning equipment.

The metering devices must be fully compatible (approved meter type and communication media) with Duke Energy Carolinas' remote metering and data acquisition system. Duke Energy Carolinas will review and provide final approval of all metering equipment and design.

4.2.4.2 Telecommunication and SCADA Requirements

Voice communication is required between the Duke Energy Carolinas **Energy Control Center (ECC)** and the **Project Operator**. A typical phone line at the **Project** may be sufficient to supply this communication path. In the event that the **Project** is supplying additional services (AGC, load following, reserves, system restoration, etc.) or if the **Project** is in excess of a specified generation capacity, back-up communication with the **Project** may be necessary and can be specified by Duke Energy Carolinas.

Coordination of system protection, control, and maintenance activities between Duke Energy Carolinas and the **Project** will be required in addition to the voice communications specified above.

All generating facilities and transmission facilities are required to have in place a means of transmitting monitoring, accounting, and control data where appropriate to the Duke Energy Carolinas control center(s) as noted below:

- a) Telecommunications system utilized to support **SCADA** data exchange between Duke Energy Carolinas transmission substation facility and Duke Energy Carolinas **Energy Control Center** will consist of wireline based primary data circuit with cellular based backup data circuit.
- b) Telecommunications system utilized to support **SCADA** data exchange between the Duke Energy Carolinas transmission substation facility and **Project** facility will consist of point-to-point fiber-optic connections. All **SCADA** communications between facilities shall utilize DNP 3.0 protocol via RS232 transport with fiber-optic transceivers.
- c) For revenue-accuracy metering, a compatible and reliable communication media must be provided and maintained to enable Duke Energy Carolinas to interrogate the meter, collect, merge, and store metering and usage data with Duke Energy Carolinas' remote metering and data acquisition system. Modes of communications could be, but not limited to, fiber optics, Ethernet, wireless modem, etc.
- d) Communications for protection must function at the full performance level before, during, and after any power system fault condition (Service Performance Objective Class A per IEEE SA - 487-2015 - IEEE Standard for the Electrical Protection of Communications Facilities Serving Electric Supply Locations -- General Considerations).
- e) Throughput operating times of the telecommunications system must not add unnecessary delay to the clearing or operating times of protection or remedial action schemes. Maximum permissible clearing times for faults are specified in Protection Requirements section of this standard. The throughput operating times of the telecommunications system is only a portion of that total clearing time.
- f) In order to provide maintainability and operability between the **Project** and Duke Energy Carolinas, tele-protection terminal equipment such as transfer trip units shall be functionally compatible. 'Tone' equipment must be of the same manufacturer and type. The need or implementation of peripheral capabilities such as signal counters, test switches, etc. are not required to be identical to those used at Duke Energy Carolinas facilities. Duke Energy Carolinas prefers the use of terminal equipment that is the current Duke Energy Carolinas standard for the control application. Duke Energy Carolinas will consider the use of alternative equipment and/or technologies as proposed by the **Project Sponsor** as long as the equipment is suitable for the purposes of the control application required

Phasor measurement units (PMU) and a high-accuracy satellite clock will be required for a proposed new generation facility that will be connected to the transmission system. At Duke Energy's discretion for generators less than or equal to 20 MW and for all generators greater than 20 MW, a phasor measurement unit (PMU) will be required on both the customer side and the Duke side of the Connection Point. A PMU is a device that measures the electrical waves at a location using a common time source for synchronization. Upon request, Duke Energy will provide the Project Sponsor the type of device currently being applied to the Duke Energy Transmission System.

A PMU shall be installed on the Duke side of the Connection Point. The PMU must be capable of performing phasor measurements at a minimum of 30 samples per second which are synchronized via a high-accuracy satellite clock. A local phasor data collector (PDC) is not required at the substation.

The customer shall install and maintain a PMU, at its expense, on the low side of the generator step-up transformer. The PMU must be capable of performing phasor measurements at a minimum of 60 samples per second which are synchronized via a high-accuracy satellite clock. A PDC is required to aggregate the data and be able to store the PMU data locally for thirty days and to transport the information to the Transmission Provider. To the extent the customer installs similar quality equipment, such as relays or digital

fault recorders, that can collect data at least at the same rate as PMUs, and which data is synchronized via a high-accuracy satellite clock, such equipment would satisfy this requirement.

Upon request from the Transmission Provider, the customer shall provide all requested PMU data, including, but not limited to, the following: (a) gross MW and MVAR measured at the customer's side of the generator step-up transformer or other location approved by Duke Energy; (b) generator terminal voltage; (c) generator terminal frequency; and (d) generator field voltage and current, where available. Additional details regarding the requirements and guidelines of PMU data and telecommunication of such data are contained in NERC's Reliability Guideline for PMU Placement and Installation (https://www.nerc.com/comm/PC_Reliability_Guidelines_DL/Reliability%20Guideline%20-%20PMU%20Placement.pdf).

SCADA data requirements for **Duke Energy Carolinas Transmission System** operations will be determined on a case-by-case basis depending on the location of the generating facility, the number and size of the units, and the extent to which system operations will control the generators. Normally, all sites with greater than 1 MVA aggregate capacity must be equipped with **SCADA** to ensure that the **Duke Energy Carolinas Transmission System** operations has the information necessary for maintaining transmission system reliability and accurate Balancing Authority Energy Accounting.

The following SCADA measurements are required:

- a) Generator breaker(s) status (if not installed, then the status of the generator isolation device(s) shall be provided instead)
- b) Generator step-up transformer high voltage breaker status
- c) Status of any other high voltage breaker at the site
- d) Status of the **Connection Point** isolation device(s)
- e) Generator MW and MVAR output
- f) Voltage of the bus controlled by the generator(s) (may be its own low voltage bus or the bus at the high voltage terminals of the step-up transformer)

Intermittent generation resources (Solar, Battery Storage, Wind, etc.) and all generators providing Automatic Generation Control (AGC) services or dynamic scheduling/pseudo-tie services will require additional **SCADA** measurements and capabilities.

4.3 Performance Requirements

All **Projects** must be properly designed, constructed, operated, and maintained to avoid degrading the reliability of the transmission network. A **Project** must comply with the **Project** performance criteria, listed below; and must be able to operate satisfactorily within the limits defined in the **Duke Energy Carolinas Transmission System** characteristics section, below, in order to be considered properly connected. The **Project Sponsor** or **Project Operator** is expected to demonstrate, through monitoring, that the **Project** meets the performance criteria. It is required that the criteria of Sections 4.3.1.1 and 4.3.1.2 be continuously monitored. The remaining criteria must be met and considered in the design and operation of the **Project** although these do not necessarily have to be continuously monitored. However, if problems are suspected at any time, Duke Energy Carolinas may require the **Project Sponsor** and/or **Project Operator** to demonstrate through monitoring that the performance of the **Project** at the **Connection Point** meets these requirements. If the requirements are not met, the **Project Sponsor** or **Project Operator** must demonstrate to Duke Energy Carolinas a plan to improve and meet the performance criteria. Additional relay and control requirements may be developed and enforced by Duke Energy Carolinas after connection is made if these performance criteria are violated. Enforcement of these performance criteria and penalties associated with them are beyond the scope of this document and will be in contracts and operating agreements specific to the **Project**.

4.3.1 Project Performance Criteria

To ensure the **Reliability and Integrity** of the supply system, all **Projects** must meet the **Project** performance criteria at the **Connection Point**. The following sections detail the **Project** performance criteria.

4.3.1.1 Transmission System Outages

The **Project** may not operate its equipment or system in such a manner as to cause the unplanned outage of any **Duke Energy Carolinas Transmission System** component more than once in any twelve month period, more than three times in any five year period, or more than five times in any ten year period. An unplanned outage is defined as the electrical isolation of equipment from the electrical system, without scheduling and notification of Duke Energy Carolinas, such that the equipment is unable to perform its intended function for the duration of the isolation.

4.3.1.2 Temporary Undervoltages

The **Project** may not operate its equipment or system in such a manner as to cause temporary undervoltages at the **Connection Point** more than twice in any twelve month period, more than five times in any five year period, or more than eight times in any ten year period. A temporary undervoltage is defined as an oscillatory phase-to-ground or phase-to-phase voltage of 85% or less of nominal voltage lasting greater than 20 milliseconds, occurring during fault conditions. Undervoltages due to non-fault events are covered in the in the Voltage Fluctuations and Flicker requirements. Multiple temporary undervoltage conditions occurring within one minute will be considered the same event.

4.3.1.3 Transient Overvoltages

The **Project** may not operate its equipment or system in such a manner as to cause a peak transient voltage at the **Connection Point** greater than or equal to 140% of the nominal peak voltage. A transient overvoltage is defined as the peak line-to-line or line-to-ground voltage during the transient condition resulting from operation of a switching device. Any transient voltage condition caused by the operation of the **Project's** equipment or system that results in a peak transient voltage greater than or equal to 140% of the nominal peak voltage at the **Connection Point** is not allowed.

4.3.1.4 Temporary Overvoltages

The **Project** may not operate its equipment or system in such a manner as to cause a temporary overvoltage at the **Connection Point** greater than or equal to 120% of the nominal system voltage. A temporary overvoltage is defined as an oscillatory phase-to-ground or phase-to-phase overvoltage lasting greater than 20 milliseconds which is undamped or only weakly damped. Any temporary voltage condition caused by the operation of the **Project's** equipment or system that results in a temporary overvoltage greater than or equal to 120% of the nominal system voltage at the **Connection Point** is not allowed.

4.3.1.5 Voltage Fluctuations and Flicker

Per IEEE SA - 1453-2015 - IEEE Recommended Practice for the Analysis of Fluctuating Installations on Power Systems, planning levels of $P_{st}=0.8$ and $P_{it}=0.6$ define the allowable voltage fluctuation limits at the **Connection Point**. In unique cases, higher limits can be considered with the understanding that the **Project Sponsor** or **Project Operator** will be required to mitigate the flicker that they cause if significant customer complaints are generated. Additionally, any single customer that creates disturbances for other customers will be required to mitigate the disturbance, regardless of the actual measured value.

Operation of the **Project's** system or equipment in such a manner as to create a voltage fluctuation greater than 3% on the **Duke Energy Carolinas Transmission System** or on the primary of the distribution system is not allowed.

4.3.1.6 Harmonic Distortion

The maximum allowable harmonic current injections (percentage harmonic distortion at each frequency as a function of load current) at the **Connection Point** for **Projects** connected at 230 kV or 500 kV, 100 kV, and 44 kV are defined in Table 4, Table 5, and Table 6, respectively. Operation of the **Project's** system or equipment in such a manner as to create a condition where the harmonic current injection at the **Connection Point** exceeds the limits provided for in Tables 4, 5, and 6 for a duration greater than or equal to one hour on any single day or exceeds 150% of the limits provided for the given connection voltage for a duration greater than five minutes on any two days during a six month period is not allowed.

**Table 4 – Current Injection Harmonic Distortion Limits:
Connection Point Voltage >161 kV**

Individual Harmonic Order (Odd Harmonics)						
I_{sc}/I_{load}	$h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$h > 35$	TDD
<50	2.0 %	1.0 %	0.75 %	0.3 %	0.15 %	2.5 %
≥ 50	3.0 %	1.5 %	1.15 %	0.45 %	0.22 %	3.75 %

Notes:

- a) Even harmonics are limited to 25% of the odd harmonic limits.
- b) Current distortions that result in DC offset are not allowed.
- c) I_{load} is the maximum load current (fundamental frequency component) at the **Connection Point**.
- d) I_{sc} is the maximum short-circuit current at the **Connection Point**.
- e) TDD (Total Demand Distortion) is the total harmonic current distortion expressed in % of maximum demand load current

**Table 5 – Current Injection Harmonic Distortion Limits:
Connection Point Voltage 69.1 kV to 161 kV**

Individual Harmonic Order (Odd Harmonics)						
I_{sc}/I_{load}	$h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$h \geq 35$	TDD
<20	2.0 %	1.0 %	0.75 %	0.3 %	0.15 %	2.5 %
20<50	3.5 %	1.75 %	1.25 %	0.5 %	0.25 %	4.0 %
50<100	5.0 %	2.25 %	2.0 %	0.75 %	0.35 %	6.0 %
100<1000	6.0 %	2.75 %	2.5 %	1.0 %	0.5 %	7.5 %
>1000	7.5 %	3.5 %	3.0 %	1.25 %	0.7 %	10.0 %

**Table 6 – Current Injection Harmonic Distortion Limits:
Connection Point Voltage 44 kV to 69 kV**

Individual Harmonic Order (Odd Harmonics)						
I_{sc}/I_{load}	$h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$h \geq 35$	TDD
<20	4.0 %	2.0 %	1.5 %	0.6 %	0.3 %	5.0 %
20<50	7.0 %	3.5 %	2.5 %	1.0 %	0.5 %	8.0 %
50<100	10.0 %	4.5 %	4.0 %	1.5 %	0.7 %	12.0 %
100<1000	12.0 %	5.5 %	5.0 %	2.0 %	1.0 %	15.0 %
>1000	15.0 %	7.0 %	6.0 %	2.5 %	1.4 %	20.0%

4.3.1.7 Phase Unbalance

Unbalanced phase voltages and currents can affect protective relay coordination and cause high neutral currents and thermal overloading of transformers. To maintain the **Reliability and Integrity** of the **Duke Energy Carolinas Transmission System**, the **Project** shall not operate its system or equipment in such a manner as to cause a voltage unbalance greater than 1% nor a current unbalance greater than 5% at the **Connection Point**. Any unbalance condition in excess of the specified limits for a duration greater than or equal to one minute is not allowed. Phase unbalance is defined as the percent deviation of one phase from the average of all three phases.

4.3.2 Duke Energy Carolinas Transmission System Characteristics

All **Project** equipment connected to the **Duke Energy Carolinas Transmission System** should be designed to operate within the system conditions defined in this section. These characteristics are typical to the **Duke Energy Carolinas Transmission System** during normal and contingency conditions but may be exceeded for very short times or if exceptional circumstances prevail. These characteristics are:

4.3.2.1 Frequency

The frequency of the **Duke Energy Carolinas Transmission System** shall be nominally 60 Hz and shall be controlled within the limits of 59.9 Hz - 60.1 Hz unless exceptional circumstances occur. The facility’s control equipment shall be set such that the voltage and frequency ride-through capability is in accordance with NERC Reliability Standard PRC-024 Attachment 1 (for frequency) and Attachment 2 (for voltage) and FERC Order 828 (Requirements for Frequency and Voltage Ride Through Capability of Small Generating Facilities). Settings will be coordinated with Duke Energy Carolina’s Under Frequency Load Shed plan. Anti-islanding schemes shall not be employed unless they meet the specified voltage and frequency ride-through requirements.

4.3.2.2 Steady-state Voltage Variations

The transmission system planning guidelines for **Voltage Regulation** and range at the **Connection Point** is listed in Table 7.

Table 7 – System Voltage Variations at the Connection Point

Nominal Voltage (kV)	Absolute Voltage		Voltage Regulation	
	Minimum	Maximum	Normal	Contingency
44	94 %	109%	8.5%	10%
66	94 %	109%	8.5%	10%
100	95 %	107%	6%	7%

4.3.2.3 Harmonic Voltage Distortion

The maximum harmonic voltage distortion at the **Connection** transmission voltage level is defined in Table 8.

Table 8 -- System Harmonic Voltage Distortion Limits

Nominal Voltage (kV)	Maximum Individual Harmonic Voltage Distortion (%)	Maximum Total Voltage Distortion (%)
44	3.0	5.0
66	2.5	4.0
100	1.5	2.5
115	1.5	2.5
161	1.0	1.0
230	1.0	1.5

The limits in Table 8 represent the maximum harmonic voltage distortion at a given connection voltage for a duration less than or equal to one hour on any single day. The maximum harmonic voltage distortion will not exceed 150% of the limits for a given connection voltage for a duration greater than five minutes on any two days during a six-month period.

4.3.2.4 Voltage Unbalance

The maximum voltage unbalance on the **Duke Energy Carolinas Transmission System** at the **Connection Point** for a duration greater than or equal to one minute will be less than or equal to 2.0%.

4.3.2.5 Transient Overvoltages

The maximum peak transient overvoltage at the **Connection Point** will be less than or equal to 200% of the nominal system peak voltage.

4.3.2.6 Temporary Overvoltages

The maximum temporary overvoltage at the **Connection Point** will be less than or equal to 180% of the nominal system voltage. For **Effectively Grounded** portions of the **Duke Energy Carolinas Transmission System**, the maximum may be significantly lower than 180%.

4.3.2.7 Switchgear – All voltages

Circuit breakers, disconnect switches, and all other current-carrying equipment connected to Duke Energy Carolinas transmission facilities shall be capable of carrying normal and emergency load currents without damage. For **Interconnections**, the equipment shall not become a limiting factor (bottleneck) in the ability to transfer power on the **Duke Energy Carolinas Transmission System**.

All circuit breakers and other fault-interrupting devices shall be capable of safely interrupting fault currents for any fault that they may be required to interrupt. Application shall be in accordance with IEEE C37 Standards. These requirements apply to the generation site, the interconnecting substation, the **Connection Point** as well as other locations on the **Duke Energy Carolinas Transmission System**. Minimum fault-interrupting requirements are supplied by Duke Energy Carolinas as part of the coordinating studies and are based on the greater of the fault duties at the time of the connection request or those projected in long-range plans.

4.3.2.8 Circuit Breaker Operating Time

Table 9 specifies the component operating times typically required of circuit breakers on the **Duke Energy Carolinas Transmission System**. These times also apply to equipment at the generation site and the **Connection Point**. System stability considerations may require very fast opening and reclosing times. The total automatic recloser times would be the summation of the breaker interrupt and close time plus intentionally added delay to allow for deionization and subsequent extinction of the fault arc (referred to as the dead timer delay), and the protective relay requirements. Table 9 shows Duke Energy Carolinas' required interrupting time of the breaker and the dead "timer" delay at various system voltages.

Table 9 – Circuit Breaker Operating Times

Voltage Class (kV)	Rated Interrupting Time (Cycles)	Dead Timer Delay (Cycles)
500	2	30
230	3	25
161 and below	3	18
138 and below	5	18

4.3.2.9 Other Fault-Interrupting Device Operating Times

Depending on the application, the use of other fault-interrupting devices such as circuit switchers may be allowed. Trip times of these devices are generally slower, and current interrupting capabilities are often lower than those of circuit breakers. Often circuit switchers are utilized to isolate generator step-up transformers from the transmission breakers. The dead "timer" delay on circuit switchers is typically 15 seconds and consequently, these devices usually are not reclosed.

4.3.3 Excitation System and Power System Stabilizer (PSS)

The excitation system shall operate in the automatic-terminal-**Voltage Regulation** mode. For planned operation in manual mode, the plant operators shall obtain the approval of the Duke Energy Carolinas **Energy Control Center (ECC)** in advance. For unplanned operation in manual mode, the **Project Operator** shall notify the **Energy Control Center (ECC)** as soon as practical but within 30 minutes of switching to manual mode and provide an expected duration for operation in this mode. Operation in the manual mode for extended periods shall only be permitted when approved by the **Energy Control Center (ECC)**.

For generators that have a PSS, Duke Energy Carolinas will determine if the PSS needs to be put into service and will work with the generator operator to calculate appropriate settings prior to connection to the grid. For planned operation with the PSS out of service, the plant operators shall obtain the approval of the Duke Energy Carolinas **Energy Control Center (ECC)** in advance. For unplanned operation with the PSS out of service, the **Project Operator** shall notify the **Energy Control Center (ECC)** as soon as practical but within 30 minutes of the PSS being removed from service, and provide an expected duration for operation in this mode. Operation with the PSS out of service for extended periods shall only be permitted when approved by the **Energy Control Center (ECC)**.

4.3.4 Governor Speed and Frequency Control

A speed governor system is required on all synchronous generators. The governor regulates the output of the generator as a function of system frequency and desired MW output. This function is called the governor's 'droop' characteristic and must be coordinated with the governors of other generators located within the same Balancing Authority Area, to assure proper system response to frequency variations. All speed governor systems must respond to system frequency changes to help maintain the stability of the power system.

The speed governor system shall have a droop characteristic settable between three and seven percent and typically set to five percent. Droop equals change in frequency or speed, in per unit of nominal, divided by change in generator load, in per unit of full load. An example equation is: $0.05 = (0.1/60)/0.0333$; where if a generator has a 5% droop setting, a system frequency change of 0.1 Hz, will cause the generator load to change by 3.33% (ignoring dead bands and other non-linearities).

Non-synchronous generators must regulate their output as a function of system frequency and desired MW output to maintain the nominal 60 Hz system frequency.

4.3.5 Voltage Regulation and Reactive Power Requirements

4.3.5.1 Duke Energy Carolinas Transmission System Voltages

Duke Energy Carolinas operates its transmission system within the voltage guidelines defined in Tables 10 and 11 below. Projects shall have the capability to operate within the full voltage range at the **Connection Point** so as not to restrict the operational range of the transmission system. Explanation of the meaning of the terms **Absolute Voltage Limits**, **Contingency Voltage Drop**, and **Voltage Regulation** are available in the Definitions section.

Table 10 – Bulk Transmission System Voltage Guidelines

Nominal Voltage (kV)	Absolute Voltage Limits Minimum – Maximum	Nominal Voltage (kV) Contingency Voltage Drop
230	95% – 105%	5%
500	100% – 110%	5%

Table 11 – Transmission System Voltage Guidelines for 44 through 161 kV

Nominal Voltage (kV)	Absolute Voltage Limits Minimum – Maximum	Voltage Regulation Normal – Contingency
44	94% – 109%	8.5% – 10%
66	94% – 109%	8.5% – 10%
100	95% – 107%	6% – 7%
161	95% – 105%	6% – 7%

4.3.5.2 Voltage schedules and operation of the Project

Major generators (as determined by Duke Energy Carolinas) are provided voltage schedules by the **Energy Control Center (ECC)**. Voltage schedules are necessary for efficient and reliable electric power transmission and for adequate service to loads. The voltage schedules establish operating requirements for generators and may be set for seasons, holidays, days of the week, and time of day. These schedules may be changed at any time by the **Energy Control Center (ECC)** System Operator to meet transmission system requirements. When requested by the **Energy Control Center (ECC)**, **Project Operators** shall provide the date, duration and reason for the **Project** not maintaining the established voltage schedule.

Generator step-up transformers (GSU or unit transformers) must have taps that cover the entire range of possible transmission system voltages given in the previous section, with less than or equal to 2.5% difference between adjacent taps. The GSU tap must be set to allow the generator to produce or absorb reactive power between 0.95 leading and 0.90 lagging power factor to meet the voltage schedule. At the same time, the plant electrical system must be designed so that all modes of unit operation are not restricted by transmission system operation within the voltage range given in the previous section. In the project design phase, the **Project Sponsor** shall demonstrate to Duke Energy Carolinas that the **Project** meets these requirements.

Dynamic sources of reactive power, such as synchronous generators, are necessary to operate a reliable power system. Therefore, synchronous generators are required to participate in **Voltage Regulation** by meeting voltage schedules. Operating requirements for each **Project** are determined by facility studies and/or operating experience with similar projects. Operating requirements may be refined based on actual **Project** operating experience or future system changes.

Synchronous generators and projects with solid-state inverters are required to produce or absorb reactive power up to the temporary thermal capability of the generator during disturbances.

The voltage regulator is set to maintain constant voltage rather than constant power factor. The regulator set point is coordinated with voltage schedules in the area. The Project generators are not required to operate at more than 105% or less than 95% of the nominal voltage rating of the generators under steady state conditions. However, seasonal adjustment of the transformer tap settings may be required when voltage schedules are changed by the **Energy Control Center (ECC)** System Operator. It is the **Project Sponsor** or **Project Operator's** responsibility to ensure that the voltage regulator is initially set up correctly to allow the full range of adjustability. If the midpoint of the range of adjustability (or operating range "window") is not set correctly the ability of the regulator to be adjusted may be significantly reduced in either the raise or lower position.

Projects using induction generators (without solid-state inverters) are usually not required to participate in **Voltage Regulation**; however, they must not adversely affect voltage schedules. The facility studies determine the reactive power capability necessary to ensure that these voltage schedules are maintained.

4.3.5.3 Reactive power and voltage regulator requirements

Each generating facility must be capable of supplying at least 0.395 MVARs (0.93 lagging power factor) of dynamic reactive power for each MW supplied at the **Connection Point**. The facility shall have the capability to supply this reactive power on a continuous basis at rated MW and the transmission voltage stated below:

- a) 100 kV and below 1.00 p.u.
- b) 161 kV 1.00 p.u.
- c) 230 kV 1.00 p.u.
- d) 500 kV 1.05 p.u.

Each generating facility shall have the capability to absorb at least 0.251 MVARs (0.97 leading power factor) of dynamic reactive power for each MW supplied at the **Connection Point**. The facility shall have the capability to absorb this reactive power on a continuous basis at rated MW and the transmission voltage stated below:

- a) 100 kV and below 1.05 p.u.
- b) 161 kV 1.04 p.u.
- c) 230 kV 1.04 p.u.
- d) 500 kV 1.09 p.u.

The **Projects** which have an intermittent MW output (such as solar PV and wind) shall have the capability to supply/absorb dynamic reactive power in the range of 0.93 lagging to 0.97 leading at the point of **Interconnection**. The 0.93 lagging requirement is equivalent to $[0.395 * \text{maximum approved MW output level}]$ MVARs and the 0.97 leading requirement is equivalent to $[0.251 * \text{maximum approved MW output level}]$ MVARs at the point of **Interconnection**. This capability shall be automatically and immediately available, subject to equipment voltage limitations.

Synchronous generators and **Projects** with solid state inverters must also have a voltage regulator capable of maintaining stable voltage at the generator terminal, within 0.5 percent of any set point. The operating range of the regulator shall be at least plus or minus five percent of the rated voltage of the generator.

The generator continuous reactive capability between 0.95 leading and 0.90 lagging power factor shall not be restricted by any main or auxiliary equipment, e.g. main or auxiliary transformer settings, hydrogen cooling system, stator water cooling system, equipment voltage or current ratings, control, protection and so on. The generator step-up transformer shall be chosen so as not to limit the real or reactive power output of the generator. IEEE SA - C57.116-2014 - IEEE Guide for Transformers Directly Connected to Generators should be consulted when specifying the step-up transformer turns ratio and impedance. Each **Project** shall have a program to verify the gross and net reactive power capability in compliance with applicable **North American Electric Reliability Corporation (NERC)** Reliability Standards.

A Project using induction generators (without solid-state inverters) shall provide at a minimum, sufficient reactive power capability or the 'equivalent' to deliver the **Project** output at unity power factor at the **Connection Point**. 'Equivalent' reactive power includes adding shunt capacitors at locations other than at the **Connection Point** or the Generation Site or acquiring sufficient reactive power from Duke Energy Carolinas or another utility. Duke Energy Carolinas determines the acceptable locations for 'equivalent' reactive power in the **Facilities Study**.

Power factor correction capacitors added to the **Project** to meet the unity power factor requirement may need to be switchable (while energized). Depending on the size of the Project and location on the system, these capacitors may need to be switched to participate in **Voltage Regulation**. The control methods and set points for switching these capacitors will be coordinated by Duke Energy Carolinas with voltage schedules in the area.

4.3.5.4 Voltage and Frequency Operation During Disturbances

Power system disturbances initiated by events such as faults or forced equipment outages expose connected generators to oscillations in voltage and frequency. It is important that generators remain in service while the oscillations are damped, and the system returns to a stable operating point. Therefore, each generator must be capable of continuous operation at 0.95 to 1.05 pu voltage and 59.5 to 60.5 Hz and limited time operation for larger deviations. Nearly all generators have inherent capability for off-nominal operation. Over/under voltage and over/under frequency relays are normally installed to protect the generators from extended off-nominal operation. To ensure that the **Project** generator is not tripped prematurely, the required time delays for setting these relays are presented in [Section 4.2.2.2, Breaker Duty](#).

To avoid large-scale blackouts that can result from the excessive generation loss during a disturbance, underfrequency load shedding has been implemented throughout the Eastern Interconnection. When system frequency declines, loads are automatically interrupted in discrete steps, with most of the interruptions between 59.3 and 58.5 Hz. Load shedding attempts to stabilize the system by balancing the generation and load. It is imperative that generators remain connected to the system during frequency declines, both to limit the amount of load shedding required and to help the system avoid a complete collapse. This need, as well as the restricted ability of some generators to withstand off-nominal frequency operation, has been taken into account in the relay-setting delays provided in this document.

To avoid voltage collapse within the **Duke Energy Carolinas Transmission System**, undervoltage load shedding may be implemented in the future. If required in the future, the **Project** may be required to add undervoltage relaying and coordinate undervoltage relay settings with the Duke Energy Carolinas undervoltage load shedding program.

For those generators connected to Duke Energy Carolinas through a tapped transmission line, a 'local island' is created when the breakers at the ends of the transmission line open. This leaves the generator and any other loads that also are tapped off this line isolated from the power system. Delayed fault clearing, overvoltages, ferro resonance, or extended undervoltages can result from this 'local island' condition and are therefore not allowed to persist on Duke Energy Carolinas transmission facilities. For protection, special relaying and settings are used to disconnect the generator(s) in the 'local island.' (See also [Section 4.2.2.4 Protection Criteria](#)).

4.4 General Operating Requirements

4.4.1 Safety

All safety and operating procedures for joint use equipment shall be in compliance with the Occupational Safety and Health Administration (OSHA) standard 29 CFR 1910.269, the National Electrical Safety Code (NESC), the Duke Energy Corporation Health and Safety Handbook, the Duke Energy Corporation Work Standards Manual and the **Project Sponsor's** safety manuals. The **Project** must also comply with Duke Energy Carolinas' switching, tagging and isolation procedures.

The **Project Operator** shall not energize any **Duke Energy Carolinas Transmission System** line or equipment unless the **Energy Control Center (ECC)** specifically approves energization. If, for any reason, a protective device operation separates the **Project** from the **Duke Energy Carolinas Transmission System**, the **Project Operator** will contact the **Energy Control Center (ECC)** before attempting to restore the connection to the **Duke Energy Carolinas Transmission System**.

The disconnect switch provided for the purpose of physically and visibly isolating the **Project** from the **Duke Energy Carolinas Transmission System**, shall not be operated without advance notice to either party, unless an emergency condition requires that the device be opened to isolate the **Project**. Duke Energy Carolinas personnel may open the switch if:

- a) It is necessary for the protection of Duke Energy Carolinas maintenance crew personnel when working on de-energized circuits
- b) The **Project** or **Duke Energy Carolinas Transmission System** equipment presents a hazardous condition

During emergency conditions, the **Project Operator's** duty is to ensure safety guidelines are adhered to and station equipment is protected. The **Project Operator** shall follow the Duke Energy Carolinas approved set of procedures when separating from and reconnecting to the transmission system. The **Project Operator** shall not energize any equipment, connect to any energized equipment unless instructed to do so by the **Energy Control Center (ECC)**, or parallel any generation to the system unless instructed to do so by the Duke Energy Carolinas **Energy Control Center (ECC)**. If, for any reason, the **Duke Energy Carolinas Transmission System** is disconnected from the **Project** (as a result of a fault condition, line switching, etc.), the protective equipment connecting the **Project** to the system must open and not reclose until approved by the **Energy Control Center (ECC)**.

4.4.2 Cogeneration Served by the Project

The **Project Sponsor** shall maintain a record of all cogeneration customers served by the Project and such record shall be made available to Duke Energy Carolinas. For the requirements of energized line maintenance or line construction on the **Duke Energy Carolinas Transmission System**, the **Project Sponsor** will ensure that all cogeneration customers served by the Project will disconnect their generation upon request by Duke Energy Carolinas.

4.4.3 Synchronizing the Project to the Duke Energy Carolinas Transmission System

The **Project Operator** shall be responsible for synchronizing its equipment to the **Duke Energy Carolinas Transmission System**. If the **Project** is a participant in the Duke Energy Emergency Guidelines for Capacity Shortages, then the **Project Operator** should follow those procedures during the event of a system emergency. During all other conditions, the generator should have Duke Energy Carolinas approved procedures in place when connecting to the system. For automatic synchronization, a required synchronizing relay will assure that the unit is not connected to the energized power system out of synchronization.

4.4.4 Disturbance Monitoring

Unique and unanticipated protection problems can result from the changed system configuration resulting from connection of the **Project** to the **Duke Energy Carolinas Transmission System**. Duke Energy Carolinas may, at its discretion, install or request the installation of monitoring equipment to identify possible protection scheme problems and to provide power quality measurements of the new configuration. If relay performance indicates inadequate protection of the **Duke Energy Carolinas Transmission System**, the owner of the **Project** will be notified of additional protection requirements. The monitoring equipment will provide information similar to that of an oscillograph or fault recorder. The availability of current and voltage measurements will determine the number of channels for the device. Monitoring equipment may also be installed to aid in the understanding of electrical phenomena, such as overvoltages and ferro resonance that can be associated with the **Project**.

Inverter-based generation resources will require power quality monitoring instrumentation installed by Duke Energy Carolinas to provide monitoring of harmonics and other power quality issues. The power quality metering will include communications infrastructure for remote data acquisition.

4.4.5 Protective System Fault Analysis

All operations of protective devices within the **Project** shall be reviewed and documented. This information shall then be made available to Duke Energy Carolinas on request to assist in analyzing fault operations on the **Duke Energy Carolinas Transmission System**. To facilitate the analysis of system disturbances and the evaluation of system operation, fault recorders may be required on certain types of complex substations and at all major generating stations connected to the **Duke Energy Carolinas Transmission System**. Fault recording functions in microprocessor relays may provide the detail data needed to perform the analysis.

4.5 Maintenance Requirements and Coordination

Duke Energy Carolinas maintains its system to provide reliable customer service while meeting the seasonal and daily peak demands even during certain equipment outages and disturbances. Similarly, the **Project Sponsor** or **Project Operator** shall implement a preventive maintenance program that clearly defines responsibilities and performance objectives for the **Project** equipment. The program shall be designed and executed at a level to ensure the proper operation of the **Project** equipment and ensure the reliability and continuity of service of the interconnected transmission system. The **Project Sponsor** or **Project Operator** is responsible for the regularly scheduled maintenance and/or calibration of equipment, including the following:

- a) Circuit breakers
- b) Power transformers
- c) Protective relays
- d) Metering
- e) Communications
- f) Trip circuits
- g) Grounding systems
- h) Transmission facilities

In addition, protective system maintenance shall be performed as follows:

- a) Functional testing of trip circuit
- b) Functional testing of interrupter
- c) Calibration testing of protective devices settings
- d) Inspection and maintenance of power dc sources
- e) Inspection and maintenance of interrupters

Projects shall have a maintenance and testing program for excitation systems in compliance with applicable **North American Electric Reliability Corporation (NERC)** Operating & Reliability Standards and Policies.

Revenue metering shall be tested, and calibrated if necessary, at least every two years. More frequent test intervals may be negotiated. All interested parties or their representatives may witness the calibration tests. Calibration records shall be made available to all interested parties.

The maintenance program may be based on time or other factors that may include performance levels or reliability. The **Project Sponsor** or **Project Operator** must state how relevant maintenance records and appropriate equipment performance data will be collected and maintained. Maintenance records of the **Project** equipment pertinent to interconnected operation shall be made available to Duke Energy Carolinas upon request. Duke Energy Carolinas reserves the right to review the preventive maintenance program prior to start up and throughout the life of the **Project**.

Duke Energy Carolinas and the **Project Sponsor** or **Operator** shall coordinate maintenance activities associated with equipment at the **Connection Point**. Advanced publication of maintenance schedules will be reviewed and coordinated in such a manner to ensure safety and reliability. Maintenance activities must also observe limitations imposed by unit commitment or contractual obligations, replacement power, other generation maintenance, transmission transaction schedules, area protection or system voltage requirements. Authorization, notification, and clearances for work will be managed through the **Energy Control Center (ECC)**.

4.6 Design Review

After execution of the LGIA and before construction begins, a **Design Review** shall be conducted to review and approve how the **Project Sponsor** has interpreted and applied all the requirements set forth in the Facility Connection Requirements (FCR) document. Duke Energy Carolinas will first conduct an internal review of the proposed Project in order to determine the scope of the review and what documentation the **Project Sponsor** must provide. While a complete review of the **Project** design is not required, Duke Energy Carolinas will determine, based on **Project** parameters and the type and location of the facility connection, what aspects of the design will be reviewed prior to construction to ensure the safety and reliability of the proposed facility connection.

The internal **Design Review** may include drawings, settings, equipment specifications, maintenance practices and/or other items as requested. Special emphasis will be placed on the **Protection Station** and/or protective scheme and settings of equipment that make up the **Interconnection** between the Project and Duke Energy Carolinas. At a **Pre-Design Review Meeting**, Duke Energy Carolinas will present to the **Project Sponsor** a list of documents and information required in order to perform the **Design Review**. The **Design Review** may include some or all of the following:

- a) Surge protection
- b) Specification, application and ratings of equipment
- c) Specification and coordination of the **Protection Station**
- d) Requested phase sequence
- e) Evidence that the Project equipment will not restrict timely outage coordination, automatic switching, or maintenance scheduling
- f) System grounding and safety issues
- g) Insulation coordination
- h) Total fault clearing times (including relay settings)
- i) Reclosing intervals if any
- j) Maintenance programs for certain equipment
- k) Other drawings and specifications deemed important to ensure reliability of the **facility connection**

Following receipt of the requested information, Duke Energy Carolinas will perform a **Design Review** of the proposed facility connection. During this review, Duke Energy Carolinas will perform a relay coordination study to ensure proper operation of the generator and transmission line protective equipment. The **Project Sponsor** shall provide all requested protective relay drawings, protection settings, setpoint calculation studies, and associated equipment data for protective relays that will detect faults on the **Duke Energy Carolinas Transmission System**. Any **Project** protection settings that will not coordinate or will adversely affect the proper operation of the transmission system will be required to be adjusted. Adequate protection scheme redundancy shall be considered to ensure local isolation of faults. In addition, protection scheme modifications shall be considered to remove any single points of protection scheme failure identified that could require remote station devices to isolate local faults. Results of the **Design Review** will be shared with the **Project Sponsor** at a **Design Review Meeting**. Any design and specification related items found not to be acceptable by Duke Energy Carolinas will have to be resolved by the **Project Sponsor** to the satisfaction of Duke Energy Carolinas before the **Project** can continue. Duke Energy Carolinas reserves the right to review all aspects of the **Project** considered important to system reliability, stability and safety.

4.7 Operating Communications and Procedures

After approval of the **Project** design and before startup, a set of communication protocols and procedures for operations during normal and abnormal conditions will be developed. The **Project Operator** is responsible for operating its facility in a safe and reliable manner and with full cooperation under the supervision of Duke Energy Carolinas **ECC**. The **Project Operator** will notify Duke Energy Carolinas **Energy Control Center (ECC)** before any planned startup or shutdown of generation and as soon as possible after any unplanned shutdown or trip of the facilities. Only under direct supervision of the Duke Energy Carolinas **Energy Control Center (ECC)** will the **Project Operator** energize any part of the **Duke Energy Carolinas Transmission System**. Listed below are several site-specific requirements that shall be documented in the communication protocols and procedures:

- a) **Project Operator** will provide a single point of contact for communications with Duke Energy Carolinas **Energy Control Center (ECC)**
- b) The designated **Project** single point of contact shall seek approval from **Energy Control Center (ECC)** before starting generation and connecting to the transmission system
- c) Duke Energy Carolinas shall obtain proper clearance from the **Project Operator** before commencing any work on the facility connection equipment
- d) A reliable mode or modes of communications must be established and available between Duke Energy Carolinas **Energy Control Center (ECC)** and the **Project**
- e) A circuit breaker operation procedure
- f) A generator loading and circuit protection procedure
- g) A set of unit operating conditions that should be maintained to prevent damage to the unit(s) and transmission system
- h) If Duke Energy Carolinas has entered into a contract for the **Project** to provide Load Following service, then an agreement between the parties will be developed that specifies the terms and conditions of that service. At a minimum, telemetry will be required from the **Project** to the Duke Energy Carolinas **Energy Control Center (ECC)**.
- i) In order for a **Project** to provide regulation service to Duke Energy Carolinas, the **Project** must be under Automatic Generation Control (AGC) of the Duke Energy Carolinas **Energy Control Center (ECC)**. Pulsing capability of the unit must be provided to the Duke Energy Carolinas **Energy Control Center (ECC)**, and the **Project** must be operating under the terms and conditions of the contract that will be established for the **Project** to provide Regulation Service.
- j) If Duke Energy Carolinas has entered into a contract for the **Project** to provide operating reserves to the Duke Energy Carolinas Balancing Authority Area, then an agreement between the parties will be developed that specifies the terms and conditions of that service. At a minimum, the capacity of the **Project** must be under contract to the Duke Energy Carolinas **Energy Control Center (ECC)** for its use as specified in the agreement.
- k) During emergency conditions, the **Project Operator** and Duke Energy Carolinas **Energy Control Center (ECC)** shall communicate and cooperate to support recovery efforts which may include but are not limited to:
 - i. Switching operations
 - ii. VAR support
 - iii. Adjustments in real or reactive generation net output
 - iv. Tripping of generating units
 - v. Starting of generating unit(s) including **Black Start** units
 - vi. Implementation of emergency communications procedures
 - vii. Transmission facility restoration efforts

The above operating requirements and those determined to be applicable in Sections [4.2.3 Operating and Control Requirements](#) and [4.4 General Operating Requirements](#) will be documented and discussed with the **Project Sponsor** and/or **Project Operator** during an **Operating Communications Meeting**. These operating requirements and communications will become part of a set of operating procedures that must be approved by both Duke Energy Carolinas and **Project Sponsor/Operator**. Copies of the approved operating procedures must be on file at the **Project** facility and the Duke Energy Carolinas **Energy Control Center (ECC)**. An Operating Committee with representatives from the **Project** and Duke Energy Carolinas will be formed to meet periodically to discuss these operating procedures and any unusual events.

4.8 Preoperational Testing, Calibrations and Inspections

The **Project Sponsor** and **Project Operator** are responsible for testing, calibration and inspection of its equipment up to the **Connection Point** consistent with the power purchase, operating, and **Interconnection** agreements. Before the **Project** is energized, Duke Energy Carolinas will conduct an internal review to develop a list of items that will make up a comprehensive pre-operational test plan for the **Project**. The following items will be considered in this internal review:

- a) Specific drawings, specifications, and test records of the **Project** equipment pertinent to the operation of the **Interconnection**
- b) Calibration, inspection, and test reports provided by the **Project Sponsor** or **Project Operator**

Following the internal review, Duke Energy Carolinas will develop a document of pre-operational testing, calibrations and inspections required of the **Project**. These requirements will be reviewed during a **Pre-op Testing, Inspections and Calibrations Meeting** with the **Project Sponsor**. At this meeting the **Project Sponsor** may submit a proposed test plan to Duke Energy Carolinas for consideration. Duke Energy Carolinas will review and approve this proposed test plan or suggest a new test plan for the **Project**. The final test plan will contain all inspections, testing and witnessing required of the **Project**. This plan shall include provisions for testing protective equipment that comply with the **North American Electric Reliability Corporation (NERC)** Reliability Standards. All costs associated with testing of equipment and protective functions are the responsibility of the **Project Sponsor**.

Duke Energy Carolinas personnel shall be provided access to the facility for the testing, inspections and witnessing as required in the test plan. All items in the test plan shall be addressed to the satisfaction of Duke Energy Carolinas. If protective system functional testing or other testing requires the **Project** to be connected to the transmission system, Duke Energy Carolinas' **Energy Control Center (ECC)** must approve this action in advance. Results of this test plan shall be reviewed and approved by Duke Energy Carolinas and the **Project Sponsor**.

Duke Energy Carolinas will issue final approval for connection of the **Project** to the transmission system. All startup activities must be coordinated with Duke Energy's Carolinas **Energy Control Center (ECC)** to ensure the **Duke Energy Carolinas Transmission System** is not adversely affected.

4.9 Project Completion and As-Built Documentation

Following connection of the **Project** to the transmission system, a full set of as-built drawings and documentation shall be sent to Duke Energy Carolinas within six months. This as-built information will include final connection equipment specifications, generator dynamic data and protective settings and **Connection Point** protective system settings.

4.10 Exceptions

The requirements specified in section 4.0, Facility Connection Requirements - Generation and Transmission Facilities apply to all generators. New contracts should be written to comply with this document. Existing contracts take precedence over these requirements. Existing non-compliant generators must submit a plan and schedule for meeting the requirements. Under rare circumstances the **Project Sponsor/Operator** may be granted an exemption from meeting one or more of the requirements.

5.0 Facility Connection Requirements - Load Delivery Facilities

5.1 New Facility or Modifications to an Existing Facility Requests

Project Sponsors shall contact Duke Energy Carolinas as early as possible in the planning process for any new or modified load connections to the **Duke Energy Carolinas Transmission System**. The **Project Sponsor** should not make its own assumptions about the final location, voltage, or connection requirements. Certain areas within the **Duke Energy Carolinas Transmission System** can accept only limited amounts of additional load without costly reinforcements. Duke Energy Carolinas may have to add to or modify its transmission system substantially before connecting a new **Project**. A **Connection Review** will be performed to determine the required connection facilities and system modifications to accommodate the **Project**. This study will address the transmission system capability, transient stability, voltage stability, losses, **Voltage Regulation**, harmonics, voltage flicker, electromagnetic transients, ferro resonance, metering requirements, protective relaying, system grounding, and fault duties. If necessary, joint studies with neighboring Transmission Owners may be performed to assess the impact of the **Project**. The data that the **Project Sponsor** is required to provide to enable the completion of these studies is listed in [Section 5.1.1 Project Sponsor Supplied Information](#).

Part of the **Connection Review** will include a high-level review of the design, construction, maintenance, and operation rules and standards that will be used before and after connection is made to the **Duke Energy Carolinas Transmission System**. If any portions of this review need further investigation or justification to prove all facility connection requirements will be met, it will be the responsibility of the **Project Sponsor** to provide the necessary information to illustrate the justification or provide an alternative solution to meet the facility connection requirements. This high-level review is intended to identify moderate to major discrepancies and the **Project Sponsor** remains responsible for meeting the facility connection requirements before and after connection is made to the **Duke Energy Carolinas Transmission System** regardless of the results of the **Connection Review**.

5.1.1 Project Sponsor Supplied Information

Any **Project Sponsor** desiring a new connection or modification of an existing connection must provide the required data as stated in [Appendix B – New Load Delivery Data](#) of this document. If any data previously supplied pursuant to these connection requirements changes, the **Project Sponsors** or **Project Operator** will notify Duke Energy Carolinas in writing without delay. Data changes may require additional studies to examine the impact. This notification must include the time and date at which the change became, or is expected to become, effective and if the change is only temporary, an estimate of the time and date at which the data will revert to the previously supplied values.

A request for a change in the point of connection to the **Duke Energy Carolinas Transmission System** or level of load must be submitted as a new request. A new completion date will be negotiated with the **Project Sponsor** or **Project Operator** when **Project** data is significantly changed.

5.1.2 Connection Point Considerations

Projects may be connected to the **Duke Energy Carolinas Transmission System** by tapping an existing transmission line(s) or by connecting directly into an existing transmission station. In rare cases, a new transmission switching station might be built in the middle of an existing transmission line to accommodate connection of the **Project**. Load deliveries are normally connected to the **Duke Energy Carolinas Transmission System** at voltages that range from 44 kV to 100 kV. The 500 kV and 230 kV transmission systems are typically reserved for the bulk transport of large amounts of electricity. The number of available connection options is dependent upon many factors, including location of the desired **Connection Point** relative to existing Duke Energy Carolinas transmission facilities, the size of the **Project's** load and other requirements of the **Project**. The most feasible option(s) will be considered in the **Connection Review**, with the most economic option meeting all requirements being selected.

Integration of **Projects** into the **Duke Energy Carolinas Transmission System** usually falls into one of the following two categories:

- a) Connection into an existing 44 kV, 66 kV, 100 kV, 115 kV or 161 kV substations (depending on the bus configuration) with the transmission lines terminated into one or more breakers - Switching stations are either double-bus or breaker-and-a-half arrangements. Connection at voltages below 44 kV are not usually considered part of the transmission system even at stations that have voltages of 44 kV or higher.
- b) Connection at 44 kV, 66 kV, 100 kV, 115 kV or 161 kV by tapping a transmission line - The tap may be as simple as a direct splice to the conductor where isolating switches are immediately in the substation or it may be as complex as requiring a new switching station in the transmission line.

Addressed below are system constraints and considerations that may substantially affect the costs of a particular connection plan, sometimes making an alternate **Connection Point** for the Project more desirable.

Connection to the **Bulk System**

The **Duke Energy Carolinas Transmission System** is separated by function into two main parts: the **Bulk System** (230 kV and 500 kV networks) and the **Regional System** (44 kV, 66 kV, 100 kV, and 161 kV networks). Each part of the transmission system plays an important role in the delivery of energy from generators to end-users. The **Regional System** is a group of electric transmission lines and tie-stations whose primary function is the distribution of energy to large industrial and commercial customers and to retail stations in its geographical area. The **Bulk System** is a highly inter-connected group of high-voltage electric transmission lines and tie-stations whose purpose is to enable the movement or transfer of electric energy in bulk between generators and major points of delivery. To accomplish this function effectively, the **Bulk System** has been designed and built to maintain the **Reliability and Integrity** of the interconnected generation and transmission network. The following list describes some of the major functional and design differences of the **Bulk System** as compared to the **Regional System**:

- I. The **Bulk System** provides the primary means for bulk energy transfer across the **SERC Reliability Corporation (SERC)** Region supporting Eastern **Interconnection** reliability.
- II. The **Bulk System** allows energy from dispersed generation to be moved over large geographical areas supporting economic dispatch and reliable system operation during generation contingencies.
- III. The **Bulk System** allows bulk energy to be transported with lower line losses reducing the overall cost of energy.
- IV. The **Bulk System** lowers exposure to faults and equipment failures through the reduced number of taps and stations on the **Bulk System**, thereby resulting in fewer disturbances that adversely impact generation reliability.
- V. As a result of the function and characteristics of the **Bulk System**, individual load connections to transmission lines are not allowed because of the overall detrimental effect on system reliability.

Connection to 44 kV, 66 kV, 100 kV, and 161 kV Lines

Most **Projects** are connected to the **Duke Energy Carolinas Transmission System** with a **Connection Point** at one of the above voltages. A radial extension of the line can be provided to reach the **Project**. Some lines have two circuits available from a double-bussed substation arrangement such that special service arrangements may be available at additional cost. Almost all 44 kV and 66 kV lines are operated radially without this option available.

Connection to Network Lines

Duke Energy Carolinas will own and operate any equipment in series with a transmission line that is part of the **Duke Energy Carolinas Transmission System**. Therefore, any equipment that is required for connection of a **Project** that will be in series with a transmission line will be owned and operated by Duke Energy Carolinas. This includes radial sections of transmission lines that carry load for more than one **Connection Point**.

Multi-Terminal Lines

A multi-terminal line can be defined as a customer connection that could back feed to a Duke Energy Carolinas transmission line. The sources could be generators, connections to other parts of the power system, or ground sources (e.g., transformers connected grounded-wye at the connection voltage). These types of terminals affect the ability of the **Duke Energy Carolinas Transmission System** to protect, operate, dispatch, and maintain the transmission line. The increased complexity of the control and protection schemes affects system stability and reliability. Duke Energy Carolinas will determine the feasibility of multi-terminal line connections on a case-by-case basis, often relying on the results of system review studies. If such a connection would have an unacceptable impact on the **Duke Energy Carolinas Transmission System**, a substation at the transmission voltage level would need to be developed.

The **Project Sponsor** and **Project Operator** are responsible for protecting the **Project** from fault conditions and other undesirable conditions (e.g., single phasing). The **Project Sponsor** must demonstrate that the entire **Project** is protected from fault conditions before connection will be made. This includes providing adequate protection for any transmission line sections that are part of the **Project**. The **Project Sponsor** and **Project Operator** will also be responsible for monitoring the **Project** to demonstrate that the **Project** performance criteria are being met. A **Protection Station** at the **Connection Point** is a common prerequisite to meet these requirements.

The **Project Sponsor** may discuss alternate arrangements with the transmission provider to provide protection for portions of the **Project** although the responsibility is still with the **Project Sponsor** to provide protection and monitoring that is required to measure performance at the **Connection Point**. Although "low-side" meters may be used to help calculate parameters at the **Connection Point** such as power factor and voltage flicker, they cannot indicate items such as faults on the source side of the meters or temporary undervoltages at the **Connection Point**. The **Project Sponsor** is encouraged to meet these requirements using any means necessary although a **Protection Station** appears to be a prerequisite to meeting both the protection and monitoring requirements set forth in these facility connection requirements. Alternative protection arrangements must be approved by Duke Energy Carolinas.

5.1.3 Connection Review

An internal review is performed to review the data supplied in the **New Delivery Point Data (NDPD) Form**, evaluate the requested Connection Point and identify feasible options that meet the request and requirements of the new load delivery. Requested in-service date and Project schedule are discussed as part of the **Connection Review**.

5.1.4 Project Initiation Meeting

A **Project Initiation Meeting** is conducted within Duke Energy Carolinas to review the request and supplied data. Results of the **Connection Review** are discussed along with requested in-service date and major Project milestones. Project Sponsor must provide in advance or at this meeting, a one-line diagram of the new facility along with the proposed point of connection to the **Duke Energy Carolinas Transmission System**. Alternative connection options, facility loadings, initial and future estimated loads and whether the entire load is new or some is being transferred from other deliveries will be discussed.

5.2 Technical Requirements

Existing electrical equipment, such as transformers, power circuit breakers, disconnect switches, and line conductors were originally designed based on the duties and capacity limits expected in response to system additions identified in long-range plans. However, with the connection of a new load delivery, some equipment may become overloaded and need to be replaced. All equipment purchased by Duke Energy Carolinas and the **Project Sponsor** as part of the **Project** must meet the applicable NESC and all appropriate IEEE standards for equipment testing and application. Duke Energy Carolinas reserves the right to review and set forth requirements for the specification and application of all equipment used in the **Project** that could impact the Performance Requirements for the **Project**.

The **Duke Energy Carolinas Transmission System** has been developed with careful consideration for system stability and reliability during disturbances. The size of the **Project**, equipment configurations, and the ability to set protective relays will affect where and how the **Connection Point** is made. The **Project** may also drive the need for remedial action schemes, in which it will be required to participate.

Following the **Connection Review** and **Project Initiation Meeting**, system review studies are performed to determine if the new load delivery connection is feasible and what impacts the new connection may have on the transmission system. Data supplied by the **Project Sponsor** is incorporated into power flow models and Duke Energy Carolinas will then perform various studies to determine any impact the **Project** has on the transmission system. The primary intent is to determine if the **Project** causes any violations of the Duke Energy Carolinas Transmission Planning Guidelines which is part of Duke Energy Carolinas' annual FERC 715 filing, or the **North American Electric Reliability Corporation (NERC) Reliability Standards (Planning Standards)**. The various studies that may be performed are discussed below:

a) Thermal and Voltage Studies

Thermal and voltage studies are performed to ensure that the connection of the **Project** does not create any thermal loadings or voltage levels outside of the limits provided in the Planning Guidelines. **Project** information obtained from the **Project Sponsor** is used to model the **Project**. Power system simulation tools are used to model a wide range of transmission system operating conditions to determine the thermal loading and voltage level changes created by the **Project** on the **Duke Energy Carolinas Transmission System**.

b) Transfer Capability

The purpose of this study is to ensure that the connection of the **Project** does not reduce any transfer capabilities below limits provided in the Planning Guidelines. Power transfers are simulated across the **Duke Energy Carolinas Transmission System** in various directions to determine how the **Project** affects **Duke Energy Carolinas Transmission System's** ability to transfer power across its system.

c) Voltage Unbalance

The purpose of this study is to ensure that the operation of any new **Project** does not create a voltage unbalance condition in excess of the limits provided in [Section 5.3 Performance Requirements](#). **Project** information obtained from the **Project Sponsor** is added to the power system model. Using power system simulation tools, studies are performed over a wide range of transmission system operating conditions to determine the range of voltage unbalance created by the **Project** at the **Connection Point**.

d) Voltage Flicker

The purpose of this study is to ensure that the operation of any new **Project** does not create voltage fluctuations in excess of the limits provided in [Section 5.3 Performance Requirements](#). **Project** information obtained from the **Project Sponsor** is added to the power system model. Using power system simulation tools, studies are performed over a wide range of transmission system operating conditions to determine the range of voltage fluctuations created by the **Project** at the **Connection Point**.

e) Harmonic Distortion

The purpose of this study is to ensure that the operation of any new **Project** does not create harmonic current injections in excess of the limits provided in [Section 5.3 Performance Requirements](#). **Project** information obtained from the **Project Sponsor** is added to the power system model. Using power system simulation tools, studies are performed over a wide range of transmission system operating conditions to determine the range of harmonic distortion created by the **Project** at the **Connection Point**.

f) Transient Overvoltage

The purpose of this study is to ensure that the operation of any new **Project** does not create a transient overvoltage condition in excess of the limits provided in [Section 5.3 Performance Requirements](#). **Project** information obtained from the **Project Sponsor** is added to the power system model. Using power system simulation tools, studies are performed over a wide range of transmission system operating conditions to determine the range of transient overvoltages created by the **Project** at the **Connection Point**.

g) Temporary Overvoltage

The purpose of this study is to ensure that the operation of any new **Project** does not create a temporary overvoltage condition in excess of the limits provided in [Section 5.3 Performance Requirements](#). **Project** information obtained from the **Project Sponsor** is added to the power system model. Using power system simulation tools, studies are performed over a wide range of transmission system operating conditions to determine the range of temporary overvoltages created by the **Project** at the **Connection Point**.

h) Temporary Undervoltage

The purpose of this study is to ensure that the operation of any new **Project** does not create a temporary undervoltage condition in excess of the limits provided in [Section 5.3 Performance Requirements](#). **Project** information obtained from the **Project Sponsor** is added to the power system model. Using power system simulation tools, studies are performed over a wide range of transmission system operating conditions to determine the range of temporary undervoltages created by the **Project** at the **Connection Point**.

i) Insulation Coordination

The purpose of this study is to ensure that the operation of any new **Project** does not create a condition that will require intervention of **Duke Energy Carolinas Transmission System** equipment in excess of the limits provided in [Section 5.3 Performance Requirements](#).

Results of the studies and any unusual conditions or precautions are noted in a system assessment document.

5.2.1.1 System Protection Review

The requested connection configuration that was reviewed as part of the **Connection Review** is then reviewed to determine its protective requirements. This review will require an impedance model (short-circuit data) at the **Connection Point** in order to determine any protective changes to the transmission system, protective requirements for the new load delivery and any special protective needs for the **Project**. Compatibility with existing protective relay schemes and device coordination with existing system protection will be reviewed and documented.

5.2.1.2 Power Quality and Reliability

There is a very diverse set of users connected to the **Duke Energy Carolinas Transmission System** with differing system requirements. In the past, most customers were only concerned with extended interruptions. However, the increased use of highly sensitive power electronic devices within all customer sectors has changed the definition of reliability. Due to the sensitivity of many industrial and commercial loads such as adjustable speed drives and computer-controlled processes, reliability is no longer only defined by the frequency and duration of sustained interruptions. There are many power quality variations other than sustained interruptions that may constitute inadequate service for the proper operation of customer equipment. These variations include but are not limited to voltage imbalance, voltage flicker, harmonic distortion, transient overvoltage, temporary overvoltage, temporary undervoltage and steady-state **Voltage Regulation**. In order to meet the requirements of its many customers, Duke Energy Carolinas performs studies to determine the power quality and reliability impacts the **Project** may have on the transmission system at the **Point of Connection**. The intent of these studies is to ensure that the connection of the **Project**

does not compromise the **Reliability and Integrity** of the **Duke Energy Carolinas Transmission System**. Limits for these variations and disturbances are stated in [Section 5.3 Performance Requirements](#).

5.2.1.3 System Assessment and Customer Communications (Network - Wholesale deliveries only)

Results from the **System Review** which may include power flow studies, protection and power quality reviews are summarized in a system assessment document. Any special design requirements or transmission system upgrades are so noted. A letter is prepared and sent to the **Project Sponsor** demonstrating that all parties involved in the assessment have coordinated and cooperated in the assessment of the reliability impacts of the new load delivery on the transmission system.

5.2.2 Facility Design and Equipment Specifications and Ratings

Circuit breakers, disconnect switches, buses and all current carrying equipment connected to transmission facilities shall be capable of carrying both normal and emergency load currents without damage. The design and ratings of all **Project** equipment connected to the transmission system shall not restrict the capability of any transmission circuits, reduce facility ratings of any Duke Energy Carolinas equipment nor become a limiting factor in the ability to transfer power throughout the **Duke Energy Carolinas Transmission System**. All equipment ratings shall be determined according to applicable IEEE standards. Duke Energy Carolinas operates and maintains its system to provide reliable service to all customers at all times. **Project** integration requires that the equipment at the **facility connection** not restrict timely outage coordination, automatic switching or equipment maintenance scheduling. Preserving reliable service to all Duke Energy Carolinas customers is essential and may require additional switchgear, equipment redundancy, or bypass capabilities at the **Project Connection Point** for acceptable operation of the system.

The effects resulting from wind and ice storms, floods, lightning, altitude, temperature extremes, and earthquakes must be considered in the design and operation of the **Project**. The **Project Sponsor** is responsible for determining that the appropriate standards are met, including, but not limited to, the Uniform Building Code (UBC) and the National Electrical Safety Code (NESC). Depending on **Project** location, size, type, and importance, Duke Energy Carolinas may request that additional capabilities be designed into the **Project**. Lightning is one of the most predominant causes of transmission line outages in the Duke Energy Carolinas service area and can be mitigated with proper design, surge protection and grounding improvements. The **Project Sponsor** is expected to design its power system to withstand reasonable lightning activity as is typical to the area in which it will be installed and still meet the Performance Requirements found in [Section 5.3 Performance Requirements](#) for the **Project**.

5.2.2.1 Isolation requirements

At the **Connection Point** with the **Duke Energy Carolinas Transmission System**, a disconnect switch shall be provided for the purpose of physically and visibly isolating the **Project** from the **Duke Energy Carolinas Transmission System**. With the consent of Duke Energy Carolinas and the **Project Sponsor**, the disconnect switch may be installed at another location, other than the **Connection Point**, provided that the purpose described herein is satisfied. Access to the disconnect switch will generally be the responsibility of Duke Energy Carolinas. Where access is atypical due to site constraints or requires third party access, the Project Sponsor will be required to obtain rights and construct a gravel access road. The access road shall be suitable to allow a service type vehicle, access in all weather, from a public road, all the way to the disconnect device. Access roads that cross Duke's Transmission right of ways must adhere to all Transmission Line right of way restrictions (contact Duke Energy Transmission Line Engineering/Asset Protection) as it pertains to angle of crossing, clearances to wire conductors, and permanent structures and fixtures. The device must adhere to the following design requirements:

- a) Accessible by Duke Energy Carolinas personnel and under the jurisdiction of the **Energy Control Center (ECC)**
- b) Lockable in the open position by Duke Energy Carolinas personnel, if gang-operated
- c) Suitable for safe operation under the conditions of use
- d) Operated only with advance notice to either party, unless an emergency condition requires that the device be opened to isolate the **Project**

Consideration shall be given as to the design and capacity of the switch on a case-by-case basis. The switch is required for safety and may not be required to interrupt load or energizing (charging) current. However, a suitable switch for the safety requirements listed above may also be used for other operational purposes.

5.2.2.2 Protection Requirements

This section establishes the minimum design objectives and recommended design philosophy for the protective systems associated with a load delivery from the **Duke Energy Carolinas Transmission System**.

5.2.2.2.1 Protective philosophy

The philosophy behind the implementation of any protection system is to detect and isolate all failed or faulted components as quickly as possible, while minimizing disruption to the remainder of the electric system. This objective implies that a protection system should be:

- a) Dependable - operate when required
- b) Secure - not operate unnecessarily
- c) Selective - only the minimum required number of devices should operate
- d) Fast - minimize hazards to personnel and damage to equipment

The basic design objectives of any protective scheme are to:

- a) Maintain safety of the general public
- b) Maintain dynamic stability
- c) Prevent or minimize equipment damage
- d) Minimize equipment outage time
- e) Minimize the system outage area
- f) Minimize system voltage disturbances
- g) Allow the continuous flow of power within the ratings of equipment on the system

If required, backup protection should clear any fault upon failure of the protective equipment in the primary protection system.

Operation of the **Project** should not adversely affect the **Duke Energy Carolinas Transmission System**. This requirement includes switching operations as well as faults within the **Project**. The **Project Sponsor** is responsible for providing protection for the **Project** and must demonstrate that their own equipment properly protects all of their facilities. The **Project** shall not be designed or operated with a ground source at the connected voltage unless specifically approved by Duke Energy Carolinas. This requires a delta connection on the utility side of load transformers.

Duke Energy Carolinas coordinates its protective relays and control schemes to maintain personnel safety and equipment protection and to minimize disruption of services during disturbances. **Project** connection usually requires the addition or modification of protective relays and control schemes. Modifications may also include the use of communication channels to provide protection for tap lines, dual customer feeds, generation or other special requirements of the customers. The **Project** must be compatible with existing protective relay schemes.

System protection modifications to the **Project** are to be reviewed by Duke Energy Carolinas before changes are made. These changes are defined as changes in interrupters, lines, transformers, protective devices and protective settings. This review is needed to ensure proper operation of the power systems and coordination of protective devices.

5.2.2.2.2 Protection Station

A **Protection Station** is any facility that satisfies the requirements necessary to provide complete protection for the transmission system from the **Project**.

Duke Energy Carolinas reserves the right to review and set forth requirements for the specification and coordination of the **Protection Station**. An agreement may be developed to allow Duke Energy Carolinas to operate and control this station under certain specified conditions. Duke Energy Carolinas reserves the right to modify automatic reclosing in the future. Duke Energy Carolinas may require a dedicated set of current transformers located beyond the **Connection Point** that can be used by Duke Energy Carolinas to set relays to monitor and control the **Protection Station**.

To achieve the basic protection objectives, certain equipment (relays, circuit breakers, etc.) must be installed. These devices ensure that faults or other abnormalities initiate prompt and appropriate disconnection of the **Project** from the **Duke Energy Carolinas Transmission System**. Protective equipment requirements depend on a variety of considerations. Significant issues that could affect these requirements include:

- a) The connection configuration of the **Project**
- b) The location of the **Connection Point** on the power system
- c) The level of existing service and protection to adjacent facilities (including those of other Duke Energy Carolinas customers and/or those of other utilities)

In addition, certain modifications and/or additions to the **Duke Energy Carolinas Transmission System** may be required for connection of the **Project**. Each individual connection will require a protection system consistent with these requirements. Duke Energy Carolinas will work with the **Project Sponsor** to achieve an installation that meets requirements of both the **Project Sponsor** and Duke Energy Carolinas. The **Project Sponsor** shall provide **Project** protection system design data as requested and shall address any aspects of the design that Duke Energy Carolinas finds unacceptable.

Duke Energy Carolinas will not assume any responsibility for protection of the **Project**. **Project Sponsors** are solely responsible for protecting their equipment in such a manner that faults, imbalances, or other disturbances on the **Duke Energy Carolinas Transmission System** do not cause damage to the **Project** facilities. The **Project Sponsor** is also expected to provide proper protective systems to ensure **Project** equipment does not adversely impact the **Duke Energy Carolinas Transmission System**. The **Project Sponsor** should follow applicable industry guides and standards such as those listed in [Section 2 - References](#). Duke Energy Carolinas may elect to require compliance with guidelines and/or standards, or portions thereof, on a project-specific basis.

5.2.2.2.3 Protection Criteria

The information in this section is provided to identify general protection practices as applied to the Duke Energy Carolinas transmission lines and connections. The overall protection system, including the **Protection Station** and **Project** protection, must be designed such that the **Project** generating equipment or **Connection Point** is automatically isolated for the following situations:

- a) Faults within the **Project**
- b) Faults within **Duke Energy Carolinas Transmission System** zones of protection determined to be significantly impacted by the **Project**
- c) Conditions that indicate abnormal operation, including unintentional islanding of the **Project**

Protection beyond the **Connection Point** is the responsibility of the **Project Sponsor** and/or **Project Operator** and must be coordinated with **Duke Energy Carolinas Transmission System** protective devices. Protection will include devices to detect and interrupt all types of faults and generally will include overcurrent protection for both phase and ground faults and a three-phase interrupting device. The overcurrent protection may include instantaneous tripping for high-value faults and/or time-delay tripping for lower value faults. Reclosing intervals must be coordinated with the **Duke Energy Carolinas Transmission System** reclosing devices. Fault monitoring and location equipment is recommended at **Protection Stations**.

For new load deliveries requiring a new Duke Energy Carolinas owned tap line, protection of the Duke Energy Carolinas tap line will be reviewed to determine if additional protection is required. If additional protection is required due to the addition of the **Project**, it will be to protect Duke Energy Carolinas facilities and the **Project Sponsor** is still required to provide protection as defined in [Section 5.2.2.2 - Protection Requirements](#) for the **Project**. Factors such as the length and location of the Duke Energy Carolinas tap line will determine if **Duke Energy Carolinas Transmission System** requires additional protection.

Request for dual transmission feeds to a **Project** will be evaluated on a case-by-case basis. The protection requirements for this type of station vary with the location and type of feeds.

Existing facilities may have protection only on the high-voltage side of the transformer. The existing protection at these installations was applied under the assumption that there was not a source from the proposed **Project** side to feed faults on the transmission system.

Duke Energy Carolinas reserves the right to require a **Protection Station** at any **Connection Point** before or after initial connection is made to the **Duke Energy Carolinas Transmission System**. Duke Energy Carolinas may install its own **Protection Station** at the **Project Sponsor's** expense if, for example, provisions in [Section 5.3 Performance Requirements](#) are not met.

5.2.2.3 Breaker Duty

All circuit breakers and other fault interrupting devices shall be capable of safely interrupting fault currents for any fault that they may be required to interrupt. Application shall be in accordance with IEEE SA - C37.95-2014 - IEEE Guide for Protective Relaying of Utility-Consumer Interconnections and other relevant standards. Minimum fault-interrupting requirements are supplied by Duke Energy Carolinas as part of this document and are based on the greater of the fault duties at the time of the connection request or those projected in long-range plans. System stability considerations may require fast opening and reclosing times. Table 12 specifies the operating times required of circuit breakers on the **Duke Energy Carolinas Transmission System**. These times also apply to equipment at the **Connection Point**.

Table 12. Circuit Breaker Operating Times

Voltage Class (kV)	Rated Interrupting Time (Cycles)	Dead Timer Delay (Cycles)
500	2	30
230	3	25
161 and below	3	18
138 and below	5	18

Depending on the application, the use of other fault interrupting devices such as circuit switchers may be allowed. Trip times of these devices are generally slower, and current interrupting capabilities are often lower than those of circuit breakers. Often circuit switchers are utilized to isolate transformers from the transmission breakers. The dead timer delay on circuit switchers is typically 15 seconds and consequently these devices usually are not reclosed.

5.2.2.4 Phase Sequence Orientation

Much of Duke Energy Carolinas uses a phase rotation of ABC (phase "A" voltage leads phase "B" voltage by 120 degrees and phase "B" voltage leads phase "C" voltage by 120 degrees). It is important that the **Project Sponsor** and **Project Operator** understand this phase sequence and coordinate with Duke Energy Carolinas before connection is made to ensure intended phase rotation is achieved. Duke Energy Carolinas can typically provide the phase sequence desired by the **Project Sponsor**, however there may be limitations in a given **Project**. Duke Energy Carolinas cannot guarantee a requested phase sequence connection until each connection request is reviewed in detail. Duke Energy Carolinas will not typically "roll phases" at the **Connection Point** for a **Project** unless Duke Energy Carolinas did not provide adequate or accurate information regarding the phase sequence to be provided at the **Connection Point**.

5.2.2.5 Equipment Grounding

Each connecting substation must have a ground grid that solidly grounds all metallic structures and fencing along with other non-energized metallic equipment. This grid shall limit the Ground Potential Rise (GPR) to such voltage and current levels that will not endanger the safety of people or damage equipment which are in, or immediately adjacent to, the station under normal and fault conditions.

If the **Project** is physically close to a Duke Energy Carolinas substation, it is required that the two ground grids be connected. However, the **Project** and substation fences should not be connected except via an isolated fence section with a minimum length of 10 feet. The interconnecting cables must have sufficient capacity to handle fault currents and control ground grid voltage rises. Duke Energy Carolinas must approve and inspect any connection to a Duke Energy substation ground grid. If the ground grids must be isolated for operational reasons, there must be no metallic ground connections between the two substation ground grids where Duke Energy Carolinas shall approve the required minimum separation of the facilities. As a note of caution, cable shields, cable sheaths, **Station Service** ground sheaths, fiber optic tracer wires, metallic cable trays and overhead transmission shield wires can all inadvertently connect ground grids. Fiber-optic cables with non-metallic sheaths are an excellent choice for telecommunications and control between two substations to maintain isolated ground grids. In the case where the **Project** is physically close to another substation, but the ground grids are isolated, the **Project Sponsor** must demonstrate that the ground grids are properly isolated and in compliance with all applicable codes and standards. Duke Energy Carolinas prefers to connect static wires on incoming transmission lines to the station ground grid. If the **Project Sponsor** prefers not to connect static wires on incoming transmission lines to the station ground grid; the **Project Sponsor** must notify Duke Energy Carolinas in writing and demonstrate that relay performance, lightning protection, and personnel safety are not compromised by isolating the static wires from the station ground grid.

The **Project** ground grid shall be designed to IEEE SA - 80-2013 - IEEE Guide for Safety in AC Substation Grounding.

It shall be measured in accordance with Part 1: IEEE SA - 81-2012 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System

It shall also be measured in accordance with Part 2: IEEE SA - 81.2-1991 - IEEE Guide for Measurement of Impedance and Safety Characteristics of Large, Extended or Interconnected Grounding Systems

Project grounding requirements shall also comply with the following (plus any applicable state and local codes):

- National Electric Safety Code
- IEEE SA - 837-2014 - IEEE Standard for Qualifying Permanent Connections Used in Substation Grounding,
- IEEE SA - 487-2015 - IEEE Standard for the Electrical Protection of Communications Facilities Serving Electric Supply Locations -- General Considerations
- IEEE 367-2012 Recommended Practice for Determining the Electric Power Station Ground Potential Rise and Induced Voltage from a Power Fault

5.2.2.6 Insulation and Insulation Coordination

Insulation and Insulation Coordination requirements are applicable to all generation, transmission and **Interconnection** facilities. Proper insulation coordination is necessary to ensure electrical system reliability and personnel safety. Power system equipment is designed to withstand voltage stresses associated with expected operation. System studies include the evaluation of the impact of the **Project** on equipment insulation coordination. Duke Energy Carolinas will identify equipment additions or specifications that are required to maintain an acceptable level of system availability, reliability, equipment insulation margins and safety. Basic Insulation Level (BILs) and arrester ratings are shown in **Table 13**.

Table 13 Substation Basic Insulation Levels and Arrester Ratings

Nominal System Voltage - kV	Substation Bus BIL kV	Transformer BIL kV	Bank Arrester kV	Line Arrester kV
525	1800	1675	420	420
230	900	900	192	192
161	650	650	132	132
138	550	550	108	108
115	550	450	108	108
100	475	450	96	88
66	350	350	72	70
44	250	250	48	48

Voltage stresses such as lightning surges, switching surges, temporary overvoltage, and normal 60 Hz voltages may affect equipment duty. Remedies depend on the equipment capability and the type and magnitude of the stress. In general, stations shall be protected against lightning and switching surges. Typically this includes, station shielding against direct lightning strokes, surge arresters on all wound devices, and shielding on the incoming lines. Below are the requirements that must be met to connect to the **Duke Energy Carolinas Transmission System**.

5.2.2.6.1 Lightning Surges

Lightning is the single largest cause of transmission line events in the Duke Energy Carolinas service area and must be considered during the design and installations of transmission lines and substations. Lightning-related causes are not exempt from the requirements listed in [Section 5.3 - Performance Requirements](#) section. Although it is not always cost effective to design and build a power system to withstand every possible lightning stroke, it has been demonstrated that with proper design and installation procedures, the effects of lightning can be mitigated to achieve a reliability level equal to or exceeding the requirements of the **Project** performance criteria section. Techniques used to help control lightning related events on transmission lines include proper use of shield wires, insulation levels, low resistance grounding, and surge arresters. Techniques used to help control lightning related outages in substations include substation shielding, proper arrester applications, and shielding of incoming transmission lines.

If the **Project** proposes to tap a Duke Energy Carolinas transmission line that is shielded, the new tap line must also be properly shielded for at least one mile from the **Duke Energy Carolinas Transmission System**. If any stations are within one mile of the **Duke Energy Carolinas Transmission System**, these also must be properly shielded from direct lightning strokes. The **Project Sponsor** must be able to demonstrate proposed designs for any transmission lines and substations will perform within the limits for service interruptions as stated in [Section 5.3 - Performance Requirements](#).

For transmission line design, an industry recognized lightning performance estimating algorithm may be used to demonstrate acceptable performance of the design. The **Project Sponsor** must make reasonable assumptions based on the area that the transmission line will be installed including ground flash density and grounding conditions. The **Project Sponsor** must be able to provide an alternative plan if the ground conditions required for acceptable performance are not achieved during construction of the transmission line.

For substation design, the **Project Sponsor** must be able to demonstrate their proposed designs will operate within [Section 5.3 - Performance Requirements](#). The shielding designs and arrester applications shall adhere to applicable IEEE standards. In addition, any normally open points that are subject to voltage "doubling" of incoming lightning surges must be protected accordingly per the requirements in Section 5.3.

5.2.2.6.2 Switching Surges

At voltages below 500 kV, modifications to protect the **Duke Energy Carolinas Transmission System** against switching surges generated by the **Project** are not anticipated although the **Connection Review** identifies the actual needs. At 500 kV, Duke Energy Carolinas may require that arresters be added at the line terminations of the substations or that pre-insertion resistors or inductors are included in **Project** breakers, if switching surge studies predict overvoltages that may cause a flashover at the **Project's** facilities.

5.2.2.6.3 Temporary Overvoltages

Temporary overvoltages can last from cycles to minutes and are not characterized as surges. These overvoltages are usually present during faults and other abnormal system conditions. The **Duke Energy Carolinas Transmission System** is typically considered to be **Effectively Grounded** at 100 kV and higher voltages. However, the 44 kV system is not **Effectively Grounded** in all locations. These systems may be impedance grounded and can have line-to-ground voltages approaching 1.73 times normal line-to-ground voltage during fault conditions on unfaulted phases. It is not acceptable for the **Project** to supply any ground source for the transmission system unless specifically approved and coordinated with Duke Energy Carolinas.

A system study may be performed for each **Project** based on the point on the **Duke Energy Carolinas Transmission System** that is being connected. The **Project Sponsor** will be supplied the system characteristics needed to calculate the temporary overvoltages that need to be considered. Gapless metal-oxide surge arresters are especially sensitive to system temporary overvoltages and Duke Energy Carolinas may review the specification of arresters used on 44 kV systems to ensure proper application.

5.2.2.6.4 Normal Operating Voltages

Duke Energy Carolinas Transmission System voltages are normally operated within the limits specified in [Section 5.3 - Performance Requirements](#) of this document. Insulation coordination usually does not need to consider this operating range once lightning and switching surge requirements are met; however, in highly contaminated areas, special consideration and additional insulation requirements may be required for proper insulation coordination. The **Project Sponsor** is responsible for determining whether special insulation requirements are needed for its system.

5.2.2.7 Station Service

Appropriate providers of **Station Service** and **Alternate Station Service** are ultimately determined during the **Project** planning process. Generally, the utility with a distribution service in the vicinity will be the preferred provider of primary **Station Service** unless:

- a) The utility is unable to serve the load
- b) Costs to connect the local utility are prohibitive

The **Project Sponsor** is responsible for metering for **Station Service** and **Alternate Station Service**, as specified by the Metering Requirements (5.2.4.1) section of this document, [Metering and Telecommunications Requirements](#).

5.2.3 Operating and Control Requirements

Duke Energy Carolinas will conduct an internal review to determine additional facility design and operational factors affecting the operations and control of the new load delivery based on the point of connection with the **Duke Energy Carolinas Transmission System**. This review may generate additional design and operating requirements. These requirements will be communicated to the **Project Sponsor** through a system assessment letter.

5.2.4 Metering and Telecommunications Requirements

All **Projects** that are connected to the **Duke Energy Carolinas Transmission System** will require revenue-accuracy metering equipment i.e. metering enclosure with meter and associated equipment, instrument transformers, and certain interface enclosures with associated isolation devices. This section states the minimum requirements for metering and telecommunications associated with a load delivery from the **Duke Energy Carolinas Transmission System**.

Loads larger than 10 MVA may require **SCADA** depending on their location to ensure that the **Energy Control Center (ECC)** has the information necessary for maintaining system reliability. The following data may be required:

- a) **Connection Point** isolation device(s) status
- b) Load MW and MVAR measured at the **Connection Point**
- c) Voltage at the **Connection Point**
- d) MW and MVAR line flow on any transmission line coming into the substation

The **Project Sponsor** is responsible for the installation, calibration and maintenance associated with metering and telecommunications equipment between the **Project** and Duke Energy Carolinas. In some cases Duke Energy Carolinas may install some or all of the metering equipment. Additional site-specific design requirements may be necessary.

5.2.4.1 Metering Requirements

It is the responsibility of the Project Sponsor to make appropriate arrangements with DEC, as the Balancing Authority, for the following: a) ensuring that their new or materially modified Facilities are within the BA metered boundaries, which also serves to facilitate the process of the coordination between the two entities that will be required under numerous other standards upon the start of operation; b) proper coordination with DEC so that DEC, as Balancing Authority, can ensure that any associated Tie-Line, Pseudo-Tie, and Dynamic Schedule with an Adjacent Balancing Authority is equipped with a common source to provide information to both Balancing Authorities for the scan rate values used in the calculation of Reporting ACE per the requirements of NERC Reliability Standard BAL-005, R7.1.

Metering equipment should be installed, if possible, at the **Connection Point**. If not installed at the **Connection Point**, the power transformer and line losses will need to be considered. A solid-state meter shall be used to measure the real and reactive power interchange between the **Duke Energy Carolinas Transmission System** and the **Project**. Three-element, three-phase, four-wire meters shall be utilized on wye connected power systems. Two-element, three-phase, three-wire meters shall be utilized on delta-connected power systems. The metering devices must be fully compatible (approved meter type and communication media) with **Duke Energy Carolinas Transmission System's** remote metering and data acquisition system.

Design and testing requirements that shall be addressed include:

- a) Bi-directionality - A bi-directional watt/var-hour meter shall be utilized to measure the power flow in and out of the **Duke Energy Carolinas Transmission System**.
- b) Metering-bypass - For metering equipment located in the **Project** substation, the installation of a metering bypass is suggested, but not required. For the replacement of failed or malfunctioning equipment a metering bypass is necessary to maintain power flow to the **Project**. If a metering bypass is not installed, an outage will be required to replace the failed or malfunctioning equipment.
- c) Metering accuracy - Meters shall be calibrated to 0.2% accuracy at unity power factor for full load and 0.3% accuracy at unity power factor for light load. These meters shall be calibrated to 0.5% accuracy for 0.5 power factor at full load. Metering accuracy limits are stated in **Table 14**.

Table 14 - Meter Accuracy

Function	Accuracy %	Load	Power Factor
Watt-hour	+/- 0.2	Full	1.0
	+/- 0.3	Light	1.0
	+/- 0.5	Full	0.5
Var-hour	+/- 0.5	Full	1.0

Notes

- a) Watt-hour and var-hour functions should be tested in both directions of energy flow (In and Out).
- b) When compensating for transformer or line loss, utilize stated limits above or 5% of desired compensation, whichever is greater.
- c) The meter shall be tested, at a minimum, at the points listed in **Table 15**, with compensation applied to obtain a true test of the installation.

Table 15 - Test Points

Test Points	Volts	Amps	Power Factor
Full Load	120	5	1.0
Full Load	120	5	0.5
Light Load	120	0.5	1.0

- d) Provisions for maintenance and calibration - Metering facilities shall be tested and calibrated, if necessary, every two years. More frequent test intervals may be negotiated. All interested parties or their representatives may witness the calibration tests. Calibration records shall be made available to all interested parties. The accuracy of the standard utilized for calibration purposes shall be traceable to the [National Institute of Standards and Technology \(NIST\)](#).
- e) Ancillary equipment specifications - Voltage transformer shall be 0.3% metering accuracy class and current transformers shall be extended range 0.15% metering accuracy class for both magnitude and phase angle over the burden range of the installed metering circuit. Instrument transformer correction factors may be applied to the meter to adjust the meter for inaccuracies associated with the secondary burdens in the current transformer and voltage transformer circuits. All instrument transformers shall comply with IEEE SA - C57.13-2016 - IEEE Standard Requirements for Instrument Transformers and ANSI C12.11-2006 (R2014) – Instrument Transformers for Revenue Metering 10 kV BIL through 350 kV BIL (0.6 kV NSV through 69 kV NSV).
- f) Loss compensation - If the metering is not located at the **Connection Point**, then Duke Energy Carolinas approved power transformer and line loss compensation values shall be applied to the meter to properly compensate for the losses in the power transformer and line.
- g) Access to metering data - If access to the meter is required, proper security measures must be taken to ensure the integrity of the meter is not compromised. If data pulses are required from the revenue meter, then the appropriate interface box with associated equipment must be installed to properly protect the revenue meter. If an additional information meter is requested, good engineering practices must be adhered to when terminating the connections in the meter circuit to ensure the integrity of the revenue-accuracy metering circuit is intact. It must be determined which party has the responsibility to install the additional meter.
- h) **Station Service Power** - Metering requirements for the **Station Service Power**, if any, will be determined on a case-by-case basis.

5.2.4.2 Telecommunication and Supervisory Control and Data Acquisition (SCADA) Requirements

The requirements for voice communication between the **Energy Control Center (ECC)** and the **Project Operator**, will be determined on a case-by-case basis. A typical phone line at the **Project** may be sufficient to supply this communication path. Most projects connected to the **Duke Energy Carolinas Transmission System** will not require any special communication devices and circuits for protection. A local voice or alarm circuit is recommended when an interrupting device is installed.

If the **Project** can back-feed the **Duke Energy Carolinas Transmission System** either from a generator or alternate source, then the protection system may require communications with remote ends of Duke Energy Carolinas' transmission line. These requirements will be evaluated on a case-by-case basis.

Supervisory Control and Data Acquisition Data (SCADA) requirements will be determined on a case-by-case basis depending on the location of the **Project**. **SCADA** communications may be established through leased phone lines, microwave channels, or fiber-optics from the site to the **Energy Control Center (ECC)**. Factors involved in selecting a type of circuitry are availability, proximity to the site, and cost. Fiber-optic communication channels are preferred. These communication links are to be dedicated channels but are not required to be redundant.

For revenue-accuracy metering, a compatible and reliable communication media must be provided and maintained to enable Duke Energy Carolinas to interrogate the meter, collect, merge, and store metering and usage data with Duke Energy Carolinas' remote metering and data acquisition system. Modes of communications could be, but not limited to, fiber optics, Ethernet, wireless modem, etc.

5.3 Performance Requirements

All **Projects** must be properly designed, constructed, operated, and maintained to avoid degrading the reliability of the transmission network. A **Project** must comply with the **Project Performance Criteria**, listed below and must be able to operate satisfactorily within the limits defined in the **Duke Energy Carolinas Transmission System** characteristics section, below, in order to be considered properly connected. The **Project Sponsor** or **Project Operator** is expected to demonstrate, through monitoring, that the **Project** meets the Performance Criteria. However, It is required that the Performance Criteria of Sections 5.3.1 a) and 5.3.1 b) be continuously monitored. The remaining criteria must be met and considered in the design and operation of the **Project** although these do not necessarily have to be continuously monitored.

However, if problems are suspected at any time, Duke Energy Carolinas may require the **Project Sponsor** and/or **Project Operator** to demonstrate through monitoring that the performance of the **Project** at the **Connection Point** meets these requirements. If the requirements are not met, the **Project Sponsor** or **Project Operator** must provide Duke Energy Carolinas a plan to improve and meet the Performance Criteria. Additional relay and control requirements may be developed and enforced by Duke Energy Carolinas after connection is made if these Performance Criteria are violated. Enforcement of these performance criteria and penalties associated with them are beyond the scope of this document and will be in **Project** specific contracts and operating agreements.

5.3.1 Project Performance Criteria

To ensure the **Reliability and Integrity** of the supply system, all **Projects** must meet the **Project Performance Criteria** at the **Connection Point**. The following section details the **Project Performance Criteria**:

- a) **Power Factor** - Facilities that serve primarily distribution load (retail stations, wholesale customers, etc.) must comply with the following power factor requirements measured at or compensated to the **Connection Point**:
 - I. **Peak Periods** - The **Project** must operate its electrical system in a manner resulting in a power factor not less than 96.5% lagging at the hour of transmission system peak load on an annual basis.
 - II. **Valley Periods** - The **Project** must operate its electrical system in a manner not resulting in a leading power factor at the hour of transmission system valley load on an annual basis.

- b) **Transmission System Interruptions** - For **Connection Points** at 161 kV and below, the **Project** shall not cause an interruption to any portion of the Duke Energy Carolinas **transmission** system more than once in a 12 month period, more than three times in a five year period, or more than five times in a ten year period. An interruption is defined as a voltage zero condition lasting greater than 20 milliseconds. Interruptions occurring within one minute of each other will be considered the same event. Exemptions are not typically given, even for lightning or other weather-related causes. A **Project** is in violation of the **Project** Performance Criteria if these requirements are not met.
- c) **Temporary Undervoltages** - For **Connection Points** at 161 kV and below, the **Project** may not cause a temporary undervoltage at the **Connection Point** more than two times in a 12 month period, more than five times in a five year period, or more than eight times in a ten year period. A temporary undervoltage is defined as an oscillatory phase-to-ground or phase-to-phase voltage of 85% or less of nominal voltage lasting greater than 20 milliseconds occurring during fault conditions. Undervoltages due to non-fault events are covered in the voltage flicker requirements in [Section 5.3 Performance Requirements \(f\)](#). Temporary undervoltages occurring within one minute of each other will be considered the same event. A **Project** is in violation of the **Project** Performance Criteria if these requirements are not met.
- d) **Transient Overvoltages** - The **Project** may not operate its equipment or system in such a manner as to cause a peak transient voltage at the **Connection Point** greater than or equal to 140% of the nominal peak voltage. A transient overvoltage is defined as the peak line-to-line or line-to-ground voltage during the transient condition resulting from operation of a switching device. Any transient voltage condition caused by the operation of the **Project's** equipment or system that results in a peak transient voltage greater than or equal to 140% of the nominal peak voltage at the **Connection Point** is in violation of the Project Performance Criteria.
- e) **Temporary Overvoltages** - The **Project** may not operate its equipment or system in such a manner as to cause a temporary overvoltage at the **Connection Point** greater than or equal to 120% of the nominal system voltage. A temporary overvoltage is defined as an oscillatory phase-to-ground or phase-to-phase overvoltage lasting greater than 20 milliseconds which is undamped or only weakly damped. Any temporary voltage condition caused by the operation of the **Project's** equipment or system that results in a temporary overvoltage greater than or equal to 120% of the nominal system voltage at the **Connection Point** is in violation of the **Project** Performance Criteria.
- f) **Voltage Fluctuations And Flicker** - Per IEEE SA - 1453-2015 - IEEE Recommended Practice for the Analysis of Fluctuating Installations on Power Systems, planning levels of $P_{st}=0.8$ and $P_{it}=0.6$ define the allowable voltage fluctuation limits at the **Connection Point**. In unique cases, higher limits can be considered with the understanding that the **Project Sponsor** or **Project Operator** will be required to mitigate the flicker that they cause, if significant customer complaints are generated. Additionally, any single customer that creates disturbances for other customers will be required to mitigate the disturbance, regardless of the actual measured value.

Operation of the **Project's** system or equipment in such a manner as to create a voltage fluctuation greater than 3% on the **Duke Energy Carolinas Transmission System** or on the primary of the distribution system is not allowed.

- g) **Harmonic Distortion** - The maximum allowable harmonic current injections (percentage harmonic distortion at each frequency as a function of load current) at the **Connection Point** for **Projects** connected at 161 kV to 69 kV and 120 V to 69 kV are defined in Tables 16 and 17 respectively. Operation of the **Project's** system or equipment in such a manner as to create a condition where the harmonic current injection at the **Connection Point** exceeds the limits provided for in Tables 16 and 17 for a duration greater than or equal to one hour on any single day or exceeds 150% of the limits provided for the given connection voltage for a duration greater than five minutes on any two days during a six month period is in violation of the **Project** Performance Criteria.

**Table 16 - Current Injection Harmonic Distortion Limits:
Connection Point Voltage 69.1 kV to 161 kV**

Individual Harmonic Order (Odd Harmonics)						
I_{sc}/I_{load}	$h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$h \geq 35$	TDD
<20	2.0 %	1.0 %	0.75 %	0.3 %	0.15 %	2.5 %
20<50	3.5 %	1.75 %	1.25 %	0.5 %	0.25 %	4.0 %
50<100	5.0 %	2.25 %	2.0 %	0.75 %	0.35 %	6.0 %
100<1000	6.0 %	2.75 %	2.5 %	1.0 %	0.5 %	7.5 %
>1000	7.5 %	3.5 %	3.0 %	1.25 %	0.7 %	10.0 %

**Table 17 - Current Injection Harmonic Distortion Limits:
Connection Point Voltage 44 kV to 69 kV**

Individual Harmonic Order (Odd Harmonics)						
I_{sc}/I_{load}	$h < 11$	$11 \leq h < 17$	$17 \leq h < 23$	$23 \leq h < 35$	$h \geq 35$	TDD
<20	4.0 %	2.0 %	1.5 %	0.6 %	0.3 %	5.0 %
20<50	7.0 %	3.5 %	2.5 %	1.0 %	0.5 %	8.0 %
50<100	10.0 %	4.5 %	4.0 %	1.5 %	0.7 %	12.0 %
100<1000	12.0 %	5.5 %	5.0 %	2.0 %	1.0 %	15.0 %
>1000	15.0 %	7.0 %	6.0 %	2.5 %	1.4 %	20.0 %

Notes:

- i. Even harmonics are limited to 25% of the odd harmonic limits.
 - ii. Current distortions that result in DC offset are not allowed.
 - iii. I_{load} is the maximum load current (fundamental frequency component) at the **Connection Point**.
 - iv. I_{sc} is the maximum short-circuit current at the **Connection Point**.
 - v. TDD (Total Demand Distortion) is the total harmonic current distortion expressed in % of maximum demand load current.
- h) **Voltage Unbalance** - The maximum voltage unbalance any **Project** is allowed to introduce on the **Duke Energy Carolinas Transmission System** at the **Connection Point** is 1%. Any voltage unbalance condition greater than 1% that has duration greater than or equal to one minute is in violation of the **Project** Performance Criteria. Voltage unbalance is defined as the percent deviation of one phase from the average of all three phases.
- i) **Standards for Degradation of Transmission System Reliability and Integrity by Customers** - This section prescribes a comprehensive approach for limiting the degradation of transmission system **Reliability and Integrity** caused by directly connected customers while the sections immediately preceding address some specific areas of interest. In any case, the more stringent limitation applies.
- Customers shall not cause power disturbances on the **Duke Energy Carolinas Transmission System** that exceed any of the annual limits listed below. Customers exceeding any of these annual limits shall be considered to have violated the standards for degradation of transmission system **Reliability and Integrity** by customers:
- i. Creation of more than 0.0067 Sustained Outages per 1 MW of customer's load (**SAIFI** of 0.0067 per MW load)

- ii. Creation of more than 0.0333 Momentary Interruptions or **Equivalent Faults** per 1 MW of customer's load (MAIFI of 0.0333 per MW load)
- iii. Creation of more than 400 **Customer Equivalent Incapacitating Disturbances** (CEID) per 1 MW of customer's load

The standards for degradation of transmission system **Reliability and Integrity** by customers apply to future system changes and reconfigurations whether these changes are initiated by the customer or the utility.

The result of the calculations in limits i, ii and iii above will change if the customers load changes.

The result of the calculation for limit iii is also subject to change if the number of **Customer Equivalent Incapacitating Disturbances** changes. This could result from a change in the number, size or location of other customers or changes in the utility facilities feeding other customers. A customer may elect to pay for dedicated facilities, with utility approval, to limit the future risk of exposing other customers to **Incapacitating Disturbances** in limit iii.

5.3.2 Duke Energy Carolinas Transmission System Characteristics

All **Project** equipment connected to the **Duke Energy Carolinas Transmission System** should be designed to operate within the system conditions defined in this section. These characteristics are typical to the **Duke Energy Carolinas Transmission System** during normal and contingency conditions but may be exceeded for very short times or if exceptional circumstances occur. These characteristics are:

- a) **Frequency** - The frequency of the **Duke Energy Carolinas Transmission System** shall be nominally 60 Hz and shall be controlled within the limits of 59.9 Hz - 60.1 Hz unless exceptional circumstances prevail. System frequency could rise to 61 Hz or fall to 59 Hz under exceptional circumstances.
- b) **Steady-State Voltage Variations** - The transmission system planning guidelines for **Voltage Regulation** range at the **Connection Point** is listed in Table 18.

Table 18 - System Voltage Variations at the Connection Point

Nominal Voltage (kV)	Absolute Voltage		Voltage Regulation	
	Minimum	Maximum	Normal	Contingency
44	94 %	109%	8.5%	10%
66	94 %	109%	8.5%	10%
100	95 %	107%	6%	7%

- c) **Harmonic Voltage Distortion** - The maximum harmonic voltage distortion at the **Connection Point** for each transmission voltage level is defined in Table 19. The limits in Table 19 represent the maximum harmonic voltage distortion at a given connection voltage for a duration less than or equal to one hour on any single day. The maximum harmonic voltage distortion will not exceed 150% of the limits for a given connection voltage for a duration greater than five minutes on any two days during a six month period.

Table 19 -- System Harmonic Voltage Distortion Limits

Nominal Voltage (kV)	Maximum Individual Harmonic Voltage Distortion (%)	Maximum Total Voltage Distortion (%)
44	3.0	5.0
66	2.5	4.0
100	1.5	2.5

- d) **Voltage Unbalance** - the maximum voltage unbalance on the **Duke Energy Carolinas Transmission System** at the **Connection Point** for a duration greater than or equal to one minute will be less than or equal to 2.0%.
- e) **Transient overvoltages** - the maximum peak transient overvoltage at the **Connection Point** will be less than or equal to 200% of the nominal system peak voltage.
- f) **Temporary overvoltages** - The maximum temporary overvoltage at the **Connection Point** will be less than or equal to 180% of the nominal system voltage. For **Effectively Grounded** portions of the **Duke Energy Carolinas Transmission System**, the maximum may be significantly lower than 180%.

5.4 General Operating Requirements

5.4.1 Safety and Operation

All safety and operating procedures for joint use equipment shall be in compliance with the Occupational Safety and Health Administration (OSHA) standard 29 CFR 1910.269, the National Electrical Safety Code (NESC), the Duke Energy Corporation Health and Safety Handbook, the Duke Energy Corporation Work Standards Manual and the **Project Sponsor's** safety manuals. The **Project** must also comply with Duke Energy Carolinas' switching, tagging and isolation procedures.

The **Project Operator** shall not energize any **Duke Energy Carolinas Transmission System** line or equipment unless the **Energy Control Center (ECC)** specifically grants approval. If for any reason, a protective device operation separates the **Project** from the **Duke Energy Carolinas Transmission System**, the **Project Operator** will contact the **Energy Control Center (ECC)** before attempting to restore the connection to the **Duke Energy Carolinas Transmission System**.

The disconnect switch provided for the purpose of physically and visibly isolating the **Project** from the **Duke Energy Carolinas Transmission System**, shall not be operated without advance notice to either party, unless an emergency condition requires that the device be opened to isolate the **Project**. Duke Energy Carolinas personnel may open the switch if:

- a) It is necessary for the protection of Duke Energy Carolinas maintenance crew personnel when working on de-energized circuits
- b) The **Project** or **Duke Energy Carolinas Transmission System** equipment presents a hazardous condition

During emergency conditions, the **Project Operator's** first duty is to ensure safety guidelines are achieved and to protect station equipment. The **Project Operator** shall follow the Duke Energy Carolinas approved set of procedures when separating from and reconnecting to the transmission system. The **Project Operator** shall not energize any equipment or connect to any energized equipment unless instructed to do so by the **Energy Control Center (ECC)**. If, for any reason, the **Duke Energy Carolinas Transmission System** is disconnected from the **Project** (through a fault condition, line switching, etc.), the protective equipment connecting the **Project** to the system must open and not reclose until approved by the **Energy Control Center (ECC)**.

All protective relays will be in service at all times and not be blocked for automatic or manual testing of the **Project**. When required for switching, ground relays may be blocked.

Manual testing of the **Project** after a lockout is to be coordinated with the **Energy Control Center (ECC)** before testing the line.

5.4.2 Generation Served by the Project

The **Project Sponsor** shall maintain a record of all generation customers served by the **Project** and such record shall be made available to Duke Energy Carolinas. For the requirements of energized line maintenance or line construction on the **Duke Energy Carolinas Transmission System**, the **Project Sponsor** will ensure that all generation customers served by the **Project** will disconnect their generation upon request by Duke Energy Carolinas.

5.4.3 Disturbance Monitoring

Unique and unanticipated protection problems can result from the changed system configuration due to connection of the **Project**. Duke Energy Carolinas may, at its discretion, install or request the installation of monitoring equipment to identify possible protection scheme problems and to provide power quality measurements of the new configuration. The monitor provides information similar to that of an oscillograph or fault recorder. The availability of current and voltage measurements determines the number of channels for the device. Monitoring equipment may also be installed to aid in the understanding of the electrical phenomena, such as overvoltages and ferro resonance that can be associated with these projects. Remote access to monitored quantities is often accomplished using communication equipment.

5.4.4 Protective System Fault Analysis

All operations of protective devices within the **Project** shall be reviewed and documented. This information shall then be made available to Duke Energy Carolinas on request to assist in analyzing fault operations on the **Duke Energy Carolinas Transmission System**. To facilitate the analysis of system disturbances and the evaluation of system operation, fault recorders may be required on certain types of complex substations. Fault recording functions in microprocessor relays may provide the detail data needed to perform the analysis.

5.5 Maintenance Requirements and Coordination

Duke Energy Carolinas operates and maintains its system to provide reliable customer service while meeting the seasonal and daily peak loads even during equipment outages and disturbances. **Project** integration requires that the equipment at the **Project** not restrict timely outage coordination, automatic switching or equipment maintenance scheduling. Preserving reliable service to all Duke Energy Carolinas customers is essential and may require additional switchgear, equipment redundancy, or bypass capabilities at the **Project** for acceptable operation of the **Duke Energy Carolinas Transmission System**.

The **Project Sponsor** or **Project Operator** shall implement a preventive maintenance program that clearly defines responsibilities and performance objectives for the **Project** equipment. The program shall be designed and executed in a manner to ensure the proper operation of the **Project** equipment. The program may be based on time or on other factors, including performance levels or reliability. Duke Energy Carolinas reserves the right to review the preventive maintenance program for the **Project** prior to start up and throughout the life of the **Project**. Maintenance records of **Project** equipment pertinent to connected operation shall be made available to Duke Energy Carolinas upon request.

Project Operator shall perform the following protective system maintenance on a regular schedule:

- a) Functional testing of trip circuit
- b) Functional testing of interrupter
- c) Calibration testing of protective devices settings
- d) Inspection and maintenance of power DC sources
- e) Inspection and maintenance of interrupters

Metering facilities shall be tested and calibrated if necessary at least every two years. More frequent test intervals may be negotiated. All interested parties or their representatives may witness the calibration tests. Calibration records shall be made available to all interested parties. The accuracy of the standard utilized for calibration purposes shall be traceable to the National Institute of Standards and Technology (NIST).

The maintenance program may be based on time or other factors that may include performance levels or reliability. **Project Sponsor** or **Project Operator** must state how relevant maintenance records and appropriate equipment performance data will be collected and maintained. Maintenance records of the **Project** equipment pertinent to connected operation shall be made available to Duke Energy Carolinas upon request. Duke Energy Carolinas reserves the right to review the preventive maintenance program prior to connection and throughout the life of the **Project**.

Duke Energy Carolinas and **Project Sponsor** or **Operator** shall coordinate maintenance activities associated with equipment at the **Connection Point**. Advanced publication of maintenance schedules will be reviewed and coordinated in such a manner to ensure safety and reliability. Maintenance activities must be coordinated with the **Project** and **Energy Control Center (ECC)** to ensure the **Duke Energy Carolinas Transmission System** are not adversely affected.

5.6 Design Review

After the **Project Sponsor** signs and submits an executed **New Delivery Point Data (NDPD) Form** and before construction begins, a **Design Review** shall be conducted to review how the **Project Sponsor** has interpreted and applied all the requirements set forth in the Facility Connection Requirements (FCR) document. Duke Energy Carolinas will first conduct an internal review of the proposed **Project** in order to determine the scope of the review and what documentation the **Project Sponsor** must provide. While a complete review of the **Project** design is not required, Duke Energy Carolinas will determine, based on **Project** parameters and the type and location of the connection, what aspects of the design will be reviewed and approved prior to construction to ensure the safety and reliability of the proposed new load delivery.

The **Design Review** may include drawings, settings, equipment specifications, maintenance practices and/or other items as requested. Special emphasis will be placed on the **Protection Station** and/or protective scheme and settings of equipment that make up the **Interconnection** between the **Project** and Duke Energy Carolinas. At a **Pre-Design Review Meeting**, Duke Energy Carolinas will present to the **Project Sponsor** a list of documents and information required in order to perform the **Design Review**. The **list of documents** should provide information in detail for the following items:

- a) Surge protection
- b) Specification, application and ratings of equipment
- c) Specification and coordination of the **Protection Station**
- d) Requested phase sequence
- e) Evidence that the project equipment will not restrict timely outage coordination, automatic switching or maintenance scheduling
- f) System grounding and safety issues
- g) Insulation coordination
- h) Total fault clearing times (including relay settings)
- i) Reclosing intervals if any
- j) Maintenance programs for certain equipment
- k) Other drawings and specifications deemed important to ensure reliability of the connection

Following receipt of the requested information, Duke Energy Carolinas will perform a **Design Review** of the proposed new load delivery point. During this review, Duke Energy Carolinas will perform a relay coordination study to ensure proper operation of the transmission line protective equipment. The **Project Sponsor** shall provide all requested protective relay drawings, protection settings, setpoint calculation studies, and associated equipment data for protective relays that will detect faults on the **Duke Energy Carolinas Transmission System**.

Any **Project** settings that will not coordinate or will adversely affect the proper operation of the transmission system will need to be adjusted. Adequate protection scheme redundancy shall be considered to ensure local isolation of faults. In addition, protection scheme modifications shall be considered to remove any single points of protection scheme failure identified that could require remote station devices to isolate local faults.

Results of the **Design Review** will be shared with the **Project Sponsor** at an **Design Review Meeting**. Any design and specification related items found not to be acceptable by Duke Energy Carolinas will have to be resolved by the **Project Sponsor** to the satisfaction of Duke Energy Carolinas before the **Project** can continue. Duke Energy Carolinas reserves the right to review all aspects of the **Project** considered important to system reliability, stability and safety.

5.7 Operating Communications and Procedures

After approval of the **Project** design and before connection to the **Duke Energy Carolinas Transmission System**, a set of communication protocols and procedures for operations during normal and abnormal conditions will be developed. The **Project Operator** is responsible for operating its facility in a safe and reliable manner and with full cooperation under the supervision of the **Energy Control Center (ECC)**. The **Project Operator** shall notify the **Energy Control Center (ECC)** before any planned separation from the **Duke Energy Carolinas Transmission System** and as soon as possible after any unplanned shutdown or trip of the facilities. Only under direct supervision of the **Energy Control Center (ECC)** will the **Project Operator** energize any part of the **Duke Energy Carolinas Transmission System**. Listed below are several site-specific requirements that shall be documented:

- a) **Project Operator** will provide a single point of contact for communications with **Energy Control Center (ECC)**.
- b) The designated **Project** single point of contact shall seek approval from the **Energy Control Center (ECC)** before connecting to the transmission system.
- c) Duke Energy Carolinas shall obtain proper clearance from the **Project Operator** before commencing any work on the facility connection equipment.

The above operating requirements and those determined to be applicable in [Section 5.2.3 - Operating and Control Requirements](#) and [Section 5.4 - General Operating Requirements](#) will be documented and discussed with the **Project Sponsor** and/or **Project Operator**. An operating committee with representatives from the **Project** and Duke Energy Carolinas will be formed to meet periodically to discuss these operating procedures and any unusual events.

5.8 Preoperational Testing, Calibrations and Inspections

The **Project Sponsor** and **Project Operator** are responsible for the inspection, testing and calibration of its equipment up to the **Connection Point** consistent with the power purchase, operating, and **Interconnection** agreements. Before the **Project** is energized, Duke Energy Carolinas will conduct an internal review to develop a list of items that will make up a comprehensive pre-operational test plan for the **Project**. The following items will be considered in this internal review:

- a) Specific drawings, specifications, and test records of the **Project** equipment pertinent to the operation of the facility connection
- b) Calibration, inspection, and test reports provided by the **Project Sponsor** or **Project Operator**

Following the internal review, Duke Energy Carolinas will develop a document of pre-operational testing, calibrations and inspections required of the **Project**. These requirements will be reviewed through a pre-op testing, inspections and calibrations external communications with the **Project Sponsor**. Through these communications, the **Project Sponsor** may submit a proposed test plan to Duke Energy Carolinas for consideration. Duke Energy Carolinas will review and approve this proposed test plan or suggest a new test plan for the **Project**. The final test plan will contain all inspections, testing and witnessing required of the **Project**. This plan shall include provisions for testing protective equipment that comply with the **North American Electric Reliability Corporation (NERC)** Reliability Standards.

Duke Energy Carolinas may require additional tests of which the costs are subject to negotiation. The **Project Sponsor** shall make available to Duke Energy Carolinas all drawings, specifications and test records of the **Project** equipment pertinent to connected operation.

Duke Energy Carolinas personnel shall be provided access to the facility for the testing, inspections and witnessing as required in the test plan. All items in the test plan shall be addressed to the satisfaction of Duke Energy Carolinas. If protective system functional testing or other testing requires the **Project** to be connected to the transmission system, the **Energy Control Center (ECC)** must approve this action in advance. Results of this test plan shall be reviewed and approved by Duke Energy Carolinas and the **Project Sponsor**.

Duke Energy Carolinas will issue final approval for connection of the **Project** to the transmission system. All activities must be coordinated with Duke Energy Carolinas' **Energy Control Center (ECC)** to ensure the **Duke Energy Carolinas Transmission System** is not adversely affected.

5.9 Project Completion and As-Built Documentation

Following connection of the **Project** to the transmission system a full set of as-built drawings and documentation shall be sent to Duke Energy Carolinas within 6 months. This as-built information will include final connection equipment specifications and **Connection Point** protective system settings.

5.10 Exceptions

The requirements specified in [Section 5.0, Facility Connection Requirements - Load Delivery Facilities](#) apply to all load deliveries. New contracts should be written to comply with this document. Existing contracts take precedence over these requirements. Existing non-compliant load deliveries must submit a plan and schedule for meeting the requirements. Under rare circumstances the **Project Sponsor/Operator** may be granted an exemption from meeting one or more of the requirements.

6.0 Appendix A - Generation and Transmission Facility Data

1. Company name and contact name
2. Address
3. Phone number, fax number, e-mail address of contact name
4. Effective date of new connection or modification
5. Proposed geographic location and Plot Plan providing orientation of the **Project** on the Site (USGS map)
6. Electrical **Connection Point**
7. Voltage level of Proposed Connection
8. One-line diagram of **Project**
9. Start-up Date
10. Commercial Operation Date
11. Contract Path & Source and Sink for the energy
12. Duration of Contract
13. Expansion Plans
14. Number and Type of Units
15. Plant Start-up Load
16. Fuel Type
17. Total Generation Capability (MW) – Summer and Winter ratings
18. Power Factor
19. Generator Operational Data
 - A. Description of length of time generator is designed to operate in parallel (momentary or long-term)
 - B. Will the generation be actively controlled to prevent reverse power flow at the **Connection Point**?
 - C. Is the intent for the generation to create reverse power flow at the **Connection Point**?
 - D. Peak and Valley load data
20. Inverter Interfaced Distributed Energy Resources (Including PV, Batteries, Fuel Cells, etc.)
 - A. If UL 1741 listed, including active islanding detection, provide certifying documentation
 - B. Inverter Manufacturer and Model Number
21. Generator Data (for each generator)
 - A. Manufacturer
 - B. Base MVA
 - C. Maximum MVA
 - D. Rated MW (Summer & Winter)
 - E. Rated kV
 - F. Rated Power Factor
 - G. % Reactance – Synchronous, Sub-Transient & Transient
 - H. Capability Curve Data
 - I. Auxiliary Load Data
 - J. Dynamic Modeling Data – H, Ra, Xd, Xq, X'd, X'q, X''d, X''q, XI, T'do, T'qo, T''do, T''qo, S(1.0), S(1.2)
 - K. Governor & Excitation System Models – IEEE or PTI format
 - L. Neutral grounding impedance

22. Step-up Transformer Data

- A. Manufacturer
- B. Connection (Delta/Wye)
- C. KVA ratings of all windings
- D. H winding kV
- E. X winding kV
- F. Y winding kV
- G. Transformer neutral load (if wye connected on the high side) in ohms
- H. Impedance (%Z) and load losses (W) @kVA for all tap combinations of H-X, H-Y, & X-Y
- I. No load losses and magnetizing current

23. Other transformer ratings, connections, voltage taps, impedances, and grounding

24. Transmission line voltage, conductor rating, impedance, length

25. Lightning protection designs for transmission lines and stations

26. Special requirements (e.g. sensitive equipment, dual feeds, etc.)

27. Preferred method of connection (ring bus, breaker and a half, etc.)

28. Relay schemes, relay settings, protection equipment, and functional description of each protective element applied

29. Maintenance schedules and procedures

Note: Generation data must be supplied if applicable.

7.0 Appendix B – New Load Delivery Data

1. Company/Member Name
2. Substation/Delivery Name
3. Proposed location of substation
4. Name of adjacent Duke Energy Carolinas facility if known
5. Is land acquisition for proposed site complete
6. Planned in-service date
7. Requested date for completion of Duke Energy Carolinas modifications
8. Initial Load Demand:
 - a) Projected summer peak (MW)
 - b) Projected winter peak (MW)
 - c) Power factor
9. Estimated Load Demand in 10 Years:
 - a) Projected summer peak (MW)
 - b) Projected winter peak (MW)
 - c) Power Factor
10. Source of initial load:
 - a) New load (MW)
 - b) Transferred (MW) from Delivery
11. Special Load Considerations:
 - a) Large motor starting (hp)
 - b) Harmonic/Flicker producing loads
 - c) Converter loads (AC, DC, ASD, UPS Systems, etc.)
12. Amount of interrupted load (kVA)
13. Any generation behind the meter (if yes complete Appendix 1 of **NDPD** Form)
14. Voltages:
 - a) Transmission voltage (kV)
 - b) Delivery Point voltage (kV)
 - c) High voltage side of substation (kV)
 - d) Low voltage side of substation (kV)
15. Transmission Line Connections (if proposed station is not adjacent to a Duke Energy Carolinas transmission line or substation, provide:
 - a) Line length
 - b) Conductor size and type
 - c) Impedance
 - d) Capacity (A)
16. Specification of Customer's Dead-End or Pull-off Structures:
 - a) Maximum design tension (lbs.)
 - b) Pull-off heights (ft.)
 - c) Orientation of structures
17. Metering:
 - a) Meter ownership
 - b) Meter voltage

- c) Location of Delivery Point metering
 - d) For low-side metering, provide transformer test data sheets
 - e) Duke owned metering
 - i. Delivery date for metering cabinet, PTs and CTs
 - ii. Any factors affecting whether high-side or low-side metering is used
 - iii. Does customer desire metering pulses?
 - iv. Type communication used to transmit data from electronic meter
 - v. **Station Service** meter required
18. High-Side Protection
- a) State what equipment will consist of
19. Transformers
- a) Number of transformers
 - b) Voltage rating
 - c) MVA rating
 - d) Any unusual characteristics
20. Regulating Equipment
- a) Voltage regulators
 - i. Voltage rating (kV)
 - ii. Rating (kVA)
 - iii. Regulation (%)
 - a) Automatic Tap Changer
 - i. Voltage rating (kV)
 - ii. Steps (%)
 - a) Capacitor banks
 - i. Number of banks
 - ii. Voltage (kV)
 - iii. Total connected MVAR
 - iv. Control scheme
21. Reactors
- a) Phase reactors:
 - i. Voltage (k)
 - ii. Impedance (ohms)
 - a) Neutral reactors
 - i. Which and impedance (ohms)
22. Relays/Protective Equipment
- a) Relay schemes
 - b) Relay settings
 - c) Other protection equipment
 - d) Lightning protection design
 - e) Functional description of each protective element applied
23. Special Requirements
24. Preferred Connection Configuration
25. Maintenance Schedules and Procedures

- 26. One-line Drawings
- 27. Contact Information
 - a) Name
 - b) Phone
 - c) E-mail
 - d) Fax
- 28. Delivery Points serving large industrial loads must provide data requested in Appendix 1 of the **NDPD** Form

Document Approval Form

issued 3/2/22

Section A: Document identification and type of action [\(Instructions for completing form on page 2\)](#)

Document no.:	TECP-EGR-TRM-00079	Revision no.:	001
Document title:	Duke Energy Carolinas Transmission Systems Facility Connection Requirements		

Applies to: (Select all that apply)

- | | | |
|----------------------------------------------------------------|-----------------------------------------------------|--------------------------------------------------------------------|
| <input type="checkbox"/> Duke Energy | <input type="checkbox"/> Duke Energy Indiana, LLC | <input checked="" type="checkbox"/> Department <u>Transmission</u> |
| <input checked="" type="checkbox"/> Duke Energy Carolinas, LLC | <input type="checkbox"/> Duke Energy Kentucky, Inc. | _____ |
| <input type="checkbox"/> Duke Energy Progress, LLC | <input type="checkbox"/> Duke Energy Ohio, Inc. | <input type="checkbox"/> Other _____ |
| <input type="checkbox"/> Duke Energy Florida, LLC | <input type="checkbox"/> Group _____ | _____ |

Type of action: <input type="checkbox"/> New <input checked="" type="checkbox"/> Revision <input type="checkbox"/> Periodic review completed <input type="checkbox"/> Ownership Change <input type="checkbox"/> Cancellation <input type="checkbox"/> Suspension <input type="checkbox"/> Renumber	Periodic Review cycle: (Default is 2-year) <input type="checkbox"/> 1-Year <input checked="" type="checkbox"/> 2-Year <input type="checkbox"/> 3-Year <input type="checkbox"/> 4-Year <input type="checkbox"/> 5-Year	Compliance Applicability: (required field) <input type="checkbox"/> None <input checked="" type="checkbox"/> NERC <input type="checkbox"/> State Codes/Standards <input type="checkbox"/> FERC Standards of Conduct <input type="checkbox"/> Patriot Act <input type="checkbox"/> Sarbanes-Oxley <input type="checkbox"/> HIPAA <input type="checkbox"/> OSHA _____ <input type="checkbox"/> Other _____	<input type="checkbox"/> Communication plan established <input type="checkbox"/> Impact Reviews completed For Doc. Mgmt staff use only: <input type="checkbox"/> Editorial Change <input checked="" type="checkbox"/> Control element revision Jo Todd 3/2/2022 <small>(does not require approval signature)</small>
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Security Restrictions Required: Yes No If yes, explain _____

Document Collection name(s): (Not Required - A unique grouping of like documents.)

Complete if submitting a form for publication: Yes (Procedure No: _____)
Does the document being submitted for publication have a parent, governing or instructional procedure? No _____
How is the form being submitted for publication to be completed or used? Hard Copy (completed by hand) Fillable PDF

Description of document action or summary of changes:

Control Element Revision performed by document management staff, with concurrence from document owners, against footer to remove proprietary business/copyright statement and replace it with the standard Duke Energy copyright. Updated the revision number and date, captured revision in version history. No changes made to document content.

The ownership and periodic review date do not change with the revision. This action was completed by the document management staff noted above.

Section B: Approval **Who should sign?** see instructions on page 2 [\(Electronic Signature Instructions\)](#)

Author(s)/Writer(s)/Preparer(s) *(signature not required)*:

Bob Pierce

Approval recommended <i>(print name)</i> :	<i>(signature)</i>	Date:
Approval recommended <i>(print name)</i> :	<i>(signature)</i>	Date:
Approval recommended <i>(print name)</i> :	<i>(signature)</i>	Date:
Final Approval <i>(print name)</i> :	<i>(signature)</i>	Date:
Edgar A Bell, III (signature on Rev 000)		

Return signed form as a PDF to TransDocumentMgmt@duke-energy.com.

Keywords: procedures and forms; procedures program; DAF; ADMP-PRO-TRM-00016; document management program
Applies to: Duke Energy - Transmission; Enterprise Operational Excellence; Transmission and Fuels Strategy and Policy

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