Document title

# Facility Connection Requirements

Document number

## EGR-TRMC-00008

Applies to: Transmission Operations and Planning Department – Carolinas

Keywords: engineering; facility connection; planning; load; generation; transmission standards

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# I. INTRODUCTION

NERC Reliability Standard FAC-001 state that Facility Connection Requirements for all facilities involved in the generation, transmission, and use of electricity be documented. All electric industry participants are required to document the facility connection requirements for their system.

Progress Energy Carolinas (PEC) has prepared this document to identify technical requirements for connecting new load deliveries, generation facilities, and control area *Interconnections* to the *Progress Energy Carolinas Transmission System* which typically consists of 115-, 230-, and 500-kV transmission lines and stations. This document is divided into two major sections: 1) Load Delivery Requirements and, 2) Generation and *Interconnection* Requirements. Important terms used in this document are capitalized and italicized (e.g. *Project, Project Sponsor, Connection Point*) and explained in Section II, Definitions. Some projects may have both load and generation on site. These technical requirements are designed to ensure the safe operation, integrity, and reliability of the PEC *System*.

These requirements do not supersede existing contracts. The document may be used to interpret some of the existing contracts where "*Prudent Utility Practice*" applies. The document can also be used in developing future contracts, operating agreements, etc. to specify requirements of individual projects connecting to the PEC *System*. These requirements are applicable to all new connections. Existing installations and modifications to them may be exempted from some requirements on a case by case basis. Furthermore the general practices described here are consistent in content and application to those requirements used by PEC in connecting its own facilities.

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 PEC *System*. It is expected that each new *Project* will adhere to these requirements. Enforcement of these requirements will be covered in the contracts, operating agreements, and/or other legal documents applicable to the specific *Project*.

The *Project Sponsor* submits the proposal for a new *Project*. PEC evaluates these proposals on a case-by-case basis and specific connection requirements are 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. PEC will study any proposed connection to its system using existing and forecasted system data and data supplied by the *Project Sponsor*. In these studies, PEC considers thermal and voltage impacts, short-circuit duties, transient voltages, reactive power requirements, stability requirements, harmonics, safety, operations, maintenance *and Prudent Electric Utility Practices*. PEC will develop connection proposals for review with the *Project Sponsor*.

This document is not intended as a design specification or an instruction manual. Technical requirements stated herein are intended to be consistent with North American Electric Reliability Council (*NERC*) and SERC, Inc. (*SERC*) planning and operating policies, principles, practices, and standards. Compliance with *NERC* Reliability Standards is expected and nothing in this document relieves the *Project Sponsor* of their responsibility for their own compliance. The information presented in this document is subject to change.

## II. DEFINITIONS

Important terms used in this document are capitalized and italicized (e.g. *Project, Project Sponsor, Connection Point*) and defined in this Section. For industry standard definitions of electric industry terminology, please refer to: The New IEEE Standard Dictionary of Electrical and Electronic Terms, IEEE Std 100-1992. For the purposes of this document the following definitions apply:

**Bulk System -** The portion of the PEC System used for transferring large amounts of power and includes all 500-kV lines, 500-kV substations, and 500/230kV transformers.

**PEC –** Refers to Progress Energy Carolinas Incorporated, a corporation organized and existing under the laws of the State of North Carolina with its principal office located at 411 Fayetteville Street, Raleigh, North Carolina.

**PEC ECC** – PEC's A. J. Skaale Energy Control Center located in Raleigh, NC responsible for generator dispatch, transmission system operation, and control area monitoring.

**PEC System -** The integrated electrical transmission facilities owned by Progress Energy Carolinas including primarily 500-kV, 230-kV, and 115-kV lines and stations.

**Connection Agreements-** – Legal document specifying connection/operating details between *PEC* and a *Project Operator* regarding the operation, inspection, testing, calibration, maintenance, and control of equipment .

**Connection Point** - The physical location on the power system of the change of ownership between PEC and the *Project* or *Interconnecting Utility*.

**Connection Review –** The review of a *Project* proposal to connect to the transmission system. This includes all studies required by the Tariff along with verification that all technical requirements in this document are properly addressed.

**High-Side Transformer Breaker –** A circuit breaker that is used in lieu of a circuit switching device with auto-transformers and transformers whose secondary winding voltages are 69 kV or greater.

**Infeed** – Contribution from a positive or zero sequence source, a transformer or generator, to a fault.

**Interconnection** – Transmission system tie point between two control areas.

**Interconnecting Utility -** The utility that owns the transmission or distribution system that connects the *Project* to the PEC *System* at the *Connection Point*.

**NERC** - North American Electric Reliability Council (www.NERC.com)

**NERC Reliability Standards**- Standards approved by FERC or NERC Board of Trustees listed at www.NERC.com.

**Planning Criteria**- Transmission Planning Criteria & Assessment Practices specified in PEC's annual FERC 715 filing.

**NERC Reliability Standards** - NERC Reliability Standards associated planning and engineering.

**Project -** The load delivery, *Interconnection*, or generation facility and all equipment associated with the *Project* up to the *Connection Point* with the PEC *System*. PEC owns none of the facilities that make up the *Project.*

**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** - Facility that satisfies the requirements necessary to provide complete protection for the *Project* immediately beyond the *Connection Point*.

**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.

**SCADA** (Supervisory Control and Data Acquisition) - A system of remote control and telemetry used to monitor and control the transmission system.

**SERC** - SERC, Inc. Corporation (www.SERC1.org), a NERC region (RRO).

**Station Service** - The electric supply for the ancillary equipment used to operate a generating station or substation.

**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.

**Voltage Unbalance -** The percent deviation of one phase rms voltage value from the average of all three phases' rms voltage values.

# III. FACILITY CONNECTION REQUIREMENTS – LOAD DELIVERIES

## A. Scope

The technical requirements contained herein generally apply to all new load deliveries connected to the PEC *System* except those noted in the Introduction. The location of the delivery and the impacts on the PEC *System*, or another utility's system, determine the specific requirements. The *Project* must not degrade the safe operation, integrity, or reliability of the PEC *System*.

- **Applicable Codes, Standards, Criteria and Regulations**

To the extent that the Codes, Standards, Criteria and Regulations are applicable, the *Project* shall be in compliance with those listed in the References section of this document and others that are applicable.

- **Safety, Protection, and Reliability**

PEC, after consultation with the *Project Sponsor* and other relevant parties, shall make the sole and final determination as to whether the PEC *System* is properly protected from any problems that the *Project* might cause before a connection is closed. The *Project Sponsor* is responsible for correcting such problems before connected operation begins.

- **Non- *PEC* Responsibilities**

*Project Sponsors* and *Project Operators* shall comply with *NERC Reliability Standards*. The *Project Sponsor* is responsible for the planning, design, construction, reliability, protection, and safe operation of non-*PEC System*-owned facilities. This may require the *Project* to include a *Protection Station* immediately beyond the *Connection Point*. The design and operation of the *Project* is subject to applicable local, state and federal statutes and regulations.

- **Cost of Connection Reviews**

The *Project Sponsor* requesting *PEC* to perform a *Connection Review* will reimburse *PEC* for its actual costs to perform the study. This includes costs associated with verifying that all technical requirements in this document are properly addressed.

## B. Connection and System Impact Studies and Project Sponsor-Supplied Information

*Project Sponsors* should contact Progress Energy Carolinas as early as possible in the planning process for any potential new or modified load connection to the *PEC System*. The *Project Sponsor* should not make its own assumptions about the final location, voltage, or connection requirements. Certain areas within the *PEC System* can accept only limited amounts of additional load without costly reinforcements. *PEC* may have to add to or modify its transmission system substantially before connecting a new *Project*. A *Connection Review* must be performed to determine the required connection facilities and modifications to accommodate the *Project*. This study may also address the transmission system capability, transient stability, voltage stability, losses, voltage regulation, harmonics, voltage flicker, electromagnetic transients, ferroresonance, metering requirements, protective relaying, substation grounding, and fault duties. The data that the *Project Sponsor* is required to provide to enable the completion of these studies are listed in the *Project Sponsor* Supplied Information section.

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 *PEC 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. The *Project Sponsor* remains responsible for meeting the facility connection requirements before and after connection is made to the *PEC System* regardless of the results of the *Connection Review*.

### 1. *Connection Configuration*

*Projects* may be connected to the *PEC System* by tapping an existing transmission line(s) or by connecting directly into an existing transmission station. In rare instances, a new transmission switching station may be built in the middle of an existing transmission line when the installed *Project* capacity is greater than 75 MVA. Load deliveries for an installed *Project* capacity greater than 75 MVA will be considered on a case-by-case basis. Load deliveries with installed Project capacity 75 MVA or less are usually connected to *PEC System*'s 115-kV and 230-kV transmission systems via a tap line. *PEC System*'s 500-kV transmission system is 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 *PEC System* transmission facilities, the size of the *Project's* load, and other requirements of the *Project*. Feasible option(s) will be considered in the *Connection Review*, with the overall most economic option meeting all requirements being selected.

## 2. *Power Flow*

The *Project* is incorporated into power flow models by *PEC* using the data provided by the *Project Sponsor*. Power flow simulations are performed to determine the impact of the *Project* on the transmission system. The primary intent is to determine if the new load causes any violations of the Planning Criteria or NERC Reliability Standards (collectively, Planning Standards).

### a. Thermal and Voltage Screening

The purpose of this study is 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 Criteria. *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 *PEC System*.

### b. Transfer Capability

The purpose of this study is to ensure that the connection of the *Project* does not reduce the ability of the transmission system to transport power between and among control areas. Joint studies with other utilities may be necessary. Power transfers are simulated on the *PEC System* in various directions to determine how the *Project* affects *PEC's* ability to transfer power across its system and to and from other control areas.

## 3. *Protection*

After studying the possible ways to connect the *Project* to the *PEC System*, the protective requirements will be determined. This will include an impedance model at the *Connection Point* (short-circuit data), protective changes to the transmission system, protective requirements for the delivery and any special protective needs for the *Project*. See the General Requirements and Protection Requirements sections for more details on these requirements.

## 4. *Power Quality and Reliability*

There is a very diverse set of users connected to the *PEC 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 (ASDs) 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. Variations such as *Voltage Unbalance*, voltage flicker, harmonic distortion, transient overvoltages, temporary overvoltages and steady-state voltage regulation can adversely affect customer processes.

The challenge for the transmission owner is to design and operate the transmission system such that it meets the requirements of this diverse set of users. To meet this challenge, *PEC* performs studies to determine the power quality and reliability impacts of any new *Project* on the *PEC System* at the *Connection Point*. The intent of these studies is to ensure that the connection of the *Project* does not compromise the reliability and integrity of the *PEC System*.

The studies performed for each new *Project* may include:

### a. Voltage Unbalance

The purpose of this study is to ensure that the operation of any new *Project* does not create an unacceptable *Voltage Unbalance* condition in excess of the limits provided in the Performance Requirements section.

### b. 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 the Performance Requirements section.

### c. 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 the Performance Requirements section

### d. 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 the Performance Requirements section.

### e. 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 the Performance Requirements section.

### f. 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 the Performance Requirements section.

### g. 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 *PEC* transmission equipment in excess of the limits provided in the General Requirements and Performance Requirements sections.

## 5. *Changes to Project Sponsor-Supplied Information*

If any data previously supplied pursuant to these "connection requirements" change, the *Project Sponsors* or *Project Operator* will notify *PEC* in writing without delay. This notification will include:

1. the time and date at which the change became, or is expected to become, effective
2. if the change is only temporary, an estimate of the time and date at which the data will revert to the previously supplied form.

A request for a change in *Connection Point* to the *PEC System* 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 changed.

*PEC* will request load growth projections to be provided on a regular basis after the initial connection is made. This will require an annual submittal for the *Project* detailing the load projections for each of the next 10 years.

## 6. *Required Project Sponsor-Supplied Information*

Any *Project Sponsor* desiring a new connection or modification of an existing connection must provide the following information:

1. Facility 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 location of *Project*
6. One-line diagram of *Project*
7. Preferred supply voltage
8. Load demand under normal and emergency conditions
9. Power factor
10. Expansion plans (type and size of potential loads)
11. Transmission line voltage, conductor rating, impedance, length, insulation, grounding, etc.
12. Transformer ratings, connections, voltage taps, impedances, and grounding
13. Lightning protection designs for transmission lines and stations
14. Special requirements (e.g. sensitive equipment, dual feeds, etc.)
15. Preferred method of connection (series, automatic high side swapover, etc.)

16. Relay schemes, relay settings, protection equipment
17. Maintenance schedules and procedures

For industrial plants served directly from the *PEC System*, or for load serving entities serving large industrial plants close to the *PEC System*, the following additional information is needed:

1. One-line diagram of plant distribution system and loads
2. Power factor correction capacitors size, connection, and control scheme
3. In-plant switchgear and protective device information
4. Motor loads, size, types, starting frequency, locked rotor amps, and rated voltage
5. Method of motor starting
6. Size, location, and characteristics of single-phase loads
7. Size, location, and characteristics of large fluctuating loads (arc furnaces, welders, etc.)
8. Size, location, and characteristics of harmonic producing loads (variable speed drives, induction furnaces, etc.)
9. Size, method of operation, and location of on-site generation
10. Size, location, and characteristics of power conditioning equipment

## C. General Requirements

### *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 *PEC* Safety Manual, and the *Project Sponsor's* safety requirements.

#### a. Isolation Requirements

The *Project Operator* shall not energize any *PEC* line or equipment unless the *PEC ECC* specifically approves energization. If, for any reason, operation of a protective device separates the *Project* from the *PEC System*, the *Project Operator* will contact the *PEC ECC* before attempting to restore the connection to the *PEC System*.

At the *Connection Point* with the *PEC System*, a disconnect switch shall be provided for the purpose of physically and visibly isolating the *Project* from the *PEC System*. With the consent of *PEC* 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 be accessible by *PEC* and under *PEC ECC* jurisdiction.
- If gang-operated, must be lockable in the open position by *PEC*.
- Must be suitable for safe operation under the conditions of use.
- Would not be operated without advance notice to either party, unless an emergency condition requires that the device be opened to isolate the *Project*.

*PEC* personnel may open the switch:

- If it is necessary for the protection of *PEC* maintenance crew personnel when working on de-energized circuits.
- If the *Project* or *PEC System* equipment presents a hazardous condition.
- If the *Project* or *PEC System* equipment interferes with the operation of the *PEC System*.
- If the *PEC System* interferes with the operation of 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 energization (charging) current. However, a suitable switch for the safety requirements herein described may also be used to provide for other operational purposes.

#### b. 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 *PEC*. For the requirements of energized line maintenance or line construction on the *PEC System*, the *Project Sponsor* will ensure that all cogeneration customers served by the *Project* will disconnect their generation upon request by *PEC*.

### 2. *Connection Point Considerations*

#### a. Protection and Monitoring of the Project

The *Project Sponsor* and/or *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/or *Project Operator* will also be responsible for monitoring the *Project* to illustrate that the *Project* performance criteria are being met. A *Protection Station* at the *Connection Point* is a normal prerequisite for non-PEC entities to meet these requirements when served by a tap line longer than one-half (½) mile. *A High-Side Transformer Breaker* will be required in lieu of a *Protection Station* for a tap line less than ½ mile if transformers used by *Project Sponsor* and/or *Project Operator* are autotransformers, or if the secondary winding voltages are 69 kV or greater.

#### b. General Configurations and Constraints

Integration of *Projects* into the *PEC System* usually falls into one of two categories:

**1)** Connection into a 115-kV substation, with (depending on the bus configuration) the transmission lines terminated into one or more breakers. Switching station buses are single bus, double-bus, or ring bus. Terminations may be into single breaker, double-breaker, or breaker-and-a-half arrangements. *PEC* will own and operate the circuit breakers and related equipment necessary to terminate the connection. Connection at voltages below 115-kV are not usually considered part of the transmission system, even at stations that have voltages of 115-kV or higher.

**2)** Connection at 115-kV or 230-kV by tapping a transmission line. This tap may be as simple as tying hard and fast to the conductor where isolating switches are immediately adjacent in the substation, or may be as complex as requiring a new switching station in the transmission line.

### c. Special Configurations and Constraints

The constraints and considerations described below may substantially affect the costs of a particular integration plan, sometimes making an alternate *Connection Point* for the *Project* more desirable.

#### 1) Connection to the ***Bulk System***

*PEC* 's bulk transmission lines include all 500-kV lines and stations. These *PEC* facilities help form the backbone of the *SERC* bulk transmission system and provide the primary means of serving large geographical areas. A comprehensive study would be required to connect any load to the *Bulk System*. A substation with additional breakers near the *Connection Point* may have to be developed. The cost of this step may make connection to non-*Bulk System* lines more appropriate for most *Projects*.

#### 2) Connection to 115- and 230-kV Lines

Most *Projects* are connected to the *PEC System* with a *Connection Point* at one of these voltages. Some lines have two circuits available from a double-bussed substation arrangement such that several special service arrangements are available at additional cost.

#### 3) Connection to Network Lines

*PEC* will own and operate any equipment in series with a transmission line that is part of the *PEC 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 *PEC*.

#### 4) Multi-Terminal Lines

A multi-terminal line refers to a customer connection that could back feed to a *PEC* transmission line. The source of the back feed 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 *PEC's* ability to protect, operate, dispatch, and maintain the transmission line. The increased complexity of the control and protection schemes affects system stability and reliability. *PEC* determines the feasibility of multi-terminal line connections on a case-by-case basis, often relying on the results of Connection Studies. If such a connection would have an unacceptable impact on the *PEC System*, a substation at the transmission voltage level would need to be developed.

### d. Other Considerations

Below are some of the other issues considered when evaluating *Project* proposals:

#### 1) Equipment

Existing electrical equipment, such as transformers, power circuit breakers, disconnect switches, and line conductors were purchased based on existing and forecast system conditions. However, with the connection of new loads, some equipment may become overloaded and need to be replaced. All equipment purchased by *PEC* and the *Project Sponsor* as part of the *Project* must meet the applicable NESC and all appropriate IEEE standards for equipment testing and application. *PEC* 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*.

#### 2) System Stability and Reliability

The *PEC 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 be required to participate in special protection schemes.

#### 3) Control and Protection

*PEC* coordinates its protective relays and control schemes to provide for 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/or control schemes. This 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. New *Projects* must be compatible with existing protective relay schemes. The *Project* shall not provide a ground source at any voltage level unless specifically approved and coordinated with *PEC*.

#### 4) Protection Stations

A major purpose of the *Protection Station* is to provide the primary protection requirements for the *Project*. *Protection Stations* must provide adequate protection to all of the *Project* facilities as stated in the Protection Requirements section without relying on any *PEC System* protective devices to provide primary protection beyond the *Connection Point*. The other purposes of the *Protection Station* include preventing *PEC System* facilities from being interrupted for faults within the *Project*, controlling reclosing practices when testing lines, monitoring equipment for Performance Requirements, and metering requirements. The Sponsor will be held responsible for its design, construction, testing, maintenance, operation, and all associated costs with these activities.

*PEC* reserves the right to review and set forth requirements for the specification and coordination of the *Protection Station*. These stations must be designed such that the *Project Operator* and *PEC* can have access to and control of the station. An agreement will be developed to allow *PEC* to operate and control this station under certain specified conditions. *PEC* may modify the reclosing requirements after connection is made if the *Project* fails to meet any of the provisions in the Performance Requirements section of this document. *PEC* may also require a dedicated set of current transformers to be used by *PEC* to monitor and control the *Protection Station* if any of the provisions in the Performance Requirements are not met.

*PEC* reserves the right to require protective stations at any *Connection Point* before or after initial connection is made to the *PEC System*. *PEC* may install its own *Protection Station*, at the *Project Sponsor's* expense, if the provisions in the General Requirements and Performance Requirements sections are violated on a regular basis.

### 5) Phase Orientation

It is important that the *Project Sponsor* and *Project Operator* understand phase sequencing and coordinate with *PEC* before connection is made to ensure intended phase rotation is achieved. *PEC* cannot guarantee a requested phase sequence connection until each connection request is reviewed in detail. *PEC* will not typically "roll phases" at the *Connection Point* for a *Project* unless *PEC* did not provide adequate or accurate information regarding the phase sequence to be provided at the *Connection Point*.

### 6) Outage Coordination & Maintenance

*PEC* 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 *PEC System* customers is essential and may require additional switchgear, equipment redundancy, or bypass capabilities at the *Project* for acceptable operation of the *PEC System*.

### 7) Atmospheric & Seismic

The effects resulting from wind 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 NESC. Depending on *Project* location, size, type, and importance, *PEC* may request that additional capabilities be designed into the *Project*. Lightning is one of the most predominant causes of transmission line outages in the *PEC System* service area and can be mitigated with proper design 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 requirements for the *Project*.

**8) High-Side Transformer Breaker**

A major purpose of the *High-Side Transformer Breaker* is to provide the primary protection requirements for the *Project* if the tap line is less than ½ mile and if the *Project* use autotransformers or transformers with secondary winding voltages 69 kV or greater. *High-Side Transformer Breakers* must provide adequate protection to all of the *Project* facilities as stated in the Protection Requirements section without relying on any *PEC System* protective devices to provide primary protection beyond the *Connection Point*. The other purposes of the *High-Side Transformer Breaker* include preventing *PEC System* facilities from being interrupted for faults within the *Project*, controlling reclosing practices when testing lines, monitoring equipment for Performance Requirements, and metering requirements. The Sponsor will be held responsible for its design, construction, testing, maintenance, and operation.

*PEC* reserves the right to review and set forth requirements for the specification and coordination of the *High-Side Transformer Breaker*. The design characteristics of these breakers must be such that the *Project Operator* and *PEC* can have access to and control of the breakers. An agreement will be developed to allow *PEC* to operate and control this breaker under certain specified conditions. *PEC* may modify the reclosing requirements after connection is made if the *Project* fails to meet any of the provisions in the Performance Requirements section of this document. *PEC* may also require a dedicated set of current transformers to be used by *PEC* to monitor and control the *High-Side Transformer Breaker* if any of the provisions in the Performance Requirements are not met.

*PEC* reserves the right to require *a High-Side Transformer Breaker* at any *Connection Point* before or after initial connection is made to the *PEC System*. *PEC* may install its own *High-Side Transformer Breaker in the tap line*, at the *Project Sponsor's* expense, if the provisions in the General Requirements and Performance Requirements sections are violated on a regular basis.

### 3. *Substation Grounding*

Each generation site and/or connecting substation must have a ground grid that solidly grounds all metallic structures and other non-energized metallic equipment. This grid shall limit the ground potential gradients 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 another substation, it is recommended that the two ground grids be connected. The interconnecting cables must have sufficient capacity to handle fault currents and control ground grid voltage rises. *PEC* must approve any connection to a *PEC* 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. Cable shields, cable sheaths, station service ground sheaths, and overhead transmission shield wires can all inadvertently connect ground grids. Fiber-optic cables are excellent choices 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* must demonstrate that the ground grids are properly isolated and in compliance with all applicable codes and standards.

The Project ground grid should be designed to ANSI/IEEE Std. 80-1986, IEEE Guide for Safety in AC Substation Grounding, and should be measured in accordance with IEEE - 81 Part 1: Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Potentials and Part 2: Measurement of Impedance and Safety Characteristics of Large, Extended or Interconnected Grounding Systems. Project grounding requirements shall also comply with the NESC, ANSI/IEEE - 665 Guide for Generating Station Grounding, IEEE - 837 Standard for Qualifying Permanent Connections Used in Substation Grounding, IEEE - 487 Protection of Wire-Line Communication Serving Electric Power Stations, ANSI/IEEE 367-1987 IEEE Recommended Practice for Determining the Electric Power Station Ground Potential Rise and Induced Voltage from a Power Fault, and any applicable state and local codes.

### 4. *Insulation Coordination*

Power system equipment is designed to withstand voltage stresses associated with expected operation. In the *Connection Review* the *Project* will be evaluated on how it impacts PEC's equipment insulation coordination. *PEC will* identify if there are additions required to maintain an acceptable level of *PEC System* availability, reliability, equipment insulation margins, and safety.

Voltage stresses such as lightning surges, switching surges, temporary overvoltages, and normal 60Hz voltages may affect equipment duty. Remedies depend on the equipment capability and the type and magnitude of the stress. Below are the requirements that must be met to connect to the *PEC System*. 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. *PEC* expects the *Project's* BIL specifications to be equal to or greater than its own.

### a. Lightning Surges

Lightning is a significant cause of transmission line disturbances in the *PEC System* service area and must be considered during the design and installation of transmission lines and substations. Lightning related causes are not exempt from the requirements in 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 *Project* performance criteria defined in the Performance Requirements section. Techniques used to help control lightning related disturbances 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 *PEC* transmission line that is shielded, the new tap line must also be properly shielded. Connected stations 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 area where 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 considered and protected accordingly so the Performance Requirements are not violated.

### b. Switching Surges

At voltages below 500-kV, modifications to protect the *PEC System* against *Project*-generated switching surges are not anticipated although the *Connection Review* identifies the actual needs. At 500-kV, *PEC* may require that arresters be added at the line terminations of the substations if switching surge studies predict overvoltages that may otherwise cause a flashover at the *Project’s* facilities.

### c. 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 *PEC System* is typically considered *Effectively Grounded* at 115-kV and higher voltages. It is not acceptable for the *Project* to supply any ground source for the transmission system unless specifically approved and coordinated with *PEC*.

A system study may be performed for each *Project* based on the point on the *PEC System* where connection is being made. The *Project Sponsor* will be supplied the system characteristics needed to calculate the temporary overvoltages that need to be considered. *PEC* may review the specification of arresters used.

### d. Normal Operating Voltages

The *PEC System* voltages are normally maintained within the limits specified in the Performance Requirements section 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 the *Project*.

## 5. *Inspection, Testing, Calibration, and Maintenance*

The *Project Sponsor* and *Project Operator* are responsible for the inspection, testing, calibration and maintenance of its equipment, up to the *Connection Point*, consistent with the connection *agreements.*

### a. Pre-energization Inspection and Testing

Before initial *Project* energization, the *Project Sponsor* or *Project Operator* shall develop an Inspection and Test Plan for pre-energization and energization testing. This plan should include provisions for testing protective equipment that comply with the *NERC Reliability Standards*. *PEC* will review and must approve the test plan prior to the test. *PEC* may require additional tests. Responsibility for the costs of these tests is subject to negotiation. The Sponsor shall make available to *PEC* all drawings, specifications, and test records of the *Project* equipment pertinent to connected operation.

### b. Calibration and Maintenance

#### 1) Revenue Metering

Revenue metering shall be tested and calibrated at least every two years. More frequent tests may be negotiated. All interested parties or their representatives may witness the calibration tests. Calibration records shall be made available to all interested parties. Refer to the Metering and Telecommunication Requirements section for further details.

### 2) All other equipment

The *Project Sponsor* or *Project Operator* shall implement a preventive maintenance program 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 should be based on regular maintenance intervals or on other factors, including performance levels or reliability. Appropriate equipment performance data will be collected and maintained by the *Project Sponsor* or *Project Operator*. *PEC* reserves the right to review the preventive maintenance program for the *Project*. Maintenance records of the *Project* equipment pertinent to connected operation shall be made available to *PEC* upon request.

## *6. Normal and Emergency Operations*

Prior to implementation of each project various connection/operating agreements will be necessary, which serve to establish written policy governing agreements on operations and maintenance between *PEC* and the *Project*. Such agreements serve the purpose of ensuring safety for *PEC* and *Project* personnel while maintaining reliability of the bulk electric power system during normal and emergency conditions,

### 1) Responsibilities and Authorization

Agreements will document the responsibilities and authorization of specific representatives from each party who are permitted to operate facilities during both normal and emergency conditions. Agreements will also address the cooperation with the appropriate authorities required to support recovery efforts during emergency conditions which may included switching, VAR support, MW/MVAR adjustments, tripping, startup, implementation of emergency or restoration procedures.

### 2) Notification

Proper notification for preplanned, day-to-day, and emergency operations will be documented. Such communication will be between the designated representatives. This includes clearances, stop-tests, maintenance, transferring load, and communications during emergencies.

### 3) Record Keeping

The *Project* will maintain records necessary to satisfy data requirements specified in the *NERC Reliability Standards*. *PEC* will have access to any data necessary to ensure the *Project* does not degrade reliability of *PEC* customers.

### 4) Maintenance Frequency Schedules

To facilitate coordination of maintenance activities, a multi-year schedule of maintenance for the P*roject* will be provided on an annual basis.

### 5) Load Transfers Between Connection Points

All load transfers by *Project Sponsor* or *Project Operator* between two or more *Connection Points* must be coordinated and approved by *PEC ECC* prior to transfer.

### 7. *Station Service*

Power provided for local use at a substation to operate lighting, heat and auxiliary equipment is termed *Station Service* and will be required at all *Protection Stations*. Appropriate providers of *Station Service* are determined during the *Project* planning process. Generally, the utility with a distribution service in the area will be the preferred provider of *Station Service*. The *Project Sponsor* may need to provide metering for *Station Service* depending on the provider of *Station Service*.

Alternate *Station Service* is a backup source of power used only in emergency situations or during maintenance when primary *Station Service* is not available. Alternate *Station Service* is usually only needed in critical stations.

### 8. *Serviceability*

*PEC* may require that *Project* facilities be maintained without disrupting electric service.

## D. 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 *PEC* 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 1.a, 1.b, and 1.c (below) be 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 monitored. However, if problems are suspected at any time, *PEC* may require the *Project Sponsor* and/or *Project Operator* to demonstrate through monitoring 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 *PEC* a plan to improve and meet the performance criteria. Relay and control requirements may be developed and enforced by *PEC* 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.

### 1. *Project Performance Criteria*

To ensure the reliability and integrity of the bulk power 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

*Projects* that serve primarily distribution load (retail stations, wholesale customers, etc.) must comply with the following power factor requirements measured at, or compensated to, the Point of Delivery:

Peak Periods - The *Project* shall maintain a power factor of 100% to 90% lagging at the point of delivery determined on the basis of the 60-minute metered or computed reactive demand (kVAr) for each hour of the month and the corresponding 60-minute metered or computed kilowatt demand for that hour. In addition, the *Project* shall maintain a power factor of 100% to 95% lagging at each point of delivery, determined on the basis of the 60-minute metered or computed kilowatt demand at the time of *PEC's* monthly transmission system peak and the corresponding 60-minute reactive demand (kVAr) for that hour.

**b. Transmission System Interruptions**

For *Connection Points* at 230kV and below, the *Project* shall not cause an interruption to any portion of the *PEC 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. For *Connection Points* at voltages higher than 230kV, requirements will be determined on a case-by-case basis. 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 230kV 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. For *Connection Points* at voltages higher than 230kV, requirements will be determined on a case-by-case basis. 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. 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. Voltage Flicker**

Voltage fluctuations may be noticeable as visual lighting variations (flicker) and can damage or disrupt the operation of electronic equipment. IEEE recommended Practices and Requirements for Harmonic Control in Electric Power Systems (IEEE Standard 519) provides definitions and limits on acceptable levels of voltage fluctuation. Projects connecting to the *PEC* System shall comply with the limits set by IEEE 519. A *Project* is in violation of the *Project* performance criteria if these requirements are not met.

**e. Harmonic Content/Harmonic Distortion**

IEEE recommended Practices and Requirements for Harmonic Control in Electric Power Systems (IEEE Standard 519) provides definitions and limits on acceptable levels harmonics. Projects connecting to the *PEC* System shall comply with the limits set by IEEE 519. A *Project* is in violation of the *Project* performance criteria if these requirements are not met.

**f. Voltage Unbalance**

The maximum *Voltage Unbalance* any *Project* is allowed to introduce on the *PEC System* at the *Connection Point* is 1%. Any *Voltage Unbalance* condition greater than 1% that has a duration greater than or equal to one minute is in violation of the *Project* performance criteria.

### g. Temporary Overvoltages

The *Project's* may not operate its equipment or system may not be operated 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 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.

### h. 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 conditions resulting from operation of a switching device. Any transient voltage condition caused by the operation of the *Project's* equipment 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.

## 2. *PEC System Characteristics*

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

### a. Frequency

The frequency of the *PEC 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

Voltage for the *Connection Point* shall comply with the criteria specified in *PEC*'s FERC 715 filing. Voltage on the transmission side of transmission-to-distribution substations and at transmission level delivery points at 230 kV and below shall be maintained between 90% and 105% of nominal voltage during normal and contingency conditions. Transmission buses at 500 kV shall be maintained between 100% and 108% of nominal voltage during normal and contingency conditions. Voltages during contingencies shall not vary more than 0.08 per unit from pre-contingency voltage.

### c. Harmonic Voltage Distortion

The maximum harmonic voltage distortion at the *Connection Point* for any transmission voltage level should be consistent with IEEE Standard 519.

### d. Voltage Unbalance

The maximum *Voltage Unbalance* on the *PEC 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 *PEC System*, the maximum may be significantly lower than 180%.

## E. Protection Requirements

This section establishes the minimum design objectives and recommended design philosophy for the protective systems associated with a load delivery from the *PEC System*. A protective system is defined as those components used collectively to detect defective power system elements or conditions of an abnormal or dangerous nature, to initiate the appropriate control circuit action, and to isolate the appropriate system components in order to alleviate or minimize the harmful effect of the abnormality.

In analyzing the relaying practices to meet the broad objectives set forth, consideration must be given to the type of equipment to be protected, e.g., generators, lines, transformers, buses, etc., as well as the importance of the particular equipment to the integrity of the transmission system. Thus, practices may vary for different equipment, and for different applications of the same type of equipment. While it is recognized that the probability of failure should not negate the single contingency principle, the practices adopted may vary, based on judgment and experience as to the development of a workable and practical set of standards. Special local conditions or considerations may necessitate the use of more stringent design criteria and practices.

### *1. Protective Relaying Philosophy*

#### a. Objectives

The basic design objectives of any protective scheme are to

- Insure safety of the general public
- Maintain dynamic stability;
- Prevent or minimize equipment damage;
- Minimize equipment outage time;
- Minimize the system outage area;
- Minimize system voltage disturbances;
- Allow the continuous flow of power within the ratings of equipment on the system.

#### b. Protective System Design Considerations

The philosophy in the implementation of any protection system should be 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: (1) dependable - operate when required, (2) secure - not operate unnecessarily, (3) selective - only the minimum required number of devices should operate, and (4) fast - minimize hazards to personnel and damage to equipment. In addition, backup protection should clear any fault upon failure of the protective equipment in the primary protection system.

### c. Operation

Operation of the *Project* should not adversely affect the *PEC System*. This 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* should not be designed or operated with a ground source at the connected voltage unless specifically approved by *PEC*.

### d. Fault Analysis

All operations of protective devices within the *Project* are to be reviewed and documented. This information will be available to *PEC* on request to assist in analyzing fault operations on the *PEC 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 large unit generating stations connected to the *PEC System*. Fault recording functions in microprocessor relays may provide the detailed data needed to perform the analysis.

### e. System modifications beyond the Connection Point

System protection modifications or additions beyond the *Connection Point* are to be reviewed by *PEC* before changes are made. These changes are defined as changes in interrupters, lines, transformers, protective devices and protective settings. This review is needed to insure proper operation of the power systems and coordination of protective devices.

### f. Maintenance of Equipment

The *Project Operator* will perform protection equipment maintenance on a regular schedule. This is to include the following:

- Functional testing of trip circuit
- Functional testing of interrupter
- Calibration testing of protective devices settings
- Inspection and maintenance of power dc sources
- Inspection and maintenance of interrupter

## 2. *115 or 230-kV Load Delivery (radial load at Connection Point)*

- *PEC* will be responsible for providing protection for the *PEC System*.
- Protection beyond the *Connection Point* is the responsibility of the *Project Sponsor* and/or *Project Operator* and must be coordinated with *PEC System* protective devices.
- The *Project Sponsor* may be required to provide a *Protection Station* or a High-Side Transformer Breaker immediately beyond the *Connection Point* to provide protection for the *Project*.
- Protection will include devices to detect and interrupt all types of faults. This generally will include overcurrent protection for both phase and ground faults and a three phase interrupting device.
- The overcurrent protection should provide both instantaneous tripping for high value faults and time delay (Inverse) tripping for lower value faults.
- 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.

- One time delayed automatic reclose to the *Project* can be performed. Manual testing of the *Project* after a lockout is to be coordinated with *PEC's ECC* before testing the line.
- Fault monitoring/location equipment is recommended at *Protection Stations.*
- Functional testing of protective circuits and interrupting device should be regularly performed.
- All protective device operations at transmission voltages will be analyzed and documented.

### *3. Dual Feeds to Projects, 115-kV, 230-kV and Higher, etc.*

These will be evaluated as needed.  The protection requirements for this type of station vary with the location and type of feeds.

## F. Metering and Telecommunication Requirements

All *Projects* that are connected to the *PEC System* will require metering. This section states the typical requirements for metering and telecommunication associated with a load delivery from the *PEC System*. Specific requirements will be established in the *Project Review.*

### *1. Metering*

Metering equipment should be installed, if possible, at the *Connection Point*. If not installed at the *Connection Point* then power transformer and/or line losses will need to be considered. While detailed metering issues will be addressed in the *Connection Review*, the following information addresses typical metering requirements for new projects planning to connect to the *PEC System*.

#### a. Equipment

1) A single solid state meter shall be installed for each load established. This same meter will provide data to both PEC and the customer.

2) The metering package should be a loss compensated package when metering is installed on the low voltage side of the step down transformer.

3) Meters should be power factor capable to permit monitoring of power factor requirements. Meter package should measure kW demand, kVar demand, kWh, kVar, and leading or lagging.

4) If power flow can be in-to or out-off with respect to the *PEC System,* metering packages shall have separate meter registers for incoming and outgoing MW-Hour and Mvar-Hour. These registers may be included in a single meter as approved by PEC.

#### b. Accuracy

1) All projects that are connected to the PEC 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). Relay-accuracy-metering is not acceptable for metering equipment.

### *2. Supervisory Control and Data Acquisition (SCADA)*

SCADA may be required for *Projects* totaling 100 MVA and larger. SCADA may also be required for *Projects* served entirely or partially from resources outside of the PEC control area.

#### a. SCADA Information

Typical SCADA information that may be required includes:

- Status of isolating devices.
- Load voltage, MW, and Mvars at the *Connection Point*.
- Station transmission line MW and Mvars.

**b. Remote Terminal Units (RTU)**

**1)** RTU will be will be specified by PEC and supplied by the *Project Sponsor*.

**2)** The *Project Sponsor* is responsible for furnishing and installing the equipment necessary to send required data to the *PEC ECC*.

**3)** Protocols will be specified by PEC at the time of the project. Custom protocols may be offered by the *Project Sponsor* and will be considered by PEC.

### *3. Maintenance*

Metering and telemetry equipment (meters, panels, and associated equipment and wiring) shall be maintained by the *Project.*

### *4. Voice Communication*

Requirements, if any, will be determined on a case-by-case basis.

### *5. Telecommunications for SCADA*

If required, the *Project Sponsor* must provide and maintain a compatible and reliable communication media for SCADA to enable *PEC* to interrogate the meter, collect, merge, and store metering and usage data with *PEC*'s remote metering and data acquisition system. This may consist of leased phone lines, microwave channels, or fiber-optics between the *Project* and the *PEC ECC*.

### *6. Telecommunications for Protection Systems*

Most *Projects* connected to the *PEC System* will not require any special communication devices/circuits for protection. A local voice/alarm circuit is recommended when an interrupting device is installed.

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

# IV. FACILITY CONNECTION REQUIREMENTS – GENERATION AND INTERCONNECTION FACILITIES

## A. Scope

The technical requirements contained herein generally apply to all new generation facilities and *Interconnections* to the *PEC System*. The location of the connection and the impacts on the *PEC System*, or another utility's system, determine the specific requirements. The *Project* must not degrade the safe operation, integrity, or reliability of the *PEC System*.

- **Applicable Codes, Standards, Criteria and Regulations**

To the extent that the Codes, Standards, Criteria and Regulations are applicable, the *Project* shall be in compliance with those listed in the References section of this document and others that are applicable.

- **Safety, Protection, and Reliability**

*PEC*, after consultation with the *Project Sponsor* and other relevant parties, shall make the sole and final determination as to whether the *PEC System* is properly protected from any problems that the *Project* might cause before a connection is closed. The *Project Sponsor* is responsible for correcting such problems before connected operation begins.

- **Non-*PEC* Responsibilities**

*Project Sponsors* and *Project Operators* shall comply with *NERC Reliability Standards*. The *Project Sponsor* is responsible for the planning, design, construction, reliability, protection, and safe operation of non-*PEC*-owned facilities. The design and operation of the *Project* is subject to applicable local, state and federal statutes and regulations.

- **Cost of Connection Reviews**

The *Project Sponsor* requesting *PEC* to perform a *Connection Review* will reimburse *PEC* for its actual costs to perform the study. This includes costs associated with verifying that all technical requirements in this document are properly addressed.

## B. Request for Generation and Interconnection Studies

*Project Sponsors* should contact *PEC* as early as possible in the planning process for any potential new/modified utility *Interconnection* or generation connection to the *PEC System*. The *Project Sponsor* should supply information about the location, voltage, and other pertinent connection requirements. Certain areas within the *PEC System* can accept only limited amounts of additional generation without costly reinforcements. *PEC* may have to add to or modify its transmission system substantially before connecting a new *Project*. A *Connection Review* must be performed to determine the required connection facilities and modifications to accommodate the *Project*. This study may also address the transmission system capability, transient stability, voltage stability, losses, voltage regulation, harmonics, voltage flicker, electromagnetic transients, ferroresonance, metering requirements, protective relaying, substation grounding, and fault duties. The data that the *Project Sponsor* is required to provide to enable the completion of these studies are listed in the *Project Sponsor* Supplied Information section.

Proposals for *Interconnection* with other control areas will require a *Connection Review*. The new *Interconnection* would require development of a new, or modification of an existing interchange or *Interconnection* agreement. In addition to the technical aspects of the new *Interconnection*, a business case would have to be developed to examine the economics of the proposal.

Generator Interconnection Requests should be submitted as described by CP&L's OATT. Official instruction is provided via CP&L's OASIS web page.

### 1. Connection Configuration

*Projects* may be connected to the *PEC System*, typically at 115-kV or 230-kV, by tapping an existing transmission line(s) or by connecting directly into an existing transmission station. A new transmission switching station may be built in the middle of an existing transmission line. *PEC*'s 500-kV transmission system is typically reserved for the bulk transport of large amounts of electricity. New *Interconnections* between control areas should have overall facility ratings greater than the rating of the associated transmission lines.

The number of available connection options is dependent upon many factors, including location of the desired *Connection Point* relative to existing *PEC* transmission facilities, the size of the *Project's* generation, present transmission line loading, 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.

### 2. Power Flow

The *Project* is incorporated into power flow models by *PEC* using the data provided by the *Project Sponsor*. Power flow simulations are performed to determine the impact of the *Project* on the transmission system. The primary intent is to determine if the new load causes any violations of the *PEC* Transmission Planning Criteria & Assessment Practices (Planning Criteria), which are part of *PEC*'s annual FERC 715 filing, or *NERC Reliability Standards*.

### a. Thermal and Voltage Screening

The purpose of this study is to ensure that the connection of the *Project* does not create any thermal loading or voltage levels outside of the limits provided in the Planning Criteria. *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 *PEC System*.

### b. Transfer Capability

The purpose of this study is to ensure that the connection of the *Project* does not reduce the ability of the transmission system to transport power between and among control areas. Joint studies with other utilities may be necessary. Power transfers are simulated on the *PEC System* in various directions to determine how the *Project* affects *PEC*'s ability to transfer power across its system and to and from other control areas.

### c. Fault Duty

The purpose of this study is to determine the changes in available fault duty caused by the *Project*. Transformer, line and generator impedances, and the circuit configuration are needed to create the model for the study. The data is inserted into the current *PEC* model. The study results are reviewed to ensure that no equipment ratings will be exceeded.

### d. Stability

Dynamics software is used to evaluate the impact of the new system configuration and additional generating capacity on system stability. In addition to the normal steady state model data, generator impedances and time constants, turbine governor data, and voltage regulator data are needed to create a model for the study. Study results are evaluated to ensure system stability will be maintained and that any necessary changes to relaying or controls are identified. See the General Requirements section for more detail on generator controls.

## 3. *Protection*

After studying the possible ways to connect the *Project* to the *PEC System*, the protective requirements will be determined. This may include an impedance model at the *Connection Point* (short-circuit data), protective changes to the transmission system, protective requirements for the generation and any special protective needs for the *Project*. See the General Requirements and Protection Requirements sections for more details on these requirements.

## *4. Power Quality and Reliability*

There is a very diverse set of users connected to the *PEC 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 (ASDs) 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 than may constitute inadequate service for the proper operation of customer equipment. Variations such as *Voltage Unbalance*, voltage flicker, harmonic distortion, transient overvoltages, temporary overvoltages and steady-state voltage regulation can adversely affect customer processes

The challenge for the transmission owner is to design and operate the transmission system such that it meets the requirements of this diverse set of users. To meet this challenge, *PEC* may perform studies to determine the power quality and reliability impacts of any new *Project* on the *PEC System* at the *Connection Point*. The intent of these studies is to ensure that the connection of the *Project* does not compromise or reduce the reliability and integrity of the *PEC System*.

The studies performed for each new *Project* may include:

### a. Voltage Unbalance

The purpose of this study is to ensure that the operation of any new *Project* does not create an unacceptable *Voltage Unbalance* condition in excess of the limits provided in the Performance Requirements section.

### b. 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 the Performance Requirements section.

### c. 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 the Performance Requirements section

### d. 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 the Performance Requirements section.

### e. 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 the Performance Requirements section.

#### f. 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 the Performance Requirements section.

#### g. 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 *PEC System*-owned transmission equipment in excess of the limits provided in the General Requirements and Performance Requirements sections.

### *5. Changes to Project Sponsor-Supplied Information*

If any data previously supplied pursuant to these connection requirements changes, the *Project Sponsor* or *Project Operator* will notify *PEC* in writing without delay. This notification will include:

1. the time and date at which the change became, or is expected to become, effective and
2. if the change is only temporary, an estimate of the time and date at which the data will revert to the previously supplied form.

A request for a change in *Connection Point* to the *PEC System*, level of generation, or expected sink 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 changed.

### *6. Required Project Sponsor-Supplied Information*

Any *Project Sponsor* desiring a new connection or modification of an existing connection must provide the following applicable information:

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 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, Xl, T'do, T'qo, T"do, T"qo, S(1.0), S(1.2)
    K. Governor & Excitation System Models – IEEE or PTI format

20. 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

21. Other transformer ratings, connections, voltage taps, impedances, and grounding
22. Transmission line voltage, conductor rating, impedance, and length
23. Lightning protection designs for transmission lines and stations
24. Special requirements (e.g. sensitive equipment, dual feeds, etc.)
25. Preferred method of connection (ring bus, breaker and a half, etc.)
26. Relay schemes, relay settings, protection equipment
27. Maintenance schedules and procedures

## C. General Requirements

### 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, NESC, the *PEC* Health & Safety Manual, and the *Project Sponsor's* safety requirements.

#### a. Isolation Requirements

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

At the *Connection Point* with the *PEC System*, a disconnect switch shall be provided for the purpose of physically and visibly isolating the *Project* from the *PEC System*. With the consent of *PEC* 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 be accessible by *PEC* and under *PEC ECC* jurisdiction.
- If gang-operated, must be lockable in the open position by *PEC*.
- Must be suitable for safe operation under the conditions of use.
- Would not be operated without advance notice to either party, unless an emergency condition requires that the device be opened to isolate the *Project*.

*PEC* personnel may open the switch:

- If it is necessary for the protection of *PEC* maintenance personnel when working on de-energized circuits.
- If the *Project* or *PEC System* equipment presents a hazardous condition.
- If the *Project* or *PEC System* equipment interferes with the operation of the *PEC System*.
- If the *PEC System* interferes with the operation of 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 energization (charging) current. However, a suitable switch for the safety requirements herein described may also be used to provide for other operational purposes.

#### b. 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 *PEC*. For the requirements of energized line maintenance or line construction on the *PEC System*, the *Project Sponsor* will ensure that all cogeneration customers served by the *Project* will disconnect their generation upon request by *PEC*.

## 2. *Point of Interconnection Considerations*

### a. General Configurations and Constraints

Integration of connecting generation projects into power systems usually fall into one of the following three categories:

**1)** Connection into a 115-kV substation, with (depending on the bus configuration) the transmission lines terminated into one or more breakers. Switching station buses are either single bus, double-bus, or ring bus. Terminations are either into single breaker, double-breaker, or breaker-and-a-half arrangements. *PEC* will own and operate the circuit breakers and related equipment necessary to terminate the connection. Connection at voltages below 115-kV are not usually considered part of the transmission system, even at stations that have voltages of 115-kV or higher.

**2)** Connection on the low-voltage side (typically 23 kV) of a new or existing customer service transformer that was originally designed to serve load. The requirements for generator connections to *PEC* at voltages of 23-kV and less are contained in the document "Protection Guidelines for Parallel Generation on *PEC* Distribution Circuits". The *Project Sponsor* must follow *PEC* facility connection requirements for serving load if applicable.

**3)** Connection at 115 kV or 230-kV to a transmission line by building a new switching station in the vicinity of the *Project*.

### b. Other Considerations

Below are some of the other issues considered when evaluating *Project* proposals:

#### 1) Equipment

Existing electrical equipment, such as transformers, power circuit breakers, disconnect switches, arresters, and line conductors were purchased 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 or large loads, some equipment may become overloaded and need to be replaced.

#### 2) Dispatching & Maintenance

*PEC* 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 Point of Connection not restrict timely outage coordination, automatic switching or equipment maintenance scheduling. Preserving reliable service to all *PEC* customers is essential and may require additional switchgear, equipment redundancy, or bypass capabilities at the Point of Connection for acceptable operation of the system.

### 3) Atmospheric & Seismic

The effects resulting from wind 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 federal, state, and local standards are met, including, but not limited to, the Uniform Building Code (UBC) and the NESC. Depending on Project location, size, type, and importance, *PEC* may request that additional capabilities be designed into the Project.

## 3. *Substation Grounding*

Each generation site and/or interconnecting substation must have a ground grid that solidly grounds all metallic structures and other non-energized metallic equipment. This grid shall limit the ground potential gradients 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 another substation, it is recommended that the two ground grids be connected. The interconnecting cables must have sufficient capacity to handle fault currents and control ground grid voltage rises. *PEC* must approve any connection to a *PEC* 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. Cable shields, cable sheaths, station service ground sheaths, and overhead transmission shield wires can all inadvertently connect ground grids. Fiber-optic cables 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* must demonstrate that the ground grids are properly isolated and in compliance with all applicable codes and standards.

The Project ground grid should be designed to ANSI/IEEE Std. 80-1986, IEEE Guide for Safety in AC Substation Grounding, and should be measured in accordance with IEEE - 81 Part 1: Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Potentials and Part 2: Measurement of Impedance and Safety Characteristics of Large, Extended or Interconnected Grounding Systems. Project grounding requirements shall also comply with the NESC, ANSI/IEEE - 665 Guide for Generating Station Grounding, IEEE - 837 Standard for Qualifying Permanent Connections Used in Substation Grounding, IEEE - 487 Protection of Wire-Line Communication Serving Electric Power Stations, ANSI/IEEE 367-1987 IEEE Recommended Practice for Determining the Electric Power Station Ground Potential Rise and Induced Voltage from a Power Fault, and any applicable state and local codes.

### *4. Insulation Coordination*

Power system equipment is designed to withstand voltage stresses associated with expected operation. Connection Studies include the evaluation of the impact of the *Project* on equipment insulation coordination. *PEC* identifies additions required to maintain an acceptable level of *PEC System* availability, reliability, equipment insulation margins, and safety. Voltage stresses such as lightning surges, switching surges, temporary overvoltages, and normal 60Hz voltages may affect equipment duty. Remedies depend on the equipment capability and the type and magnitude of the stress. Below are the requirements that must be met to connect to the *PEC System*. 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. *PEC* expects the *Project's* BIL specifications to be equal to or greater its own.

#### a. Lightning Surges

Lightning 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 *PEC* transmission line that is shielded, the new tap line must be properly shielded. Connected stations also must be shielded from direct lightning strokes. The *Project Sponsor* must be able to demonstrate that proposed designs for any transmission lines and substations will perform within the limits for service interruptions.

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 where 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 considered and protected accordingly so the Performance Requirements are not violated.

### b. *Switching Surges*

At voltages below 500-kV, modifications to protect the *PEC System* against *Project*-generated switching surges are not anticipated although the *Connection Review* identifies the actual needs. At 500-kV, *PEC* may require that arresters be added at the line terminations of the substations if switching surge studies predict overvoltages that may otherwise cause a flashover at the *Project's* facilities.

### c. 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 *PEC System* is typically considered *Effectively Grounded* at 115 kV and higher voltages.. It is not acceptable for the *Project* to supply any ground source for the transmission system unless specifically approved and coordinated with *PEC*.

A system study may be performed for each *Project* based on the point on the *PEC 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. *PEC* may review the specification of arresters to ensure proper application.

### d. Normal Operating Voltages

The *PEC System* voltages are normally operated within the limits specified in the Performance Requirements section 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. Inspection, Testing, Calibration and Maintenance

The *Project Sponsor* and *Project Operator* are responsible for the inspection, testing, calibration and maintenance of its equipment, up to the *Connection Point*, consistent with connection agreements.

### a. Pre-energization Inspection and Testing

Before initial *Project* energization, the *Project Sponsor* or *Project Operator* shall develop an Inspection and Test Plan for pre-energization and energization testing. This plan should include provisions for testing protective equipment that comply with the *NERC Reliaiblity Standards*. *PEC* will review and must approve the test plan prior to the test. *PEC* may require additional tests. Responsibility for the costs of these tests is subject to negotiation. The *Project Sponsor* shall make available to *PEC* all drawings, specifications, and test records of the *Project* equipment pertinent to interconnected operation.

### b. Calibration and Maintenance

#### 1) Revenue Metering

a) Revenue metering shall be tested and at least every two years. More frequent tests may be negotiated. All interested parties or their representatives may witness the calibration tests. Calibration records shall be made available to all interested parties. Refer to the Metering and Telecommunication Requirements for further details.

#### 2) All other equipment

The *Project Sponsor* or *Project Operator* shall implement a preventive maintenance program 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 should be based on regular maintenance intervals or on other factors, including performance levels or reliability. Appropriate equipment performance data will be collected and maintained by the *Project Sponsor* or *Project Operator*. *PEC* reserves the right to review the *Project's* preventive maintenance program. Maintenance records of the *Project* equipment pertinent to interconnected operation shall be made available to *PEC* upon request.

## *6. Normal and Emergency Operations*

Prior to implementation of each project various connection/operating agreements will be necessary, which serve to establish written policy governing agreements on operations and maintenance between *PEC* and the *Project*. Such agreements serve the purpose of ensuring safety for *PEC* and *Project* personnel while maintaining reliability of the bulk electric power system during normal and emergency conditions,

#### 1) Responsibilities and Authorization

Agreements will document the responsibilities and authorization of specific representatives from each party who are permitted to operate facilities during both normal and emergency conditions. Agreements will also address the cooperation with the appropriate authorities required to support recovery efforts during emergency conditions which may included switching, VAR support, MW/MVAR adjustments, tripping, startup, implementation of emergency or restoration procedures.

#### 2) Notification

Proper notification for preplanned, day-to-day, and emergency operations will be documented. Such communication will be between the designated representatives. This includes clearances, stop-tests, maintenance, transferring load, and communications during emergencies.

#### 3) Record Keeping

The *Project* will maintain records necessary to satisfy data requirements specified in the *NERC Planning & Operating Standards Program*. *PEC* will have access to any data necessary to ensure the *Project* does not degrade reliability of if *PEC* customers.

#### 4) Maintenance Frequency Schedules

To facilitate coordination of maintenance activities, a multi-year schedule of maintenance for the P*roject* will be provided on an annual basis.

### 7. *Station Service*

Power provided for local use at a substation to operate lighting, heat and auxiliary equipment is termed Station Service. Alternate Station Service is a backup source of power, used only in emergency situations or during maintenance when primary Station Service is not available. Alternate Station Service is usually only needed in critical stations. Appropriate providers of Station Service and alternate Station Service are determined during the Project planning process, including Project diagram development and review. Generally, the utility with a distribution service in the area will be the preference provider of primary Station Service unless 1) it is unable to serve the load, or 2) costs to connect to the local utility are prohibitive. The Project Sponsor must provide metering for Station Service and alternate Station Service, as specified by the metering section of this document.

### 8. *Isolating, Synchronizing and Black Starts*

#### a. Isolation

The *Project Sponsor* is responsible for ensuring that proper current-interrupting, isolating equipment is acquired and 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*.

During emergency conditions, the *Project Operator's* primary responsibilities are to ensure safety guidelines are followed and to protect station equipment (see General Guidelines on Safety). The *Project Operator* should have a *PEC* approved set of procedures on file at the *PEC ECC* and at the *Project* that are to be followed when separating from and reconnecting to the transmission system. These procedures, jointly developed by the *Project Operator* and *PEC*, may include: 1) a frequency limit duration table, 2) a circuit breaker operation procedure, 3) a generator loading/circuit protection procedure, and 4) a set of unit operating conditions that should be maintained to prevent damage to the unit(s) and/or the transmission system.

The *Project Operator* should NOT energize any equipment, connect to any energized equipment unless instructed to do so by the *PEC ECC* or parallel any generation to the system unless instructed to do so by the *PEC ECC*. If, for any reason, the *PEC 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 *PEC ECC.*

### b. Synchronization

The *Project Operator* shall be responsible for synchronizing its equipment to the *PEC System*. If the *Project* is a participant in any *PEC* emergency procedures, then the *Project Operator* should follow those procedures in the event of a system emergency. During all other conditions, the generator should have *PEC* approved procedures in place when connecting to the *PEC System*. A synchronizing relay shall be installed to assure that the unit is not connected to the energized power system out of synchronization.

### c. Blackstart

Blackstart is the condition when a unit of a generation *Project* starts up under local power, in isolation from the power system. Blackstart capability is needed in the rare event of a system restoration emergency. Depending on the size and location of a *Project*, this service may be needed from that *Project*. If the *Project* is supplying blackstart capability to the *PEC System*, then it will be a participant in *PEC's* emergency procedures. In the event of a local or widespread 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 *PEC ECC* of its status and await further instruction from the *PEC ECC*.

The Project Sponsor and Project Operator are responsible for complying with the blackstart requirements in the NERC Reliability Standards.

Some issues *PEC* considers when determining whether to request the capability of a *Project* to provide blackstart capability include the following:

- Proximity to other generation (i.e. Can blackstart capability be provided more efficiently from another *Project*?)
- Location of the *Project* on the transmission system (i.e. Is the *Project* near major load centers and far from other generation?)
- Cost of on-site start-up; and
- Periodic testing to ensure personnel training and capability.

### d. Serviceability

*PEC* may impose equipment requirements on the *Project* such that facilities would have to be maintained while electric service is maintained.

## D. Performance Requirements

All *Projects* must be properly designed, constructed, operated, and maintained to avoid degrading the reliability of the *PEC System*. A *Project* must comply with the *Project* performance criteria, listed below; and must be able to operate satisfactorily within the limits defined in the *PEC* 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 1.a and 1.b be 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 monitored. However, if problems are suspected at any time, *PEC* may require the *Project Sponsor* and/or *Project Operator* to demonstrate through monitoring 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 *PEC* a plan to improve and meet the performance criteria. Additional relay and control requirements may be developed and enforced by *PEC* 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.

### 1. *Project Performance Criteria*

To ensure the reliability and integrity of the supply system, all *Projects* must meet the *Project* performance criteria at their respective *Connection Point*. The following section details the *Project* performance criteria.

#### a. Transmission System Outages

The *Project* may not operate its equipment or system in such a manner as to cause an outage of *PEC System* components 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 outage is defined as the electrical isolation of equipment from the electrical system such that it is unable to perform its intended function for the duration of the isolation.

#### b. 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

### c. 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 conditions 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.

### d. 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..

### e. Voltage Fluctuations and Flicker

Voltage fluctuations may be noticeable as visual lighting variations (flicker) and can damage or disrupt the operation of electronic equipment. IEEE recommended Practices and Requirements for Harmonic Control in Electric Power Systems (IEEE Standard 519) provides definitions and limits on acceptable levels of voltage fluctuation. The Project may not operate its equipment or system in such a manner as to cause violations with the limits set by IEEE 519.

### f. Harmonics

IEEE recommended Practices and Requirements for Harmonic Control in Electric Power Systems (IEEE Standard 519) provides definitions and limits on acceptable levels harmonics. Projects connecting to the *PEC* System shall comply with the limits set by IEEE 519.

### g. 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 *PEC* 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 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.

## 2. *PEC System Characteristics*

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

### a. Frequency

The frequency of the *PEC 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

Voltage for the *Connection Point* shall comply with the *Planning Criteria*. Voltage on the transmission side of transmission-to-distribution substations and at transmission level delivery points at 230 kV and below shall be maintained between 90% and 105% of nominal voltage during normal and contingency conditions. Transmission buses at 500 kV shall be maintained between 100% and 108% of nominal voltage during normal and contingency conditions. Voltages during contingencies shall not vary more than 0.08 per unit from pre-contingency voltage.

### c. Harmonic Voltage Distortion

The maximum harmonic voltage distortion at the *Connection Point* for any transmission voltage level should be consistent with IEEE Standard 519

### d. Voltage Unbalance

The maximum *Voltage Unbalance* on the *PEC 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 *PEC System*, the maximum may be significantly lower than 180%.

## 3. *Switchgear*

### a. All Voltage Levels

*PEC*'s facilities ratings methodology was submitted to *SERC* in February 1999 for *NERC Reliability Standards compliance*. Circuit breakers disconnect switches, and all other current carrying equipment connected to *PEC's System* shall comply to that criteria. For *Interconnections,* the equipment shall not become a limiting factor (bottleneck) in the ability to transfer power on the *PEC 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 ANSI/IEEE C37 Standards. These requirements apply to the generation site, the interconnecting substation, the *Connection Point* as well as other locations on the *PEC System*. Minimum fault-interrupting requirements are supplied by *PEC* as part of the coordinating 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. All substation capacitor switching will utilize zero voltage closing breakers on capacitor banks greater than 3600 kvar.

#### b. Circuit Breaker Operating Times

The *Connection Study* (i.e. stability studies) will determine the required circuit breaker operating times of 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, and the protective relay requirements.

#### c. 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 (GSU) transformers from the transmission breakers. The deionization delay on circuit switchers is typically 15 seconds and consequently, these devices usually are not reclosed.

### *4. Excitation System and Power System Stabilizers*

The excitation system shall operate in the automatic-terminal-voltage regulation mode. For planned operation in manual mode, the *Project Operators* shall obtain the approval of the *PEC ECC* in advance. For unplanned, forced operation in manual mode, the *Project Operators* shall notify the *PEC ECC* within one (1) hour of switching to manual mode. Operation in the manual mode for extended periods shall only be permitted when approved by the *PEC ECC*.

All 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, *PEC* 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 a PSS prior to the installation of new or replacement systems.

The latest IEEE Std. 421.4-1990, *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.

The excitation system is critical to overall system performance. Therefore, *PEC* will approve the settings for these systems (gains, time constants, limiters, etc.). *PEC* 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.

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

### 5. *Governor Speed and Frequency Control*

A speed governor system is required on all 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 control 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 (5%) 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 deadbands and other non-linearities).

*Projects* shall have a maintenance and testing program for the governor control systems in compliance with applicable *NERC Reliability Standards*.

### 6. *Voltage Regulation and Reactive Power Requirements*

#### a. *PEC* Transmission System Voltages

*PEC* operates its transmission system within the voltage guidelines in the *Planning Criteria*. *Projects* shall have the capability to operate within the full voltage range at the point of connection so as not to restrict the operational range of the transmission system. The *Project Sponsor* should prepare for compatibility with operation of the *PEC* transmission system with regard to system voltage.

### b. Voltage Schedules and Operation of the Project

Major generators (as determined by *PEC*) are provided voltage schedules by the *PEC 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 *PEC ECC* to meet transmission system requirements. When requested, *Project Operators* shall provide the date, duration and reason for a generator not maintaining the established voltage schedule.

The plant electrical system should be designed so that the units can start up under low system voltage conditions and also operate at maximum lagging reactive power during high system voltage conditions. In the *Project* design phase, the *Project Sponsor* shall demonstrate to *PEC* that the *Project* meets these requirements.

GSU transformers must have taps that cover the whole range of possible transmission system voltages given in the previous section, with less than or equal to 2.5% difference between adjacent taps.

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.

The design of each *Project* should include capability that permits operation over a 'range' of power factors that assists in ensuring that the reliability of the *PEC System* is not degraded. The following describes typical parameters concerning voltage and reactive power requirements. The exact operating requirements for each *Project* will be determined by facility studies and/or operating experience with similar projects. Operating requirements may be impacted based on actual *Project* operating experience, unit characteristics, transformation, interconnected voltage level, system location, future system changes, or stability issues.

#### 1) Synchronous generators and *Projects* with solid-state inverters

Typical *Projects* of this type should be capable to produce or absorb reactive power at the generator terminals within a range of 0.95 leading and 0.90 lagging power factor for steady state conditions to meet voltage schedules. They are also 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 *PEC ECC*.  It is the *Project Sponsor/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.

#### 2) Projects using induction generators

These projects (without solid-state inverters) are usually not required to participate in voltage regulation; however they must not adversely affect voltage schedules.  The facility studies will determine the actual reactive power capability that will be necessary to insure that voltage schedules are maintained.

### c. Reactive Power and Voltage Regulator Requirements

#### 1) Synchronous generators and *Projects* with solid state inverters

Each *Project* of this type must also have a voltage regulator capable of maintaining stable voltage at the generator terminal. The operating range must be compatible with the +/- 5.0% range for the generator. The typical generator continuous reactive capability, at the generator terminals, 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 Standard. C57.116, *IEEE Guide for Transformers Directly Connected to Generators*, should be consulted when specifying the step-up transformer turns ratio, impedance, etc.

Projects shall have a testing program to verify the gross and net reactive power capability in compliance with applicable *Planning Standards*.

#### 2) *Projects* using induction generators

These *Projects* (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 *PEC* or another utility.  *PEC* determines the acceptable locations for 'equivalent' reactive using facility studies.

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. *PEC* will coordinate the control methods and set points for switching these capacitors with voltage schedules in the area.

### *7. Voltage and Frequency Operation During Disturbances*

Power system disturbances initiated by faults, forced equipment outages, and so on, 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 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, should be taken into account in the relay-setting delays determined in the *Connection Study.*

To avoid voltage collapse within the *PEC 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 *PEC* undervoltage load shedding program.

For those generators connected to *PEC* 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 to this line isolated from the power system. Delayed fault clearing, overvoltages, ferroresonance, extended undervoltages, etc. can result from this ‘local island’ condition and are therefore not allowed to persist on *PEC* transmission facilities. For protection, special relaying and settings may be required to disconnect the generator(s) in the ‘local island.’ (See also Protection Requirements section.)

## E. Protection Requirements

This section establishes the minimum design objectives and recommended design philosophy for the protective systems associated with a generator connection to the *PEC System*. A protective system is defined as those components used collectively to detect defective power system elements or conditions of an abnormal or dangerous nature, to initiate the appropriate control circuit action, and to isolate the appropriate system components in order to alleviate or minimize the harmful effect of the abnormality.

In analyzing the relaying practices to meet the broad objectives set forth, consideration must be given to the type of equipment to be protected, e.g., generators, lines, transformers, buses, etc., as well as the importance of the particular equipment to the integrity of the transmission system. Thus, practices may vary for different equipment, and for different applications of the same type of equipment. While it is recognized that the probability of failure should not negate the single contingency principle, the practices adopted may vary, based on judgment and experience as to the development of a workable and practical set of standards. Special local conditions or considerations may necessitate the use of more stringent design criteria and practices.

The following is intended to achieve the following objectives:

1. Insure safety of the general public, *PEC* personnel, and *Project* personnel.
2. Maintain dynamic stability.
3. Prevent or minimize equipment damage.
4. Minimize system voltage disturbances.
5. Minimize adverse operating conditions on the *PEC System* and to *PEC*'s customers.
6. Permit the *Project Sponsor* to operate the *Project* in parallel with the *PEC* System in a safe and efficient manner.

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 *PEC System*. Protective equipment requirements depend on a number of issues. Significant issues that could affect these requirements include:

- The configuration of the *Project* (See Section on Connection Configuration)
- The *Connection Point* to the power system.
- The level of existing service and protection to adjacent facilities (including those of other *PEC* customers and potentially those of other utilities).

In addition, certain modifications and/or additions to the *PEC System* may be required for *Project* connection. *PEC* will have final approval of the protective devices required by the *Project*. *PEC* will work with the *Project Sponsors* to achieve an installation that meets the *Project Sponsor's* and *PEC*'s system needs.

*PEC* cannot 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 *PEC System* do not cause damage to the *Project* facilities. The sponsor is also expected to provide a proper protective system to ensure the *Project Sponsor's* equipment does not adversely impact the *PEC* transmission system. *Project Sponsor* should follow the IEEE guide for Utility-Consumer connections (IEEE C37.95) and the IEEE guide for AC generator protection (IEEE C37.102-1995).

### 1. Protection Criteria

The protection system must be designed such that the *Project* generating equipment or connection point is automatically isolated for the following situations:

- Internal faults within the *Project*.
- External faults within the power system (as necessary).
- Conditions that indicate abnormal operation, including islanding of the *Project*.

The information below is provided to identify general protection practices as applied to *PEC System* transmission lines and connections thereto. The protection schemes necessary to integrate the *Project* must be consistent with these practices and the equipment used to implement them.

#### a. All voltages

**1)** 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 *PEC* 's existing customers.

**2)** Relays, breakers, etc. are required at the *Connection Point* or the Interconnecting Substation to isolate *PEC* equipment from the *Project* (or the distribution system containing the *Project*) during faults or other system abnormalities.

**3)** The *Project* is to be synchronized to the power system. A synchronizing relay must supervise all closures of the breaker connecting the generator to the power system.

**4)** Any breaker dedicated for the sole purpose of isolating the interconnecting power system or generator shall open all three phases.

**5)** Breaker automatic reclose supervision will be required at the Interconnecting Substation and/or electrically 'adjacent' stations; e.g., hot bus/dead line check, synchronization check, etc.

### b. Voltage Specific Requirements

Some protection requirements will be specific to the voltage and will be determined on a case-by-case basis. The requirements will be compatible with *PEC* practices for the voltage level, capacity, and any other characteristics that may be applicable. Issues to be addressed will be:

- Independent directional line protection
- Separate pilot communication for some relays
- Fault clearing times
- Backup protection systems
- Compatibility with existing *PEC* equipment protection
- Breaker failure systems
- Reclosing requirements based on stability studies.

## 2. *Implications for Project Connection to an Existing Customer Service Substation*

Many generation projects are proposed for integration into utility power systems through a transformer that is designed only to serve loads; e.g., connection at voltages normally at 23 kV or below. The requirements for generator connections at voltages of 23-kV and less are contained in the document "Protection Guidelines for Parallel Generation on *PEC* Distribution Circuits".

Existing facilities may have protection only on the high-voltage side of the transformer; other installations may use a circuit switcher or breaker with relay control. The device and associated relays (if any) at these sites are provided to isolate the *PEC System* from faults within the transformer and act as backup to the customers' (feeder) protective devices. The existing protection at these installations was applied under the assumption that there was not a source from the low-voltage side to feed faults on the transmission system. Responsible and thorough protective relaying strategies are necessary when generation is connected to these sites

Primary and/or backup relays used for detection of faults in the power system may be required at the *Project* as well as the Interconnecting Substation. Usually, changes to existing protection and reclosing schemes are not limited to those at the Interconnecting Substation.

## 3. *Protection Measures*

Under all circumstances, generators *Infeed* current and/or voltage effects to faults within the transmission system. The duration of this *Infeed* varies with generator size, type, and excitation. The magnitude of this *Infeed* depends on the fault type, system configuration, and fault location. Conditions for which relay schemes must operate for are:

- *Infeed* detection to phase and ground faults- Modification to stations previously without *infeed* potential may require directional phase overcurrent detection. Stations may require the addition of grounding banks to detect ground current for proper protection of equipment.

- Islanding- When *PEC* customer loads are being served over the utility's transmission system, where generation is also interconnected, implications of islanding must be addressed to minimize adverse impacts on these loads. The addition of relays may be applied as necessary to protect *PEC* loads from damage (i.e. over/under voltage and over/under frequency protection).
- Synchronizing and reclosing-The *Project* generator(s) shall be synchronized to the power system. The point of synchronism depends on the configuration of the *Project's* connection. All closures of the breaker synchronizing the *Project* generator to the power system must be supervised by a synchronizing relay. The breaker used to synchronize the generator to the power system is usually the dedicated generator breaker.
- Unique problems related to system configuration- If the *Project* includes a synchronous machine and connects to an existing line, automatic reclosing schemes at the remote line breakers may include either time delayed or instantaneous reclosing. The *Project Sponsor* may consider utilization of transfer trip or voltage supervision on instantaneous reclosing.

#### a. Disturbance Monitoring

Unique and unanticipated protection problems can result from the changed system configuration due to connection with the *Project*. *PEC* may, at its discretion, install 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 *PEC System*, the owner of the *Project* will be notified of additional protection requirements. 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 is also installed to aid in the understanding of the electrical phenomena, such as overvoltages and ferroresonance, which can be associated with these *Projects* (*PEC* may use the information acquired to update future editions of this document.). Remote access to monitored quantities is often accomplished using communication equipment.

The Project Sponsor and Project Operator must comply with NERC Reliabiliy Standardsrelated to disturbance monitoring.

### *4. Protective System Coordination*

A relay coordination study will need to be performed to insure proper operation of the generator and/or transmission line equipment. The *Project Sponsor* shall provide all protection settings that will detect faults on the *PEC System* for a coordination study. Any *Project* settings that will not coordinate or adversely affect the proper operation of the transmission will need to be adjusted.

### 5. Protective System Maintenance

The *Project Operator* will perform *Project* equipment maintenance on a regular schedule. This includes but is not limited to the following:

- Functional testing of trip circuits
- Functional testing of interrupters
- Calibration testing of protective device settings
- Inspection and maintenance of power dc sources
- Inspection and maintenance of interrupters

### 6. Protective System Fault Analysis

All operations of protective devices within the *Project* should be reviewed and documented. This information should be available to *PEC* on request to assist in analyzing fault operation on the *PEC 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 *PEC System*. Fault recording functions in microprocessor relays may provide the detail data needed to perform the analysis.

### 7. System modifications beyond the Connection Point

System modifications or additions beyond the *Connection Point* need to be reviewed by *PEC* before changes are made. These changes are defined as changes in interrupters, lines, transformers, protective devices and protective settings. This review is needed to insure proper operation of the power systems and coordination of protective devices.

## F. System Dispatching, Operation, and Control, Power Scheduling, Reserves

### 1. *General*

All *Project Operators* are required to contact the *PEC ECC* prior to starting generation and connecting the generation to the transmission system.  In addition, real-time metering is required to be transmitted via SCADA to the *PEC.*

### 2. *Scheduling*

*Projects* may be required to submit energy schedules to the *PEC ECC* prior to the hour of operation.  This requirement is dependent on the size of the generation output, the service that the *Project* is supplying and the location of the *Project's* point of delivery.  If the *Project* is delivering its output outside the *PEC* Control Area, an hourly schedule may be required.  In addition, transmission reservations and access must be acquired through the *PEC* OASIS in accordance with the *PEC*'s Open Access Transmission Tariff.

### 3. *Load Following*

If *PEC* 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. In order for a *Project* to provide Load Following service to *PEC*, the *Project's* generator output must be remotely controllable under direction of the *PEC ECC* Automatic Generation Control (AGC) in response to system needs.  The Project must provide an interface compatible with PEC's AGC control mechanisms. SCADA Telemetry will be required from the *Project* to the *PEC ECC* to support AGC.

### 4. *Regulation*

In order for a *Project* to provide regulation service to *PEC*, the *Project* must be under the *PEC ECC* AGC system. The *Project* must  operate under the terms and conditions of the contract that will be established for the *Project* to provide Regulation Service. The *Project* must provide an interface compatible with PEC's  AGC control mechanisms. SCADA Telemetry will be required from the *Project* to the *PEC ECC* to support AGC remote control capability of the unit output

### 5. *Reserves*

If *PEC* has entered into a contract for the *Project* to provide operating reserves to the *PEC* Control 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 *PEC ECC* for its use as specified in the agreement.

## G. Metering and Telecommunication Requirements

All *Projects* that are connected to the *PEC System* will require metering. This section states the minimal requirements for metering and telecommunication associated with a generator interconnection to the *PEC System*. Specific requirements will be established in the *Connection Review.*

### 1. *Metering*

Metering equipment should be installed, if possible, at the *Connection Point*. If not installed at the *Connection Point* then power transformer and/or line losses will need to be considered. While detailed metering issues will be addressed in the *Connection Review*, the following information addresses minimal metering requirements for new projects planning to connect to the *PEC System*.

#### a. Equipment

1) A single solid state meter shall be installed for each generator established. This same meter will provide data to both PEC and the customer.

2) The metering package should be a loss compensated package when metering is installed on the low voltage side of the step down transformer.

3) Meters should be power factor capable to permit monitoring of power factor requirements. Meter package should measure MW demand, Mvar demand, MWh, Mvarh , and leading or lagging.

4) Metering packages shall have separate meter registers for incoming and outgoing MWh and Mvarh. These registers may be included in a single meter as approved by PEC.

5) Metering devices are to be provided by *Project Sponsor* and must be fully compatible (approved meter type, communication protocol, and communication media) with PEC's remote metering and data acquisition system.

#### b. Accuracy

1) All projects that are connected to the PEC 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). Relay-accuracy-metering is not acceptable for metering equipment.

## 2. *Supervisory Control, Data Acquisition (SCADA), and Voice Communications*

SCADA is normally required for generating *Projects* totaling 5 MVA and larger. A circuit breaker or circuit switcher will be installed to interconnect the Project with the PEC System. PEC will retain supervisory control over this interconnection device. A supervisory remote terminal unit (RTU) will be installed at each Project and, unless otherwise agreed upon, will be owned by PEC to provide the capability of monitoring and controlling the *Project* interconnection from the *PEC ECC*.

### a. SCADA Information and Control

Typical SCADA information required includes:

- Generator MW and Mvars.
- Status of generator breaker(s).
- Status of generator step-up transformer breaker(s) .
- Voltage, MW, and Mvars at the *Connection Point*.
- Station transmission line MW and Mvars.
- Data for AGC calculations and control (if Load Following or Regulation service).
- Control mechanisms for AGC.

### b. Remote Terminal Units (RTU)

**1)** RTU will be specified by PEC and supplied by the *Project Sponsor*. RTU must be capable of processing the information types identified in above section (a) SCADA Information and Control.

**2)** The *Project Sponsor* is responsible for furnishing and installing the equipment necessary to send required data to the *PEC ECC*.

**3)** RTU communication protocols will be specified by PEC at the time of the project.

### c. SCADA Communications

**1)** *Project Sponsor* shall provide a reliable, dedicated communications circuit consisting of either leased phone line, microwave channel, or fiber-optics to transmit SCADA information from the generating facility site to the *PEC ECC*.

**2)** Switchable backup communications is required to be in place for SCADA.

**3)** Circuits are to operate at 2400 baud, or at other baud rates reasonably specified by *PEC*.

### d. Voice Communications

**1)** *Project Sponsor* shall be responsible for a dedicated Automatic Ring Down (ARD) telephone circuit between the *Project* and the *PEC ECC*. The ARD will be the primary method of communications.

**2)** A backup voice service is required to be in place.

## 3. *Telecommunications for Control & Protection*

Telecommunication channels may be used for Pilot Relay Protection or Direct Transfer Trip if performance of the channel and the equipment meets the Control and Protection requirements of the connection.

Communications for Protection must function at the full performance level before, during, and after any power system fault condition.

### a. Speed of Operation

Throughput operating times of the telecommunications system must not add unnecessary delay to the clearing or operating times of protection or remedial action schemes. The throughput operating times of the telecommunications system is only a portion of total clearing time.

### b. Equipment Compatibility

In order to provide maintainability and operability between the *Project* and the *PEC System*, teleprotection 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 *PEC* facilities. *PEC* prefers the use of terminal equipment that is the current *PEC* standard for the control application. *PEC* will acknowledge 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.

# V. REFERENCES

Occupational Safety and Health Administration (OSHA) standard 29 CFR 1910.269

National Electrical Safety Code (NESC)

*PEC* Health & Safety Manual

Uniform Building Code (UBC)

ANSI/IEEE Std. 80-1986, *IEEE Guide for Safety in AC Substation Grounding*

IEEE - 81 Part 1: *Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Potentials*

IEEE - 81 Part 2: *Measurement of Impedance and Safety Characteristics of Large, Extended or Interconnected Grounding Systems*.

IEEE – 837, *Standard for Qualifying Permanent Connections Used in Substation Grounding*

IEEE – 487, *Protection of Wire-Line Communication Serving Electric Power Stations*

ANSI/IEEE 367-1987, *IEEE Recommended Practice for Determining the Electric Power Station Ground Potential Rise and Induced Voltage from a Power Fault*

North American Electric Reliability Council (*NERC*) *Reliability Standards*

ANSI/IEEE – 665, *Guide for Generating Station Grounding*

IEEE – Std. 421.4-1990, *Guide for Preparation of Excitation System Specifications*

IEEE Std. C57.116, IEEE Guide for Transformers Directly Connected to Generators

IEEE Std. C37, *IEEE Standards for Circuit Breakers, Switchgear, Substations, and Fuses Standards Collection.*

*IEEE - Std. 519, Recommended Practices and Requirements for Harmonic Control in Electric Power Systems*