ISO NEW ENGLAND PLANNING PROCEDURE NO. 5-6

INTERCONNECTION PLANNING PROCEDURE FOR GENERATION AND ELECTIVE TRANSMISSION UPGRADES

EFFECTIVE DATE: March 9, 2018

REFERENCES:

ISO New England Transmission, Markets and Services Tariff (Schedules 22, 23 and 25)

ISO New England Planning Procedure 3 (PP3): Reliability Standards for the New England Area Pool Transmission Facilities

ISO New England Planning Procedure 5-1 (PP5-1): Procedure for Review of Governance Participant's Proposed Plans

ISO New England Planning Procedure 5-3 (PP5-3): Guidelines for Conducting and Evaluating Proposed Plan Application Analyses

ISO New England Planning Procedure 9 (PP9): Major Substation Bus Arrangement Requirements and Guidelines

ISO New England Planning Procedure 10 (PP10): Planning Procedure to Support the Forward Capacity Market

ISO New England Operating Procedure No. 12 – Voltage and Reactive Control

ISO New England Operating Procedure No. 14 – Technical Requirements for Generators, Demand Response Resources, Asset Related Demands and Alternative Technology Regulation Resources

ISO New England Operating Procedure No. 19 – Transmission Operations

ISO New England Transmission Planning Technical Guide

NERC TPL-001, Transmission System Planning and Performance Requirements

NERC FAC-001, Facility Interconnection Requirements

NERC FAC-002, Facility Interconnection Studies

NERC FAC-013, Assessment of Transfer Capability for the Near-term Transmission Planning Horizon

NERC MOD-026, Verification of Models and Data for Generator Excitation Control System or Plant Volt/Var Control Functions

NERC MOD-027, Verification of Models and Data for Turbine/Governor and Load Control or Active Power/Frequency Control Functions

NERC MOD-032, Data for Power System Modeling and Analysis

NERC PRC-024, Generator Frequency and Voltage Protective Relay Settings

NPCC Directory 1, Design and Operation of the Bulk Power System

NPCC Procedure C-33, Procedure for Analysis and Classification of Dynamic Control Systems

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INTERCONNECTION PROCEDURE FOR GENERATION AND ELECTIVE TRANSMISSION UPGRADES

1.0 Introduction

The purpose of this procedure is to describe the scope of Interconnection Studies conducted pursuant to Schedule 22 ("Large Generator Interconnection Procedures" or "LGIP"), Schedule 23 ("Small Generator Interconnection Procedures" or "SGIP") and Schedule 25 ("Elective Transmission Upgrade Interconnection Procedures" or "ETU IP") of Section II of the ISO New England Transmission, Markets and Services Tariff (the "Tariff"). One objective of this document is to provide guidance which ensures that the Network Capability Interconnection Standard ("NCIS") is consistently applied in defining the scope and study assumptions for generator and ETU Interconnection Studies. While not all ETUs are eligible for Network Import Interconnection Service ("NIIS"), all are interconnected in a manner that, at a minimum, meets the requirements of the NCIS. A second objective of this document is also to provide guidance which ensures that the scope and study assumptions for preliminary nonbinding analyses for generators and certain External ETUs that are eligible to request interconnection under the Capacity Capability Interconnection Standard ("CCIS") are consistently applied.

Studies conducted in accordance with this procedure are also used to support applications made pursuant to Section I.3.9 ("Review of Market Participant's Proposed Plans") of the Tariff.[1]

This document (and the relevant documents referenced herein) describes the interconnection requirements and procedures for coordinated studies of new or materially modified existing Generating Facility and ETU interconnections and their impacts on affected system(s) as required by NERC FAC-001, Facility Interconnection Requirements. Those responsible for the reliability of affected system(s) of new or materially modified existing interconnections are notified in accordance with the "coordination with affected systems" provisions of the interconnection procedures.

The studies conducted in accordance with this procedure also serve to meet the requirements of NERC FAC-002, "Facility Interconnection Studies", to demonstrate that the proposed Generating Facility or ETU has been comprehensively studied to identify any reliability impact of the new interconnection, or materially modified existing interconnection, on affected system(s). As described in this document, studies shall include steady-state, short-circuit, dynamics and other studies, as necessary, to evaluate system performance under both normal and contingency conditions and to ensure that the proposed implementation will not cause non-compliance with the applicable NERC Standards including TPL-001, "Transmission System Planning Performance Requirements".

Studies that follow the guidance provided by this document will typically be sufficient to comply with Tariff requirements; however, that does not preclude the possibility that some situations may require additional analyses.

[1] Additional information on the relevant planning procedures is found in Planning Procedures PP5-1 and PP5-3.

1.1 Interconnection Standards

NCIS describes the minimum requirements to interconnect a proposed new Generating Facility in the New England Control Area, to interconnect an Eligible External ETU,[2] to materially change an existing Generating Facility, to materially change an Eligible External ETU, or to increase the capability of an existing Generating Facility or Eligible External ETU.

The NCIS is defined in the LGIP, the SGIP and the ETU IP of the Tariff.

The basic principle underlying the study approach to making the determination of no significant adverse impact is that the energy, incrementally injected by Generating Facilities or injected by virtue of the requested objective associated with an ETU, is allowed to be dispatched in an economic, security-constrained manner provided that there is no significant adverse impact on the reliability of the system, and that the ability to reliably and practicably operate the system is not compromised. Thus, when the new Generating Facility or ETU is added to the system models used in the study, energy injections from other Generating Facilities, external transactions, other interface transfers or ETUs generally may be reduced by an amount not more than the net energy injection associated with the new Generating Facility or ETU, adjusted for changes in system losses caused by the redispatch.

CCIS is defined in the LGIP, SGIP and ETU IP of the Tariff.[3]

1.2 Interconnection Studies

An Interconnection Study is an Interconnection Feasibility Study, an Interconnection System Impact Study, an Optional Interconnection Study or a re-study thereof. The scopes of these studies are described in the LGIP, SGIP and ETU IP of the Tariff. An Interconnection System Impact Study, or a re-study thereof, shall meet all of the requirements of this procedure. When the alternative Interconnection Feasibility study scope is elected, the analysis may consist of a limited subset of the analyses in this procedure, focusing on the issues that are expected to be most significant for the proposed Generating Facility or ETU.

1.3 Elective Transmission Upgrade Interconnection Requests

The approach used in the study of an Interconnection Request for an ETU will differ depending on the type of ETU.

When addition of a specific technology is identified in an ETU Interconnection Request, the study will take into account the type of the facility and the project's performance objective.

When a performance objective associated with a specific Generating Facility(s) is identified in an ETU Interconnection Request, the study will take into account both the generation and the objectives.

[2] External ETUs eligible for NIIS are controllable Merchant Transmission (MTF) or Other Transmission Facility (OTF). In this Planning Procedure, these External ETUs are referred to as "Eligible External ETUs."
[3] The details regarding the conduct of the CCIS test are contained in Planning Procedure PP-10

When a performance objective of increasing transfer capability between points is identified in an ETU Interconnection Request, the study, while meeting the requirements of Section 7 of this procedure, will address what is specified for:

- Transfer points (from/to)
- Transfer capability increase and direction(s) of flow

2.0 Requirements for Interconnection Studies

2.1 General Requirements

The Interconnection Studies of all Interconnection Requests for Generating Facilities and ETUs, conducted in accordance with Sections 3, 4, 5, 6 & 7 of this procedure, shall identify the minimum required upgrades to meet all of the following requirements:

- The proposed Generating Facility or ETU must satisfy the requirements of ISO New England Planning Procedure 3: "Reliability Standards for the New England Area Pool Transmission Facilities" (the "Reliability Standards") and NPCC Directory 1, "Design and Operation of the Bulk Power System" on a regional (i.e., New England Control Area) and sub-regional basis, subject to the conditions analyzed; and shall not compromise the ability of the system to meet NERC TPL-001: "Transmission System Planning Performance Requirements".

- The proposed Generating Facility or ETU must not diminish system transfer capability, whether limited by an individual constrained element or a relevant interface – including those relevant interfaces evaluated in accordance with NERC FAC-013 "Assessment of Transfer Capability for the Near-term Transmission Planning Horizon", below the level of achievable transfers during reasonably stressed conditions[4] and does not diminish the reliability or operating characteristics of the New England Area bulk power supply system and its component systems.

- For a proposed new Generating Facility in an exporting area, or ETU with a terminal in an exporting area, an increase in the transfer capability out of the exporting area is not required to meet this interconnection standard unless the transfer capability needs to be increased to allow the proposed new Generating Facility or ETU to operate at the requested maximum output even after the allowed redispatch described in this procedure.

- The proposed Generating Facility or ETU must not diminish system transfer capability, whether limited by an individual constrained element or a relevant interface, below the level of possible imports into an importing area during reasonably stressed conditions and does not diminish the reliability or operating characteristics of the New England Area bulk power supply system and its component systems.

[4] Reasonably stressed conditions are defined in PP5-3 as "those severe load and generation system conditions which have a reasonable probability of actually occurring." Reference PP5-3 for additional information

- The addition of the proposed Generating Facility or ETU does not create a significant adverse effect on the ISO's or local Transmission Owner's ability to reliably operate and maintain the system. Creation of new constraints, particularly due to stability or dynamic voltage performance, may likely be deemed to be unacceptable, as this compromises the ability to operate the system, especially where the number of existing interfaces cannot be increased due to operating complexity. Creation of operating limitations, particularly those caused by short circuit contribution or equipment with limited voltage ratings are also likely be deemed unacceptable.

2.2 System Configuration

Analyses shall be performed with the existing system facilities and topology, with the addition of all Planned transmission projects (those with approved Proposed Plan Applications under Section I.3.9 of the Tariff) and with all relevant Generating Facilities and ETUs with active Interconnection Requests along with their associated upgrades in the Interconnection Queue ahead of the Generating Facility or ETU under study.[5]

In situations where some of the above projects have later in-service dates than the Generating Facility or ETU under study, the Interconnection Study may need to analyze the topology when the Generating Facility or ETU goes into service and the topology when all of the above projects are planned to be in service. In addition, sensitivity analysis shall be performed as appropriate for proposed transmission facilities that are relevant to the Interconnection Study for the Generating Facility or ETU under study.[6]

2.3 Load Levels

The following load levels may be utilized in Interconnection Studies: [7]

- Peak load: Load shall be at 100% of the projected ("90/10 forecast") peak New England Control Area load for the year the Generating Facility or ETU is projected to be in service

- Intermediate Load: 18,000 MW New England Control Area load

- Light Load: 12,500 MW New England Control Area load

- Minimum Load: 8,000 MW New England Control Area load

2.4 Resources[8]

For steady-state analysis, the maximum output for a Generating Facility shall be its summer Network Resource Capability ("NRC") value, its maximum output at fifty degrees Fahrenheit or higher. For stability analysis, the maximum output for a Generating Facility shall be its winter NRC value, its

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[5] Reference Section 2.1 of the ISO New England Technical Planning Guide for additional information

[6] Reference Sections 2.1.3, 2.1.4 and 2.1.5 of the ISO New England Technical Planning Guide for additional information

[7] Reference Section 2.2 of the ISO New England Technical Planning Guide for additional information

[8] Reference Section 2.3.1 of the ISO New England Technical Planning Guide for additional information on NRC and Section 2.3 for additional information on treatment of different types of resources

maximum output at zero degrees Fahrenheit or higher. For controllable ETUs, steady-state and stability analysis shall be done with the maximum flow (in one direction if unidirectional or in each direction if bidirectional) described in the requested objective.

2.5 Second Contingency Testing

Sufficient steady state and stability N-1-1 testing to assess performance relative to NERC, NPCC and ISO New England criteria shall be performed.[9]

2.6 Data Provision

The LGIP, SGIP and ETU IP specify data submittal requirements for the associated stages of each procedure. Starting with the submission of the Interconnection Request and before the completion of the System Impact Study, resources undergoing the Interconnection Procedures, shall submit all data through the Interconnection Request Tracking Tool (IRTT)[10]. NERC Standard MOD-032[11] requires that dynamic models be provided for Generating Facilities, HVDC lines, and other power electronic devices that are a part of the Bulk Electric System. ISO Operating Procedure OP-14 Section II.A.6 also requires dynamics models for Generating Facilities that are 5 MW or greater in size when ISO New England determines it to be necessary for the ISO to carry out its responsibility to reliably and efficiently operate the power system.

Appendix B describes the usability and acceptability requirements for PSS/E models for use in Interconnection Studies and in accordance with NERC Standard MOD-026 and MOD-027.

Resources undergoing the ISO Interconnection Procedures, shall submit the as-studied data through the Dynamics Data Management System (DDMS)[12] after the System Impact Study results have been accepted by the Interconnection Customer at the System Impact Study Results Meeting.

3.0 Steady-State Analysis

3.1 Steady-State Criteria

Steady-state analyses shall be performed to demonstrate compliance with applicable voltage and thermal loading criteria and shall identify any system upgrades required to satisfy these criteria.

3.2 Steady-State Stresses

Steady-state studies shall be performed with a dispatch of Generating Facilities, with flows on controllable ETUs, and with imports and exports such that it stresses power flows across applicable

[9] Reference Section 3.4 of the ISO New England Technical Planning Guide for additional information
[10] The IRTT system can be accessed from the ISO New England website at: http://www.iso-ne.com/system-planning/transmission-planning/interconnection-request-queue
[11] Refer to ISO New England Compliance Bulletin - MOD-032 – Model Data Requirements and Reporting Procedures for additional information on generator characteristics located at: http://www.iso-ne.com/participate/rules-procedures/nerc-npcc
[12] The DDMS system can be accessed via the SSO/SMD home page by selecting the Dynamic Data Management System application. Instructions will be provided to Interconnection Customers during the interconnection process.

transmission lines or interfaces. A stressed line or interface shall, to the extent reasonable, be at or near their ratings or transfer limits.

A reasonable condition when power flows may not be at or near their transfer limits would exist when the maximum number of fully loaded Generating Facilities and ETUs that may reasonably be expected to be in service does not result in stressed power flows.

3.3 Steady-State Redispatch

The steady-state portion of an Interconnection Study typically includes an analysis of the transmission system without the proposed Generating Facility or ETU (pre-project case) and an analysis of the transmission system with the proposed Generating Facility or ETU in service (post-project case). The change to output of Generating Facilities and external controllable ETUs from the values in a pre-project case to the values in the post-project case is commonly referred as redispatch.

As a result of the addition of the proposed project, the maximum collective change in the output of other generation and changes to the flows of controllable external ETUs (the maximum redispatch) to meet the Reliability Standards must not exceed the capacity of the proposed Generating Facility or ETU, as measured by its intended high limit.

If the request for interconnection involves multiple generating units at a Generating Facility and the applicant for interconnection controls all the existing generating units at that Generating Facility, the applicant for interconnection shall specify the desired maximum output for the Generating Facility in the Interconnection Study Agreement and the design of the interconnection shall be based on this specified maximum output.

In addition, the following restricts the redispatch of Generating Facilities or external ETUs:

- Redispatched Generating Facilities and redispatched ETUs and the new Generating Facility or ETU must be able to be practicably monitored and observed for purposes of system operation and unit commitment (for example a facility monitored and controlled by the System Operator via SCADA).

- Generating Facility and ETU redispatch is not acceptable for limiting system constraints that occur on sub-transmission or lower voltage (less than 100 kV) facilities.

3.4 No Increase in Conditional Dependence

If no existing Generating Facility or ETU is required to be in service to avoid criteria violations for the conditions studied prior to placing the new Generating Facility or ETU in service, no existing Generating Facility or ETU can become required to operate as a condition for acceptable operation of the new Generating Facility or ETU for that study condition. If an existing Generating Facility or ETU is required to be in service to avoid criteria violations for the conditions studied prior to placing the new Generating Facility or ETU in service, the existing Generating Facility or ETU may continue to be modeled as required to avoid criteria violations, but such reliance shall not be increased. Generating Facilities and ETUs that continue to be required to be in service to avoid criteria violations for the conditions studied shall not be reduced, by redispatch in the study, below the level required for system reliability before the addition of the Generating Facility or ETU. Studies must examine relevant stressed existing Generating Facility and

ETU outage conditions in addition to outages or reductions that have been considered as part of Generating Facility and ETU redispatch.

3.5 Post Contingency Resource Adjustments

No Generating Facility or ETU can be manually tripped or manually ramped down to relieve any first contingency facility loading in excess of the more limiting of either the Short Time Emergency Ratings or any other applicable Transmission Owner-specific emergency ratings. Manually ramping down Generating Facilities or ETUs to relieve first contingency overloads within the more limiting of the Short Time Emergency ratings or any other applicable Transmission Owner specific emergency ratings can only be applied to the Generating Facility or ETU under study, provided that the Generating Facility or ETU reduction is acceptable to the ISO. If a reduction in Generating Facility or ETU output is required in the pre-project system in order to relieve overloads the same reduction shall be allowed in the post project case.

3.6 Steady-State Load Levels

Steady-state analysis shall be performed at the following load levels:

- Analysis shall be performed at Peak Load with the Generating Facility or ETU operating at full capability.

- Analysis shall be performed at Intermediate Load with the Generating Facility or ETU operating at full capability in the cases where conditions such as the preservation of transfer capability are a concern.

- Analysis shall be performed at Light Load in cases:

    - When a proposed Generating Facility or ETU cannot start up and reach minimum output within two hours. Other Generating Facilities that may be dispatched at Intermediate Load shall also be assumed to be running, but may also be at minimum output except for units which can reach minimum output within 2 hours. Units that can start up and reach minimum output within 2 hours may be off in the Light Load analysis. Careful consideration of realistic operating conditions needs to be provided when simulating nuclear and hydro (run of river or ponding) facilities.
    - Regardless of the time taken to reach minimum output, analysis shall be performed at Light Load to identify any upgrades that are required to allow the Generating Facility or ETU to operate at the requested output level while no other nearby generating facilities (that would contribute to any identified violations) are operating.

- Analysis shall be performed at Minimum Load in cases where the Generating Facility or ETU, and its Interconnection Facilities and Network Upgrades, add a significant amount of charging current to the system or in areas where there are significant resources without significant voltage control.

4.0 Stability Analysis

4.1 Stability Criteria

Stability analyses shall be performed to demonstrate compliance with applicable criteria and shall identify any system upgrades required to satisfy these criteria.

4.2 Stresses in Stability Analysis

For normal contingency testing, power flows across applicable transmission lines or interfaces shall be at the most limiting of the existing stability or thermal (set using winter transmission equipment ratings, with appropriate margin, for light load testing) transfer limits.[13]

4.3 Stability Analysis Scenarios

Stability analysis shall consider reasonable combinations of all relevant Generating Facilities, ETUs and devices that would be expected to have significant interactions.

The Generating Facility or ETU under study as well as all local and relevant Generating Facilities and ETUs shall be modeled at full capacity. If all Generating Facilities and ETUs cannot be dispatched behind the limiting lines or interface, a reasonable number of combinations may need to be studied.

4.4 Stability Load Levels

Stability analysis shall be performed at the following load levels:

- Analysis shall be performed at Light Load. Appropriate combinations of relevant Generating Facilities and ETUs shall be studied to ensure that stability is maintained for all reasonable conditions.

- Analysis shall be performed at Peak Load when required by the ISO. The emphasis of the stability analyses performed at this load level is to confirm that the response has not significantly changed with the load level. It may also be used to assess changes in damping if the possibility of an oscillatory response is recognized in the light load analyses.

5.0 Short Circuit

Short circuit analyses[14] shall be conducted to demonstrate that short circuit duties will not exceed equipment capability and shall identify any system upgrades required to satisfy this criterion. The short circuit study base case shall include all generation and transmission projects that are proposed for the New England Transmission System and any Affected System and for which a transmission expansion plan has been submitted and approved by the applicable authority and which, in the sole judgment of the System Operator, may have an impact on the Interconnection Request. The base case shall include all generating facilities and ETUs (and with respect to (iii), any identified upgrades) that, on the date the study is commenced: (i) are directly interconnected to the New England Transmission System; (ii) are interconnected to Affected Systems and may have an impact on the Interconnection Request; and (iii)

[13] Note: All units modeled as in service for a particular stability case shall be modeled at their full output, which may result in total transfers greater than the existing thermal transfer limit. More detail on modeling is available in PP5-3.

have a pending higher queued Interconnection Request to interconnect to the New England Transmission System and may have an impact on the Interconnection Request. A Generating Facility that has notified the ISO that it will retire will not be included in short circuit studies for timeframes beyond its retirement date.

6.0 Other Requirements

6.1 Voltage Control and Reactive Power Requirements

Where specified in Schedule 22, 23 or 25, Generating Facilities, ETUs and their associated Interconnection Facilities, that are capable of voltage control, are required to be capable of a composite power delivery at their maximum rated power output (maximum MW) at the Point of Interconnection (or at the high side of the station transformer in the case of a wind generating facility) at both the power factor of 0.95 leading and 0.95 lagging. The Interconnection Study shall verify this capability. System Impact Study testing shall evaluate the compliance of the voltage control capability with the requirements of OP-14. While it shall be identified in the Interconnection Study if the voltage control strategy must be designed with the purpose of maintaining a scheduled voltage at the Point of Interconnection (or some other appropriate point), it shall be acceptable for the resource to dynamically control its terminal voltage under transient conditions, unless the Interconnection Study identifies a reliability issue that requires the resource be capable of controlling voltage at another point, such as the Point of Interconnection.

The power factor evaluation shall be conducted with the new Generating Facility or Eligible ETU modeled at unity terminal voltage and maximum rated power output. The maximum leading and lagging reactive power capabilities at maximum rated power output shall be taken from the associated facility "D-Curve" or similar specification. At both the maximum leading reactive output and at the maximum lagging reactive output, the real and reactive power losses in the step-up transformer(s) and other interconnection facilities, station service real and reactive load, as well any additional reactive contribution provided by project auxiliary reactive devices, shall be calculated. The resulting net real and reactive power at the Point of Interconnection (or the high side of the station transformer in the case of a wind generating facility) shall be required to meet the 0.95 leading and 0.95 lagging dynamic reactive power standards. Generating Facilities that operate in a combined mode (such as combined cycle generation) shall be evaluated on an overall combined basis.

System Impact Study testing shall evaluate the compliance of the voltage ride-through capability with the requirements of NERC PRC-024-1, Generator Frequency and Voltage Protective Relay Settings.

6.2 Governor Control/Frequency Response

System Impact Study testing shall evaluate the compliance of the new Generating Facility frequency response with the droop, deadband and overall response requirements of OP-14. Testing shall include an appropriate frequency changing event such as a large loss of load or generation.

System Impact Study testing shall evaluate the compliance of the frequency ride-through capability with the requirements of NERC PRC-024-1, Generator Frequency and Voltage Protective Relay Settings.

[14] Reference Section 4.3 of the ISO New England Technical Planning Guide for additional information

6.3 NPCC Procedure C-33 Dynamic Control System Classification

System Impact Study testing shall evaluate the classification of Dynamic Control Systems in accordance with NPCC Procedure C-33 Dynamic Control System Testing

6.4 Shaft Torque (Delta P) Testing

Where there is a likelihood of large angular difference across an open transmission line, or of a large change in power flow when closing a transmission line, an Interconnection Study for a Generating Facility shall include determination of the largest change in power (Delta P) that the Generating Facility, and other Generating Facilities in proximity, could experience as the result of reclosing following an N-1 contingency. The value of Delta P shall be included in the Interconnection Study report. The Generating Facility or ETU shall be required to mitigate any unacceptable consequence of increased Delta P which they cause.

6.5 Subsynchronous Resonance and Subsynchronous Torsional Interaction Screening

An Interconnection Study for an HVDC facility or any project that includes a series-connected capacitor in Interconnection Facilities or Network Upgrades shall include screening for the potential of causing subsynchronous stresses on nearby generation. This screening shall examine N-1, N-1-1 and other potential contingent or operating conditions specified by the ISO. The results of this screening shall be included in the Interconnection Study report.

6.6 PSCAD Testing

A wind or inverter-based Generating Facility, an ETU that includes power electronics as part of the facility or a Generating Facility or ETU that includes power electronics as part of Interconnection Facilities or Network Upgrades shall provide a PSCAD model(s) of that equipment. The need for a PSCAD model will be discussed at the Scoping Meeting for non-inverter based technology. Based on the size of the project and its location in the electric system, the ISO will determine if a study of interactions, such as control interactions, with near-by equipment or an evaluation of equipment performance(for example under low short circuit conditions, if applicable to the proposed location) is required as part of the Interconnection Study. The PSCAD study shall examine N-1, N-1-1 and other potential contingent or operating conditions specified by the ISO. Guidance regarding the requirements for PSCAD model submittals and for PSCAD testing is provided in Appendix C.

These PSCAD requirements shall not apply to wind or inverter based Generating Facilities that are not connected to the PTF and that are not subject to the requirements of Schedules 22 or 23 of the OATT, unless ISO New England identifies that the PSCAD requirements are needed to be met by the Generating Facility for reliability reasons.

6.7 Operating Procedure Requirements

An Interconnection Study shall ensure that the Generating Facility or ETU satisfies the relevant equipment design requirements in Operating Procedures OP-12, OP-14 and OP-19.

7.0 Additional Considerations for Studies of ETUs

The appropriate study of an Interconnection Request for an ETU will differ depending on the type and objective of the ETU.

7.1 Eligible External ETUs

The scope of study of Eligible External ETUs is described in Section 2 of this procedure. The analysis of ETUs that have one or more terminals outside of the New England Control Area shall be coordinated with the other Control Area(s). The analysis at the point of injection to the New England transmission system shall be performed similar to the analysis of a Generating Facility connecting at that terminal. The impact of loss of the ETU when it is operating at full output shall be analyzed.

The analysis of a new Eligible External ETU shall include analysis with relevant existing external interfaces modeled with imports and exports at the maximum levels used in planning studies.

7.2 Internal Controllable ETUs

A controllable ETU could be a HVDC line or an AC line with a phase-angle regulator or other control device.

In a manner consistent with other parts of this procedure, the Interconnection Customer shall identify the generator dispatch or dispatches that will be used to provide the energy and/or capacity transmitted by the ETU at each terminal which is drawing power from the transmission system. The analysis shall identify the system upgrades required to maintain the reliability of the sending area in accordance with New England planning standards. This analysis shall be similar to the analysis that would be conducted if a new load was added at the point of withdrawal from the New England system.

The analysis at the point of injection to the transmission system shall be performed similar to the analysis of a Generating Facility connecting at that terminal. The analysis shall identify the system upgrades required to maintain the reliability of the receiving area.

The impact of loss of the ETU when it is operating at full output shall be analyzed.

7.3 Non-controllable ETUs Involving Specified Equipment Additions without Associated Specified Objectives

The analysis of a non-controllable ETU involving specified equipment additions without specified objectives shall be conducted consistent with the analysis of transmission additions pursuant to PP5-3.

7.4 ETUs Involving Specified Objectives

An ETU Interconnection Request may not always specify the equipment that it wishes to install. For example, a request may have the objective to increase the transfer limit across an interface by a certain amount. When an ETU Interconnection Request specifies an objective without specifying facilities, the study shall identify the solution necessary to satisfy the needs identified in the Interconnection Request and shall identify the transmission upgrades required. Section 3.1 of the Elective Transmission Upgrade Interconnection Procedures states that the ISO, at its sole discretion, determines if a proposed objective is appropriate to propose in a single Interconnection Request.

8.0 Preliminary Nonbinding Overlapping Impact Studies

An Interconnection Customer with a Capacity Network Resource Interconnection Service (“CNRIS”) Request or a Capacity Network Import Interconnection Service (“CNIIS”) Request may request that the Feasibility Study or System Impact Study include a preliminary, non-binding, analysis to identify potential upgrades that may be necessary for the Interconnection Customer's Generating Facility or External ETU to qualify for participation in a Forward Capacity Auction ("FCA") under Section III.13 of the Tariff, based on a limited set of assumptions to be specified by the Interconnection Customer.

The preliminary, non-binding analysis shall use the same criteria and assumptions that are prescribed in the analysis of overlapping interconnection impacts in Planning Procedure 10: Planning Procedure to Support the Forward Capacity Market ("PP10"). The starting point for the base case to be used in the preliminary analysis shall be the latest developed base case that has been prepared, pursuant to PP10, for the analysis of New Generating Capacity Resources seeking to participate in an FCA.

The set of additional assumptions that may be specified by the Interconnection Customer are limited to additional transmission projects and/or generation projects with active Interconnection Requests under the L/SGIP that the Interconnection Customer requests to be added to the base case.

To the extent the Interconnection Customer requests a preliminary non-binding analysis of Overlapping Interconnection Impacts under the CCIS, a report shall contain the results of the requested preliminary analysis, along with an identification of potential upgrades that may be necessary for the Interconnection Customer's Generating Facility to qualify for participation in a FCA pursuant to Section III.13 of the Tariff.

An Interconnection Customer with an ETU Interconnection Request may specify as its performance objective a capacity transfer capability increase. As part of the Feasibility Study or the System Impact Study for this Interconnection Request, as requested by the Interconnection Customer; an analysis similar to a preliminary, non-binding analysis shall be performed to verify the increase in capacity capability. In this case, the study shall include all relevant Generating Facilities and ETUs with earlier queue positions and all Planned transmission projects.

9.0 Operational Considerations

As appropriate, the analysis shall include an assessment of the operating constraints of the proposed transmission and generation system without identifying the additional upgrades (beyond those identified pursuant to Section 2 of this procedure) necessary to reduce the operating constraints. The analysis shall determine the estimated magnitude of required redispatch of generation under typical and reasonably stressed conditions. If requested by the ISO, limited operating studies may be required to demonstrate viable operability of the proposed Generating Facility or ETU and provide some indication of the system conditions for which the Generating Facilities or ETU's operation may be restricted. The conditions to be considered in these studies shall be coordinated through the ISO. Examples of studies that may be expected include, but are not limited to:

- Examination of the operation of the proposed transmission or generating facilities over expected or suspected constrained conditions with examination of the limiting performance concern (for example thermal, voltage or stability issues). Hour-to-hour operability or performance over longer periods may be considered. Light, intermediate or peak load levels may be considered. Any increased need for operational oversight of the system, such as resource operating restrictions, atypical switching or the creation of additional procedures under outage conditions shall be noted.

- Determination if the system adjustments required to reliably serve the area of interest within 30 minutes following the first contingency change significantly, or are no longer effective, given the proposed change.

(Note: Extensive operating studies, separate from the Interconnection Studies, may be necessary prior to actual operation.)

10.0 Additional Considerations for Generating Facilities that include Storage

The study of the discharging (i.e. generating) operating condition of a proposed electrical storage facility shall use the same study approach described in this procedure as that used for a Generating Facility. The charging operating condition shall be studied under similar conditions to the conditions used when studying the discharging mode to ensure the charging operating condition does not introduce reliability criteria violations, diminish transfer capability or increase conditional dependence in accordance with the requirements of this Planning Procedure.

Document History[15]

Rev. No.	Date	Reason
Rev 0	RTPC – 4/13/99	
Rev 1	RC – 2/13/01; PC 3/2/01	
Rev 2	Effective 2/1/05	Addition of overlapping impact language to PP to conform with recently approved updates to the ISO Tariff
Rev 3	RC 5/19/09; NPC 6/5/09; ISO-NE 7/7/09	
Rev 4	RC 7/19/10; NPC 8/6/10; ISO-NE 8/10/10	Administrative document changes to conform to Tariff terminology and to add back miscellaneous footnotes that were lost in prior versions.
Rev 5	RC 8/12/14; NPC 9/12/14; ISO-NE 9/15/14	Additions made to describe load level modeling.
Rev 6	RC 07/14/2015 NPC 08/07/2015	Additions made to address Elective Transmission Upgrades and add clarifications. Format updated to be consistent with Operating Procedures
Rev 7	RC 06/09/16 NPC 06/21/16	Additions made to conform with Interconnection Process Improvements filing (February 18, 2016)
Rev 8	RC 02/13/2018 NPC 03/02/2018	Additions to: (i) clarify alignment with other planning procedures, (ii) clarify certain provisions, (iii) clarify compliance with NERC standards, and (iv) clarify certain requirements for inverter-based generators.

[15] This Document History documents action taken on the equivalent NEPOOL Procedure prior to the RTO Operations Date as well as revisions to the ISO New England Procedure subsequent to the RTO Operations Date.

Appendix A – General Transmission System Design Requirements for the Interconnection of New Generating Facilities and ETUs to the Administered Transmission System

All electrical facilities must be designed, built and operated in accordance with applicable NERC, NPCC, ISO New England (including Planning Procedure 9) and the Interconnecting Transmission Owners' standards, guidelines, criteria, or the equivalent. This document describes only the general transmission system design requirements for new Generating Facilities and ETUs to interconnect to the Pool Transmission Facilities (PTF). Additional technical and design requirements related to resource interconnection and operation may also apply.

Point of Interconnection

The following shall be applied to the design of a new Generating Facility (resource) or ETU interconnection:

1. All new Generating Facilities or ETUs shall be connected to the system at a new or existing station on the existing Administered Transmission System.
2. The station shall be designed to provide independent switching of each Generating Facility or ETU interconnection to the system and each transmission line terminating in the station. The intent is to design the interconnection in a manner that does not adversely affect the ability to maintain major components of the transmission system.
3. A ring bus or breaker-and-a-half connection shall be used at the point of Generating Facility or ETU interconnection with the transmission system. Transmission system needs and use may require a breaker-and-a-half arrangement. Alternative interconnection designs to Non-PTF facilities shall be considered where appropriate. Additionally, two circuit breakers placed in series may be required to mitigate the consequences of a stuck breaker that would otherwise result in an unacceptable system performance.
4. Transmission system circuit breakers shall not be used for synchronization of new Generating Facilities.

Interconnection Design – Loss-of-Source

The interconnection shall be designed such that, with all lines initially in service, there is no normal design contingency or common mode transmission system, station, or internal plant failure which could result in a net loss of more than 1,200 MW of resources.

Out of Step Protection

Each PTF connected synchronous generating resource shall be required to have out-of-step protection installed. This protection shall detect an out-of-step condition and trip the Generating Facility to protect the transmission system against adverse impact associated with the Generating Facility losing synchronism with the system. Additionally, the Transmission Owner and/or the ISO may require that supplementary supervisory detection be used in conjunction with the out-of-step protection when necessary to prevent unnecessary and undesirable out-of-step protection operation.

Transmission Circuit Breakers

All new 345 kV and, where identified as necessary, 230 kV and 115 kV, circuit breakers must meet the requirements of Planning Procedure 9.

Appendix B – Requirements of PSS/E Models

All power flow and dynamic models must be made available for use in the version of PSS/E that is in use by ISO New England and must accurately model all of the relevant control modes and characteristics of the equipment, such as:

- All available voltage/reactive power control modes
- Frequency/governor response control modes (which may be provided by a park controller)
- Low voltage ride through characteristics, if applicable
- Low frequency ride-through characteristics, if applicable
- Park controller or group supervisory functionality (e.g. for a wind farm)
- Appropriate aggregate modeling capability (e.g. for a wind farm)
- Charging or pumping mode, if applicable (e.g., for a battery energy storage device or pumped storage hydro Generating Facility)

Standard Dynamics Models
For all Interconnection Studies all models must be standard library models in PSS/E or applicable applications. User-models will not be accepted.

User-Written Dynamics Models
A user written model is any model that is not a standard Siemens PSS/E library model. For all Interconnection Studies commencing before January 1, 2017, when no compatible PSS/E standard dynamics model(s) can be used to represent the dynamics of a device, accurate and appropriate user written models can be used, if accepted by ISO New England after testing.

User-written models for the dynamic equipment and associated data can be in either dynamic model source code (.lib) or dynamic model object code (.obj) or dynamic linked library (dll):

- User-written source code, object code, and parameters shall be updated for the latest PSS/E version in use and specified by ISO New England:
    a. Dynamics models related to individual units shall be editable in the PSS/E graphic user interface. All model parameters (CONS, ICONS, and VARS) shall be accessible and shall match the description in the model's accompanying documentation. Certain CONEC or CONET models may be acceptable.
    b. Dynamics models shall have all their data reportable in the "DOCU" listing of dynamics model data, including the range of CONS, ICONS, and VARS numbers. Models that apply to multiple elements (e.g., park controllers) shall also be fully formatted and reportable in DOCU.
    c. Dynamics models shall be capable of correctly initializing and run through the simulation throughout the range of expected steady state starting conditions without additional manual adjustments.
    d. Dynamics models shall be capable of allowing its accompanying element or elements to be switched out-of-service (including when the bus is disconnected) in the steady-state network without additional steps and without errors. Documentation of any special requirements for this condition shall be clearly defined in the model documentation.
    e. Dynamics models shall be capable of allowing all documented (in the model documentation) modes of operation without error.
    f. A park controller model to control more than one generator (e.g., in a wind farm or photovoltaic park) shall be able to accurately control multiple equivalent generators.

The relative reactive output of each generator shall be correctly representative of its representation of number of units and impedance data. The park controller shall be able to regulate a minimum of eight equivalent generator units.

g. Dynamic models shall be coded in such way that any internal changes of model variables or parameters incurred in one simulation run shall not be automatically passed on to the same models in subsequent simulation runs given both load-flow file and snapshot file are restored in the same PSS/E application.

- Models requiring allocation of bus numbers shall be compatible with the New England bus numbering system, and shall allow the user to determine the allocation of the bus numbers.
- Models shall initialize correctly and be capable of successful "flat start" and "ring down" testing using the following guideline (models shall be capable of meeting these requirements when operating at full rated (nameplate) power, and also at partial power within the physical operating range of the equipment, across a range of feasible reactive power output conditions and terminal voltages):
  a. 20 Second No-Fault Simulation (a/k/a "flat start"): This test consists of a 20 second simulation with no disturbance applied. The test will be considered to be passed if the following criteria are met:
     i. No generator MW change of 0.1 MW or more
     ii. No generation MVAR change of 0.1 MVAR or more
     iii. No line flow changes of 0.3 MW or more
     iv. No line flow changes of 0.3 MVAR or more
     v. No voltage change of 0.0001 p.u. or more
  b. 60 Second Disturbance Simulation (a/k/a "ring down"): This test consists of the application of a 3-phase fault for a few cycles at a key transmission bus, followed by removal of the fault without any lines being tripped. The simulation is run for 60 seconds to allow the dynamics to settle and will be considered to be passed if the following criteria are met:
     i. No generator MW change of 1 MW or more from pre-fault to steady-state post-fault conditions
     ii. No generator MVAR change of 1 MVAR or more, except for exciters with dead band control (typically IEEE Type 4) from pre-fault to steady-state post-fault conditions
     iii. No voltage change of 0.0001 p.u. or more, except in vicinity of exciters with dead band control from pre-fault to steady-state post-fault conditions
     iv. No undamped oscillations related to the addition of the new user-written model

User-written model(s) shall be accompanied by the following documentation:

- A user's guide for each model
- Appropriate procedures and considerations for using the model in dynamic simulations
- Technical description of characteristics of the model
- Block diagram for the model, including overall modular structure and block diagrams of any sub-modules
- Values, names and detailed explanation for all model parameters
- Text form of the model parameter values (PSSE dyr file format)
- List of all state variables, including expected ranges of values for each variable

Appendix C – Requirements of PSCAD Models

1.0 PSCAD model requirement

PSCAD models are required to support current and future study efforts which are required to maintain a reliable power system. Models are required for one or more of the following reasons. Other specialty studies may also be performed from time to time.

1.1 Weak System Analysis

In simple terms, when a device (such as a wind plant) connecting to a supporting transmission system (or collection of devices such as a cluster of wind farms) is large relative to the rest of the system, it has a relatively large dynamic influence on the system, and the system may be termed weak. “Weak” is a relative term, and typically does not have hard quantitative metrics associated with it.
It is not always initially clear when a system will become too weak to support generation. Conventional modeling tools such as PSSE may not be sufficiently detailed to represent the issues which will be encountered in actual equipment. Power electronic equipment provided by different manufacturers may respond differently to similar network conditions. Additionally, influences from nearby devices may or may not have a significant impact on a particular generator interconnection. Usually, if there is any consideration by planners that the network may be too weak to support additional generation, detailed studies are performed using electromagnetic transient type tools such as PSCAD.

1.2 Sub-synchronous Oscillation (SSO) Analysis

Series compensated transmission lines introduce the risk of SSO. SSO is a family of stability phenomena where the electrical resonance introduced by a capacitor causes the capacitor to exchange energy with either conventional generators, or renewable generators like wind.

In the case of conventional generators, these interactions are termed “Subsynchronous Resonance” or SSR (although more specific and formal definitions exist, and other phenomena are also studied in relation to conventional generation).

In the case of wind, these interactions are termed “Subsynchronous Control Interactions”, or SSCI. SSCI is most probable when certain types of wind turbines are operated in very close proximity to series capacitors, particularly if there are no other parallel outlets for the wind energy (“radial” connections). If unchecked, SSCI can introduce oscillations onto the power system which can very quickly grow to damaging levels. In the worst cases, it can lead to electrical instability which can trigger power system protection, damage wind turbines, or damage series capacitor equipment.

Many modern wind turbines are susceptible to SSCI, and therefore a direct connection to a series compensated line, or a connection which may (through outages) become radial or near-radial, requires careful study. An SSCI study is performed using very detailed electromagnetic transient type computer models such as PSCAD. These models shall represent the turbine controls in minute detail, and any possible network conditions requiring operation of the wind plant directly (or nearly directly) into a series capacitor shall be simulated to ensure the specific turbines chosen will be immune to SSCI phenomena. Conventional transient stability models such as PSS/E are unable to represent the SSCI phenomena due to inherent limitations in the model type.

Other power electronic devices such as HVDC ties also require consideration of SSO phenomena, and usually require electromagnetic transient based studies to evaluate this and other concerns.

1.3 Control Interaction Analysis

Power electronic based devices such as wind turbines, HVDC transmission systems, STATCOMs, and SVCs are highly controllable, and the controls may operate to perform specific functions within a wide range of timeframes and operating conditions. If two or more of these devices are in operation in close electrical proximity to each other, but have been designed and commissioned in isolation from each other, there is a potential for the controllers to interfere with each other, and the overall system performance could be degraded. Due to the level of detail required in the models to accurately represent the fast control loops used in these devices, electromagnetic transient models such as PSCAD are normally used to test for adverse control interactions.

1.4 Dynamic Performance Studies

For devices which are very influential in the system, represent unique designs, or of concern to the reliable operation of the grid, very detailed PSCAD models are sometimes requested to perform studies to test the general dynamic performance of the system. Specific control functions or stressed network conditions are sometimes tested for correct behavior. Typical devices which warrant PSCAD dynamic performance studies as part of routine connection processes include HVDC converters, SVCs, STATCOMs, and large renewable energy projects.

1.5 Other Studies

It is noted that there are many other types of studies which may require PSCAD models (e.g. harmonic studies), which are not described here. Such specific type of PSCAD model may be necessary as part of a System Impact Study and may vary depending on the specific analysis being done. If required, the appropriate modeling and analysis shall be specified as part of the individual system impact study.

2.0 PSCAD Model Requirements

As mentioned above, specific model requirements for a PSCAD study depend on the type of study being done. A study with a scope covering weak system interconnection, ride-through, voltage control and event response, and islanding performance (for example) would require a model which has the following characteristics, and unless specified otherwise, this type of model is what is required.

2.1 Model Accuracy Features

For the model to be sufficiently accurate, it shall:

- Represent the full detailed inner control loops of the power electronics. The model cannot use the same approximations classically used in transient stability modeling, and shall fully represent all fast inner controls, as implemented in the real equipment. It is possible to create models which embed the actual hardware code into a PSCAD component, and this is the best type of model.[16]

[16] The model must be a full thyristor representation (preferred) if thyristors are used, or may use a voltage source interface that mimics thyristor switching (ie. A firing pulse based model). A three phase sinusoidal source representation is not acceptable. Models manually (ie. block-by-block) translated from MATLAB are often unacceptable because the method used to model the electrical network and interface to the controls may not be accurate. Note, however, that Matlab may be used to generate C code which is used in the real control hardware, and if this approach is used by the developer, the same C code may be directly used to create an extremely accurate PSCAD model of the controls. The controller source code may be compiled into DLLs if the source code is unavailable due to confidentiality restrictions.

- Represent all pertinent control features (e.g., external voltage controllers, plant level controllers, phase locked loops, etc). Operating modes that require system specific during the system impact study adjustment shall be user-accessible. In particular, plant level voltage control shall be represented along with adjustable droop characteristics.
- Represent all pertinent electrical and mechanical configurations, such as filters and specialized transformers. There may be other mechanical features (such as gearboxes, pitch controllers, etc.) which shall be modeled if they impact electrical performance.
- Have all pertinent protections that are relevant to network performance shall be modeled in detail for both balanced and unbalanced fault conditions. Typically this includes various OV and UV protections (individual phase and RMS), frequency protections, DC bus voltage protections, and overcurrent protection. There may be other pertinent protections that shall be included.

2.2 Model Usability Features

In order to allow study engineers to perform system analysis using the model, the PSCAD model must:

- Have control or hardware options which are pertinent to the study accessible to the user. (For example, adjustable protection thresholds or real power recovery ramp rates) Diagnostic flags (e.g. flags to show control mode changes or which protection has been activated) shall be accessible to aid in analysis.
- Be capable of running at a minimum time step of 20 microseconds, or no less than 10 microseconds if required by specific control parameters. Most of the time, requiring a smaller time step means that the control implementation has not used the interpolation features of PSCAD, or is using inappropriate interfacing between the model and the larger network. Lack of interpolation support introduces inaccuracies into the model at higher time-steps.
- Include user model guide and a sample implementation test case. Access to technical support engineers is desirable.

2.3 Model Efficiency Features

In addition, the following elements are required to improve study efficiency and enable other studies which include the model to be run as efficient as possible:

- Initializes as quickly as possible (e.g. < 1-3 seconds) to user supplied terminal conditions.
- Support multiple instances of the model in the same simulation.
- Support the PSCAD “snapshot” feature.
- Support the PSCAD “multiple run” feature.

3.0 Model Submission Report Requirements

Studies utilizing electromagnetic transient tools such as PSCAD rely heavily on model accuracy and quality to be conducted in a timely manner. Failures in model quality control or insufficient care in preparing site specific models can (and often does) result in long study delays. In order to allow ISO New England planning studies which may involve electromagnetic transient analysis to be conducted efficiently and accurately, PSCAD model submissions are required to be delivered along with a basic model submission report, outlined as follows:

3.1 Section 1: Statement of model compliance

In this section, a statement of model compliance is required which affirms basic conformance with the model requirements stated above.

3.2 Section 2: Instructions for model use

In this section, a list of instructions for model use shall be included. This list shall include (at least):

- Directions for compiling and running the model
- Any special requirements for the model (e.g. simulation time-step, run-time settings, etc)
- Instructions on directory path settings if applicable, including a list of libraries, object files, or other files which may be required to run the model.

3.3 Section 3: List of plant-specific settings

In this section, any control parameters which are specific to an individual plant must be stated. These parameters may include (among others):

- Ride-through thresholds and parameters
- Active power ramp rates following faults
- Plant-level voltage controller gains and time constants
- Interface parameters with non-turbine plant devices such as STATCOMs, if applicable

Where applicable, these parameters shall be matching with PSSE model settings, which studies are usually performed ahead of or in parallel to PSCAD studies.

3.4 Section 4: Basic performance testing at approximate connection location

In this section, a brief demonstration of model performance is required based on the location in the ISONE network where the plant will be connecting (POI).

Create Network Model

Using a provided PSSE network as a reference,[17] a small passive PSCAD model shall be built surrounding the POI which represents the correct short circuit MVA under system intact, fault, and under line outage conditions. As noted above, the presence of nearby devices can degrade performance, and this shall be born in mind, although detailed studies will follow (in other words, performance in simplified models may be better than performance when nearby devices are included, and design margin may be desirable). A short description of the SCMVA values resulting from the fault conditions considered shall be provided.

Apply Faults

Basic fault and contingency performance shall be tested to show plant recovery and stability under these approximated network conditions. Plant shall be capable of riding through faults with acceptable oscillations, and maintaining stable and accurate terminal voltage control. A set of representative plots shall be provided to demonstrate performance[18].

[17] Reference cases can be found at the following location on the ISO-NE website: http://www.iso-ne.com/system-planning/transmission-planning/ferc-form-no-715-reports

[18] Note: It will be possible for manufacturers to re-use basic model performance testing across multiple locations, provided:

- The site-specific model parameters are identical
- The SCMVA levels (for N-0 and N-1 conditions) used for the testing are the same or lower than those at the POI
- The inverter control topology and mechanical performance is expected to be identical

Important Note
These basic tests are requested to provide basic quality control and site-specific testing of the plant model. More detailed studies are required to analyze the phenomena described above, and the results of these studies may indicate problems which are not evident in these basic tests. For example, interactions with nearby devices will be impossible to test in a simple model without detailed models of the nearby devices available. Other issues may be found as more detailed system models and network conditions are tested.

3.4.1 Detailed Instructions for the conduct of benchmarking analysis to confirm acceptable performance of the PSS/E model in comparison to the PSCAD model

PSS/E Simulation

1. The project shall be modeled at full output per the project's Interconnection Request.
2. Sufficient data channels shall be included in the snapshot file for reporting purposes. Example channel data would include bus voltages within the project and around the project's POI, line and transformer flows (both real and reactive), and LVRT status signal. Channel selection shall enable PSCAD modeling results to be directly compared against the PSS/E results.
3. Two fault simulations, each using a 6 cycle clearing time, at a bus close to the point of interconnection, for both pre-project (without the project modeled in-service) and post-project (with the project modeled in-service) :
    a. With all lines in service
    b. With one line close to the point of interconnection out of service.
4. Plot scales shall be set appropriately for the reviewers to discern the entirety of the plotted signals, without clipping. Multiple signals may be plotted together in the same plot, as long as the signals are discernible from one another—otherwise, some of those signals should be separated out into multiple plot diagrams.

PSCAD Simulation

1. PSCAD simulation shall be performed under as similar conditions as possible to the PSS/E simulations discussed above, for the best possible comparison.
2. The Project and its associated auxiliary equipment shall be modeled with comparable parameters between the PSS/E and PSCAD modeling, with each model's parameters detailed in the summary report.
3. The PSCAD transmission system case model shall be created from the PSS/E case model, with sufficient buses included after forming the system equivalent to allow simulation of the line outage and fault conditions modeled in the PSS/E simulations discussed above.
4. Steady-state line outage scenarios shall be created similar to those in the PSS/E simulation. For each scenario, a short description of the SCMVA values resulting from the fault conditions considered shall be provided.
5. The PSCAD model shall initialize properly and that the same power flow and voltage conditions shall be observed between the PSCAD and PSS/E models.
6. Output channels shall be set up to capture similar data to that of the PSS/E simulations
7. Fault simulations using the same modeling as those for PSS/E shall be run
8. Comparison plot sets modeling the same data channels from PSS/E and PSCAD shall be developed.

Evaluation of Results

1. Comparison plots shall show similar results between PSS/E and PSCAD. If any significant differences are shown between the traces, sufficient explanation shall be included about why these differences should be considered acceptable.

Report

1. Statement of Model Compliance—a statement of model compliance is required which affirms basic conformance with the PSCAD model requirements
2. List of Plant-Specific Settings—data shall be included for both PSCAD and PSS/E models. Any control parameters which are specific to the plant must be stated. Where applicable, these parameters shall be matching with PSS/E model settings. These parameters may include (among others):
    a. Ride-through thresholds and parameters (e.g., undervoltage thresholds or fault-Q contribution limits)
    b. Active power ramp rates following faults
    c. Plant-level voltage controller gains and time constants
    d. Interface parameters with non-turbine plant devices such as STATCOMs
3. Results Documentation—Plots and related discussion regarding acceptability
    a. PSS/E
        i. Initialization Results
        ii. Flat Run (No Disturbance)
        iii. Fault simulation results
    b. PSCAD
        i. Initialization Results
        ii. Power flow and voltage matching to PSS/E
        iii. Fault simulation plots comparison to PSS/E
    c. PSS/E steady-state raw data (.RAW) data file and dynamics data (.DYR) file, in the latest version of PSS/E in use by ISO-NE, shall be included in the report. These files shall be ready to be incorporated into the base case and snapshot without further modifications. These files shall be also fully-compatible with the PSS/E model(s) designated (and if user-defined, provided to ISO New England) for the Project.

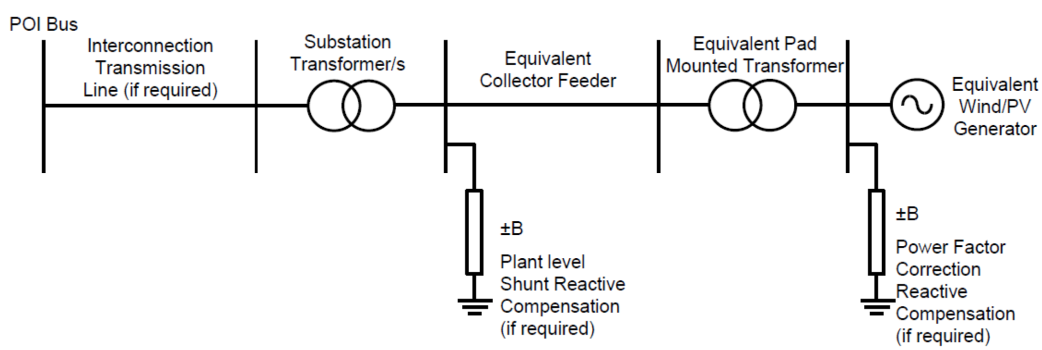
Appendix D – Detailed Considerations for the Study of an Inverter Based Generating Facility

Typical Order of Study for an Inverter Based Generating Facility

1. Short Circuit Ratio calculation
2. Review of PSS/E-PSCAD benchmarking
3. PSCAD analysis of performance if Short Circuit Ratio is low
4. Review of performance of PSS/E model
5. Collector system/GSU tap setting/voltage control strategy calculation
6. Steady state reactive margin analysis
7. Initial dynamic fault testing
8. Full steady state testing to meet the requirements of this Planning Procedure
9. Full dynamic testing to meet the requirements of this Planning Procedure

Use of Aggregate Models for Collector-Based Generating Facilities
For the steady-state portion of the System Impact Study, including the detailed collector system analysis described below, a fully explicit model of the collector system, including all branch connections and step-up transformers shall be used.

For the stability portion of the System Impact Study, an equivalent model shall be used for each major feeder branch of the Generating Facility. The following figure provides a representation of the appropriate equivalent to be used.



Collector system/GSU tap setting/voltage control strategy calculation
A detailed evaluation using a fully explicitly modeled collector-based Generating Facility allows for analysis of voltage control strategies by showing the real and reactive power flow and losses across every element of the facility. Being able to monitor the terminal voltage at each individual generating unit makes it possible to ensure each unit remains within a reasonable voltage range to avoid tripping. All collector branches, junctions, individual high and low voltage busses (including the GSUs and generating units) shall be modeled using the configuration, network impedances, generating unit reactive capabilities and facility ratings for the project.

- The following voltage regulation modes should be reviewed as appropriate:
    - Generating units regulating voltage at a remote bus
    - Generating units regulating voltage at a Park transformer high side bus
    - Generating units regulating voltage at a Park transformer low side bus
    - Generating units regulating voltage at a fixed power factor

Step 1 – Reactive Power Capability

This step investigates the reactive power range of the overall Generation Facility and seeks to determine if the collector system design allows full reactive power capability. It also tries to determine what unit and station transformer taps allow for the largest reactive power injection range of the generating units.

- The POI may be modeled as a swing bus for this analysis. A fictitious machine may be placed at the swing bus to consume the Project output and to allow for adjustment of transmission system voltages.
- Testing is performed to determine if the generating units would violate any voltage trip settings given the full leading and lagging reactive power range of the generating units.
- The reactive power output of the generating units is ramped to the maximum leading negative MVAR and to the maximum lagging capability positive MVAR for various system voltages and transformer tap settings.
- If any bus voltage within the Project or collector system is outside of the specified range, the generating unit reactive power output for the wind park should be recorded along with the first bus that showed a voltage outside of the range. This information is used to determine which transformer tap settings result in the greatest usable reactive power range of the generating units as a way to pre-screen the testing required for Step 2.

Step 2 – Collector System Voltage Range

The goal of this testing is to develop a strategy to maintain sufficient margin to the generating unit trip settings and if possible maintain a preferred Generation Facility terminal voltage range (typically 0.95 to 1.05pu) for any transmission system voltage (typically 0.9 pu to 1.1 pu).

- Testing is performed at different plant output levels 0% to 100% output in 10% intervals with equal loading across all individual generating units.
- For each of the applicable control strategies described above, and optimum tap settings from Step 1, a voltage profile is created and the minimum and maximum voltages within the facility is recorded.

Step 3 – VAR impact to the System and Voltage Schedule Margin

- The goal of this testing is to identify a strategy that will minimize the reactive power demand from the system under normal conditions, but also provide VAR support under low voltage conditions and consume MVAR under high voltage conditions.
- To ensure there is proper margin with the scheduled voltage (as determined by ISO during the study), +/-2% from scheduled voltage is evaluated.

Appendix E – Procedures for Material Modification Determinations

This Appendix E provides implementation guidance in the application of the material modification procedures contained in Schedules 22, 23 & 25 of the OATT.

Different thresholds for determining Material Modification of a Generating Facility or ETU depend on the stage of the project:

1. After an Interconnection Request is received and before a Feasibility Study Agreement is executed
2. After the Feasibility Study Agreement is executed and before the Feasibility Study is completed
3. After the Feasibility Study is completed and before a System Impact Study has commenced
4. After the System Impact Study has commenced and before the System Impact Study is completed
5. After the System Impact Study, including evaluation of "as purchased data," "as built/as tested data" and changes to existing facilities (e.g., equipment upgrade, replacement of failed equipment)
    - "As purchased data" is required to be submitted no later than 180 Calendar Days prior to the Initial Synchronization Date and shall be reviewed prior to the project being allowed to be synchronized to the New England system
    - "As built/as tested" is required to be submitted prior to the Commercial Operation Date and shall be reviewed prior to the project being allowed to become Commercial

1 (a). After an Interconnection Request is received and before a Feasibility Study Agreement is executed the following will be deemed material and require a new Interconnection Request

- Any increase to the energy capability or capacity capability output of a Generating Facility or ETU above that specified in an Interconnection
- A change from Network Resource (NR) Interconnection Service to Capacity Network Resource (CNR) Interconnection
- An extension of three or more cumulative years in the Commercial Operation Date, In-Service Date or Initial Synchronization Date of the Large Generating Facility or ETU unless provisions of Section 4.4.5 of the Schedules 22 or 25 are satisfied

1 (b). After an Interconnection Request is received and before a Feasibility Study Agreement is executed the following will not be deemed material

- Extensions of less than three (3) cumulative years in the Commercial Operation Date, In-Service Date or Initial Synchronization Date of the Large Generating Facility or ETU to which the Interconnection Request relates provided that the extension(s) does not exceed seven (7) years from the date the Interconnection Request was received by the System Operator
- A decrease of up to 60 percent of electrical output (MW) of the proposed project
- Modification of the technical parameters associated with the Large Generating Facility or ETU technology
- Modification of the Large Generating Facility or ETU step-up transformer impedance characteristics
- Modification of the interconnection configuration
- Modification of the Point of Interconnection (POI) based on information from the Scoping Meeting and identified within five (5) business days of the Scoping Meeting

2 (a) Changes after the Feasibility Study Agreement is executed and before the Feasibility Study is completed

- Once the Feasibility Study has started, it will be completed without making any changes except those based on study results that were not anticipated at the Scoping Meeting and are agreed to by the System Operator and the Interconnecting Transmission Owner. Other changes will be addressed in the System Impact Study.

2 (b). The following changes after the Feasibility Study Agreement is executed and before the Feasibility Study is completed will be deemed material and require a new Interconnection Request

- Any increase to the energy capability or capacity capability output of a Generating Facility or ETU above that specified in an Interconnection
- A change from NR Interconnection Service to CNR Interconnection
- An extension of three or more cumulative years in the Commercial Operation Date, In-Service Date or Initial Synchronization Date of the Large Generating Facility or ETU unless provisions of Section 4.4.5 of the Schedules 22 or 25 are satisfied
- Modification of the POI that is not based on unanticipated study results

2 (c). The following changes after the Feasibility Study Agreement is executed and before the Feasibility Study is completed will not be deemed material and will not require a new Interconnection Request

- Extensions of less than three (3) cumulative years in the Commercial Operation Date, In-Service Date or Initial Synchronization Date of the Large Generating Facility or ETU to which the Interconnection Request relates provided that the extension(s) does not exceed seven (7) years from the date the Interconnection Request was received by the System Operator
- A decrease of up to 60 percent of electrical output (MW) of the proposed project
- Modification of the technical parameters associated with the Large Generating Facility or ETU technology
- Modification of the Large Generating Facility or ETU step-up transformer impedance characteristics
- Modification of the interconnection configuration
- Modification of the POI based on study results that were not anticipated at the Scoping Meeting and are agreed to by the System Operator and the Interconnecting Transmission Owner
- Modification of settings of the project's controls, such as wind farm voltage control scheme

3. Changes after the Feasibility Study is completed and before the System Impact Study has commenced

- ISO-NE will notify the Interconnection Customer 65 days before the study begins and allow the Interconnection Customer 60 days to refresh its data to the degree allowed under the same materiality standards for changes prior to execution of the System Impact Study Agreement
- Once the System Impact Study has started, it will be completed without making any changes except those based on study results that were not anticipated and are agreed to by the System Operator and the Interconnecting Transmission. Other changes will be addressed in the same way as changes made after the System Impact Study is complete.

4 (a). During the System Impact Study the following will be deemed material and require a new Interconnection Request

- Any increase the energy capability or capacity capability output of a Generating Facility or ETU above that specified in an Interconnection

- A decrease of the electrical output (MW) of the proposed project where the decrease would result in the transfer of an upgrade obligation to a later queued project
- A change from NR Interconnection Service to CNR Interconnection
- An extension of three or more cumulative years in the Commercial Operation Date, In-Service Date or Initial Synchronization Date of the Large Generating Facility or ETU unless provisions of Section 4.4.5 of the Schedules 22 or 25 are satisfied
- Modification of the POI and/or interconnection configuration that is not based on unanticipated study results

4 (b). During the System Impact Study the following may be deemed material and will require review after the System Impact Study is completed using the post System Impact Study criteria

- A decrease of the electrical output (MW) of the proposed project where the decrease would not result in the transfer of an upgrade obligation to a later queued project
- Modification of the technical parameters associated with the Large Generating Facility or ETU technology
- Modification of the Large Generating Facility or ETU step-up transformer impedance characteristics

4 (c). During the System Impact Study the following will not be deemed material and will not require a new Interconnection Request

- Extensions of less than three (3) cumulative years in the Commercial Operation Date, In-Service Date or Initial Synchronization Date of the Large Generating Facility or ETU to which the Interconnection Request relates provided that the extension(s) does not exceed seven (7) years from the date the Interconnection Request was received by the System Operator
- Modification of the POI and/or the interconnection configuration based on study results that were not anticipated and are agreed to by the System Operator and the Interconnecting Transmission Owner

5. Changes after the System Impact Study is completed

- A proposed project that has a completed System Impact Study, or an existing generating facility or ETU can request that a proposed change be evaluated to determine if the change is a Material Modification. If this happens, the proposed change will be evaluated using technical screening criteria. However, there may be proposed changes that have not been contemplated and might require additional analysis beyond the normal screening criteria
- The following will be deemed material and require a new Interconnection Request
    - Where the change(s) would either require significant additional study of the same Interconnection Request and could substantially change the interconnection design, or have a material impact (i.e., an evaluation of the proposed modification cannot be completed in less than ten (10) Business Days) on the cost or timing of any Interconnection Studies or upgrades associated with an Interconnection Request with a later queue priority date

5 (a). Screening Criteria for Changes in Dynamic Models or Voltage Control Schemes

- The following will not be deemed material and require a new Interconnection Request
    - There is no voltage or dynamic stability problem that may be adversely affected by the change to the project that is found in any base cases for the most severe N-1 and N-1-1 contingencies

  - The new models provide similar or better dynamic voltage and stability performance based on dynamic simulation of a few severe faults

5 (b). Screening Criteria for Short Circuit Impacts of Changes in Generation or ETU or Interconnection Facility Impedances

- The following will not be deemed material and require a new Interconnection
  - The total impedance is greater than that of the previously submitted unit(s) and X/R ratio is less than or equal to that of the previously submitted unit(s)
  - A short circuit study at only the interconnecting bus confirms that short circuit duty is less than or equal to that of the previously submitted unit(s)

5 (c). Screening Criteria for Stability Impacts of Changes in Generation or ETU or Interconnection Facility Impedances

- The following will not be deemed material and require a new Interconnection
  - The new models provide similar or better dynamic performance (better damping, smaller angular swing) based on dynamic simulation of a few severe faults

5 (d). Screening Criteria for Voltage Impacts of Changes in Generation or ETU or Interconnection Facility Impedances

- The following will be deemed material and require a new Interconnection Request
  - A change that will result in the Generating Facility or ETU not meeting the Tariff's power factor requirement
- The following will not be deemed material and require a new Interconnection
  - The change of impedance is small (less than 10% of the impedance used in the SIS), the power factor requirement is satisfied, and there is no pre-existing voltage problem

5 (e). Screening Criteria for PSCAD Changes to Generating Facilities or ETUs that Required a PSCAD model

- The following will not be deemed material and require a new Interconnection Request
  - The new models provide similar or better performance for the most severe N-1 and N-1-1 contingencies