TRANSMISSION PLANNING CRITERIA

Purpose

This document summarizes the PSEG Long Island Transmission Planning Criteria for assessing the reliability performance of the LIPA transmission system throughout the operating and planning horizon. These Criteria shall be utilized in the design of the LIPA transmission system and shall guide future expansion of the system. Application of these Criteria will ensure that the LIPA transmission system is planned to maintain a consistent level of reliability.

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1. Introduction

This document describes PSEG Long Island's Transmission Planning Performance Criteria used in the design of the LIPA Transmission system. The material contained in this document is consistent with prudent utility practices. In addition to this document, LIPA adheres to the standards and criteria of the North American Electric Reliability Corporation (NERC), the Northeast Power Coordinating Council (NPCC), the New York State Reliability Council (NYSRC), and the New York Independent System Operator (NYISO).

2. Transmission Planning Tools

PSEG Long Island utilizes various types of power system simulation software tools for power system analysis. These software tools allow Transmission Planning Engineers to conduct steady state power flow studies (thermal and voltage), dynamic stability studies, short circuit studies, as well as various transmission system security and reliability studies.

2.1 PSS®E

Power System Simulator for Engineering (Power Transmission System Planning Software) is a Siemens program utilized for electric transmission system analysis and planning. Typical PSS/E analyses consist of steady state power flow (thermal and voltage) and dynamic stability analyses. The principal uses are to identify thermal, voltage and stability constraints and to assess solutions to these issues.

2.2 TARA (Transmission & Reliability Assessment)

TARA is a PowerGem load flow program which is an add-on to Microsoft Excel. Transmission Planning uses this primarily for N-1-1 contingency analysis, optimal re-dispatch of generation for N-1 and N-1-1 studies, thermal transfer limit analysis, and PV analysis.

2.3 ASPEN Oneliner

ASPEN Oneliner is utilized to perform Transmission System short circuit studies and to assess the adequacy of transmission circuit breaker interrupting ratings.

3. Load Forecast

PSEG Long Island develops the following two load forecasts for the LIPA service territory.

Forecast	Probability of Occurrence
Normal Weather	50/50 --> 50% probability of occurrence
Extreme Weather (compliance & voltage studies)	90/10 --> 10% probability of occurrence

4. Transmission System

The transmission system consists of Bulk Electric System (BES) facilities (as defined by NERC), Bulk Power System (BPS) facilities (as defined by NPCC), NYS Bulk Power System (as defined by NYSRC), and Local Transmission facilities.

4.1 BULK ELECTRIC SYSTEM (BES)

The Bulk Electric System (BES) definition was revised by NERC and became effective July 1, 2014. The BES definition includes bright line criteria with various enumerated inclusions and exclusions. Application of the BES definition has resulted in the entire LIPA 138 kV transmission system being classified as BES. This includes transmission lines, transformers, generator step-up transformers (GSUs), phase angle regulators (PARs), and static and dynamic reactive power devices.

All BES elements shall be designed to meet the performance requirements specified in the applicable NERC Transmission Planning Reliability Standard (Transmission System Planning Performance Requirements; TPL-001-4). NERC Reliability standards are accessible from the following link:

http://www.nerc.com/pa/stand/Pages/ReliabilityStandardsUnitedStates.aspx?jurisdiction=United%20States

4.2 BULK POWER SYSTEM (BPS)

The NPCC, which the NYISO is part of, defines the Bulk Power System as:

"The interconnected electrical systems within northeastern North America comprising generation and transmission facilities on which faults or disturbances can have a significant adverse impact outside of the local area. In this context, local areas are determined by Council members." NPCC BPS facilities are identified based on the application of NPCC's Document A-10 "Classification of Bulk Power System Elements." This criterion is based on a performance based test for significant adverse impact.

Based on the A-10 criteria, the only two circuits within the LIPA system that are designated as BPS facilities are the Y50 and Y49 inter-tie cables. The Y50 cable is co-owned by LIPA and Con Edison and the Y49 cable is fully owned by NYPA.

All BPS elements shall be designed to meet the performance requirements specified in NPCC Directory 1.

4.3 NYS BULK POWER SYSTEM (NYS BPS)

The New York State Reliability Council (NYSRC) is a not-for-profit corporation responsible for promoting and preserving the reliability of the New York State power system by developing, maintaining and, from time to time, updating the Reliability Rules which must be complied with by the New York Independent System Operator and all entities engaging in electric power transactions on the New York State power system. The requirements of these NYSRC Reliability Rules apply to the Bulk Power System portion of the whole New York State Power System.

The present NYS Bulk Power System (NYS BPS) definition is as follows:

"The portion of the bulk power system within the NYCA, generally comprising generating units 300 MW and larger; and generally comprising transmission facilities 230 kV and above. However, smaller generating units and lower voltage transmission facilities on which faults and disturbances can have a significant adverse impact outside of the local area are also part of the NYS Bulk Power System."

All applicable BPS elements that are identified per NPCC A-10 shall comply with the NYSRC rules. The NYSRC Reliability Rules & Compliance Manual can be found at the following website:

http://www.nysrc.org/NYSRCReliabilityRulesComplianceMonitoring.html

4.4 Local Area Operation Reliability Rule G.3 Loss of Gas Supply – Long Island:

NYSRC local reliability rule G.3 applies to the Long Island zone. Local Area Operation Reliability Rule G.3 Loss of Gas Supply – Long Island:

The NYS Bulk Power System shall be operated so that the loss of a single gas facility does not result in the uncontrolled loss of electric load within the Long Island zone.

NYSRC G.3 governs the loss of gas supply which is considered a single contingency that impacts the LIPA electric system. In observing this rule, Northport units may be required to utilize oil as the primary fuel such that the unit(s) will not trip on a loss of gas. System planning studies will evaluate the impact of loss of gas at Northport.

4.5 Applications of NYSRC Reliability Rules

The NYISO establishes and maintains Applications of the NYSRC Reliability Rules (Applications) consisting of Transmission Owner (TO) procedures for meeting the NYSRC Reliability Rules that apply to specific system locations or conditions. The list of Applications is posted on the NYISO web site at:

http://www.nyiso.com/public/markets_operations/market_data/reports_info/index.jsp

TO Application of NYSRC Reliability Rule Numbers ARR 27 and ARR 28 apply to LIPA. These Applications of NYSRC Reliability Rules are expected to be updated as needed.

5. Local (LIPA) Transmission System

The LIPA transmission system is divided into transmission and sub-transmission systems. The transmission system consists of 138 kV and 345 kV voltage levels and the sub-transmission system consists of 23, 34.5 kV and 69 kV voltage levels.

5.1 INTERFACES

The primary path for bulk power deliveries to LIPA's load center is across three internal bulk transmission interfaces defined as: Newbridge Road, Northport and Holbrook. These interfaces divide Long Island into western, central, and eastern regions. The Long Island load center itself is defined to be located at the Eastern Nassau and Western Suffolk area bounded by the Newbridge Road and Holbrook interfaces.

These interfaces are important for analytical purposes in determining the ability to deliver generating capacity across the LIPA system. The interface analysis shall utilize the contingency and performance criteria outlined in this document.

6. Design

The LIPA BES transmission system shall be designed to meet the performance criteria outlined in NERC reliability standards, NPCC Directory 1 and NYSRC reliability rules as applicable. Additionally, both BES and non-BES transmission systems shall be designed to meet thermal and voltage performance criteria outlined in this document.

Table A-1: Contingency Criteria Applicable to the Design of All LIPA Transmission

Contingency Events: Simulate the removal of all elements that protection systems are expected to automatically disconnect for each event that involves an AC fault.	**Fault** Type (permanent) On the listed elements where applicable	**Thermal rating criteria for BES (See 7.4 for non BES)**
1. Fault on any of the following: a. Transmission Circuit b. Transformer c. Shunt Device d. Generator e. Bus Section	Three-phase fault with normal fault clearing	LTE rating without system adjustments and Normal rating with system adjustments for "a" through "d". LTE rating for "e"
2. Loss of single pole of a DC facility	No fault	LTE rating without system adjustments and Normal rating with system adjustments
3. Fault on any of the following: a. transmission circuit b. transformer c. shunt device d. generator e. bus section	Phase to ground fault with failure of a circuit breaker to operate and correct operation of a breaker failure protection system and its associated breakers	LTE rating
4. Internal circuit breaker fault	Phase to ground fault, with normal fault clearing	LTE rating
5. Simultaneous fault on two adjacent transmission circuits on a common structure.	Phase to ground faults on different phases of each circuit, with normal fault clearing. *Excludes circuits that share a common structure for 1 mile or less.*	LTE rating
6. Simultaneous permanent loss of both poles of a DC bipolar facility.	Without an AC fault	LTE rating

Notes:
- Requirements which are applicable to shunt devices also apply to FACTS devices that are connected to ground.
- An internal breaker fault means a breaker failing internally, thus creating a System fault which must be cleared by protection on both sides of the breaker.
- A failure of a circuit breaker to operate means that for a gang-operated breaker, all three phases of the breaker have remained closed. For an independent pole operated (IPO) or an independent pole tripping (IPT) breaker, only one pole is assumed to remain closed. The failure of a circuit breaker to operate results in a Delayed Fault Clearing.
- A 3Ø or a double line to ground fault study indicating the criteria are being met is sufficient evidence that a SLG condition would also meet the criteria.
- Requirements which are applicable to transformers also apply to variable frequency transformers and phase shifting transformers.

Table A-2: Additional Contingency Criteria Applicable to the Design of the LIPA BES

Initial Condition	Contingency Event	Thermal rating criteria for BES (See 7.4 for non BES)
1. Loss of one of the following followed by system adjustments[1]: a. generator b. transmission Circuit c. transformer d. shunt device e. single pole of a DC line	1. Loss of one of the following: a. generator b. transmission circuit c. transformer d. shunt device e. Single pole of a DC line	LTE rating without system adjustments and Normal rating with system adjustments after the first event.
2. Normal system conditions	2. Delayed Fault Clearing due to the failure of a non-redundant relay protecting the Faulted element to operate as designed, for one of the following[2]: 1. Generator 2. Transmission Circuit 3. Transformer 4. Shunt Device 5. Bus Section	LTE rating

1. Examples of the system adjustments implemented to get back to Normal rating include, but are not limited to, the following: generation re-dispatch, dispatching quick-start GT's (operating reserve), Phase Angle Regulator (PAR) control, HVDC control, switched shunts, and tap changer control.
2. Non-consequential load loss may be considered for this contingency event.

Note: For NPCC BPS facilities refer to NPCC *Directory 1 Design and Operation of the BPS*.

7. Thermal Assessment

7.1 Applicability of Thermal Criteria

Table B below summarizes the various analyses for the different voltage levels on the LIPA system.

For the BES, N-0, N-1, and N-1-1 contingencies are evaluated using both a Normal and an Extreme weather forecast.

For the sub-transmission system (69 kV and below voltage levels), both N-0 and N-1 contingency analyses are conducted, using a Normal weather forecast.

Table B

Thermal Criteria Analyses				
Analysis	**BES**		**69 kV & Below**	
Forecast	Normal	Extreme*	Normal	Extreme
N-0	✓	✓	✓	N/A
N-1	✓	✓	✓	N/A
N-1-1	✓	✓	Design considerations considered where emergency generation cannot be sited.	N/A

*For BES violations under Extreme Weather conditions, non-consequential load loss may be considered as a corrective action plan.

7.2 PRE-CONTINGENCY

Under normal system conditions, no transmission facility is permitted to be loaded past its normal rating.

7.3 LIPA'S BULK ELECTRIC SYSTEM (BES) THERMAL CRITERIA

N-1 Contingency

For N-1 system contingencies (listed in Table A-1) no facility shall exceed its LTE rating.

After an N-1 single element contingency (Table A-1.1a through d, 1.2) occurs and an overload ensues, system adjustments must be executed within four hours to return the overloaded facility back to the Normal rating.

For the contingency listed in Table A-2.2, LTE rating shall be observed for BES facilities.

The table below summarizes the rating limits that are imposed for N-1 contingencies.

Table C-1

Thermal Ratings for Contingencies – for N-1 Criteria		
	BES (345, 138 kV) Post-Contingency	**System Adjustments**
N-1 (L/O generator, trans. Circuit, transformer, shunt device or single pole of HVDC)	LTE	Normal
N-1 (all other contingencies listed in Table A-1)	LTE	N/A

*System adjustments can include, but are not limited to, any of the following: generation re-dispatch, dispatching quick-start GT's (operating reserve), Phase Angle Regulator (PAR) control, HVDC control, switched shunts, and tap changer control.

N-1-1 Contingency

N-1-1 analysis evaluates the ability of the system to meet design criteria after an element has already been lost, following allowable system adjustments.

Table C-2 below summarizes the ratings that shall be met for N-1-1 scenarios. The N-1-1 criteria applied to the LIPA BES system are consistent with NERC TPL-001-4 standards. Refer to Table A-2.1 for a complete list of applicable N-1-1 contingencies.

Table C-2

Thermal Ratings for Contingencies – for N-1-1 Criteria		
	BES (345, 138 kV) Post-Contingency	**System Adjustments**
First N-1 Contingency	LTE	Normal
****Second N-1 Contingency**	LTE	N/A

**Second N-1 single element contingency follows the first N-1 single element contingency, after system adjustments

7.4 SUB-TRANSMISSION SYSTEM (69 KV AND BELOW) THERMAL CRITERIA

For N-1 (Table A-1) system contingencies, no facilities shall exceed its LTE rating.

N-1-1 design solutions are considered for the local transmission system where long term outages can occur (underground cables, submarine cables etc.) and emergency generation cannot be sited.

Where BES violations are identified, corrective action plans are required. Such corrective action plans shall consider the impact to the LIPA 69kV and below facilities.

7.5 SINGLE CABLE NNC OPERATION

The NYISO and ISO-NE have agreed that the STE rating (430 MVA) can be used to solve the post contingency flow on the Northport-Norwalk Harbor Cable (NNC) when 601, 602, or 603 is the only cable in service, so long as LIPA can reduce the loading on NNC below its LTE rating in 15 minutes and not cause any other facility to be loaded beyond its LTE rating.

7.6 EMERGENCY TRANSFER CONDITIONS

Certain power system studies require the evaluation of emergency transfer capabilities. Emergency transfer capability is defined as the amount of power transfer allowed between areas or within an area when operating to meet NPCC emergency criteria contingencies (as defined in NPCC Directory 1). These studies shall utilize the following thermal criteria:
For both the BES and sub-transmission systems:

- For N-0 scenarios, no transmission facility is permitted to be loaded past its normal rating.
- For applicable N-1 contingencies, no circuits shall exceed their STE ratings.

8. Voltage Assessment

8.1 APPLICABILITY OF VOLTAGE CRITERIA

For the BES (138 kV and above), N-0, N-1, and N-1-1 voltage studies are conducted using both a Normal and an Extreme weather forecast. Refer to Tables A-1 and A-2 for applicable contingencies.

For the sub-transmission system (69 kV and below voltage levels), both N-0 and N-1 voltage analyses are conducted using both a Normal and an Extreme weather forecast. Table D below summarizes the various analyses for the different voltage levels on the LIPA system.

Table D

Voltage Criteria Analyses				
Analysis	**BES**		**69 kV & Below**	
Forecast	Normal	Extreme	Normal	Extreme
N-0	✓	✓	✓	✓
N-1	✓	✓	✓	✓
N-1-1	✓	✓	N/A	N/A

8.2 VOLTAGE LIMITS

For all applicable contingencies, voltages must satisfy pre- and post-contingency limits for both Normal and Extreme weather conditions. Table E summarizes these requirements for the LIPA transmission system.

Sufficient reactive resources shall be available in order to maintain system voltages within their applicable limits. No bus voltage shall be above or below its applicable pre-/post-contingency limits.

Table E

	BES / 138 kV		System & Load Pockets 69 kV		System & Load Pockets 34.5 kV & 23 kV	
	Lower Limit (p.u.)	Upper Limit (p.u.)	Lower Limit (p.u.)	Upper Limit (p.u.)	Lower Limit (p.u.)	Upper Limit (p.u.)
Normal Weather & Extreme Weather Voltage Criteria N-0	0.95	1.05	0.95	1.05	0.95	1.05
Normal Weather Voltage Criteria N-1			0.95	1.05	0.90	1.10
Normal Weather Voltage Criteria N-1-1			N/A	N/A	N/A	N/A
Extreme Weather Voltage Criteria N-1			0.92	1.05	0.90	1.10
Extreme Weather Voltage Criteria N-1-1			N/A	N/A	N/A	N/A

8.3 Transient Voltage Recovery (TVR) Criteria

All LIPA 69 kV and 138 kV bus voltages shall recover to at least 0.90 p.u. of the nominal voltage within one second of the clearing of any fault and remain continuously above 0.90 p.u. of the nominal voltage, excluding reoccurrence of a fault within this one second period. Analysis considers complex dynamic load models, where load at select substations is modeled at the distribution bus. This may be more constraining than load flow voltage analysis.

8.4 Energization / De-energization of a Switched Element

- With all lines in service, bus voltages shall not deviate by more than +/- 2.5% upon (de)energization of a switched component while observing any post contingency threshold limit that may apply.
- Under an N-1 condition, bus voltages shall not deviate by more than +/- 5.0% upon (de)energization of a switched component while observing any post contingency threshold limit that may apply.

8.5 GENERATOR STEADY STATE VOLTAGE RIDE THROUGH CRITERIA

For the steady state analysis, the assumed minimum generator steady state or ride through voltage limitation is 0.9 per unit of the nominal voltage based on NERC Standard PRC-024 Attachment 2, which contains a plot of the voltage ride-through time duration curve. The voltage limitation of 0.9 per unit is the largest low voltage ride through allowed per this standard; therefore, it is conservative to assume in the analysis that if the generator step-up transformer (GSU) voltage is below 0.9, the generator trips out-of-service. In instances where the transmission security analysis shows generator bus voltages or the high side of a GSU transformer voltage less than 0.9 per unit, the system response to the contingency condition resulting in this condition is re-evaluated to include the loss of generation.

9. Stability Assessment

9.1 SYSTEM STABILITY

a.) Stability of the LIPA Bulk Electric System (BES) and the sub-transmission system shall be maintained during and after the most severe of design criteria contingencies (refer to Tables A-1 and A-2 for all contingencies and applicable facilities, and NERC TPL-001-4 for additional BES Criteria). The BES must also be stable if the faulted element is reenergized by delayed reclosing before any manual system adjustment, unless specified alternate procedures are documented.

b.) Cascading and uncontrolled islanding are not permitted.

c.) Stability analysis will generally be performed for both peak and light load conditions for targeted areas of the LIPA system.

d.) A 3Ø or a double line to ground fault study indicating the criteria are being met is sufficient evidence that a SLG condition would also meet the criteria.

9.2 GENERATOR STABILITY

a.) With all transmission facilities in service, generator unit stability shall be maintained on those facilities not directly involved in clearing the fault for the most severe of design criteria contingencies (refer to Tables A-1 and A-2 for all contingencies and applicable facilities, and NERC TPL-001-4 for additional BES Criteria).

b.) For the stability analysis, based on NERC Standard PRC-024 Attachment 2, the assumed generator low voltage ride-through capability on non-wind generator GSU buses is 0.65 p.u. by 0.4 seconds after the fault has cleared. For wind generator GSU buses, the actual low voltage ride-through capability is used in the simulation. If the voltage response is less than this criterion, the system response to the contingency condition resulting in this condition is re-evaluated to include the loss of generation.

This analysis will generally be performed for both peak and light load conditions for targeted areas of the LIPA system.

9.3 STABILITY CRITERIA

a.) The methodology for identifying system instability is described in NYISO Transmission Planning Guideline #3-1, Guideline for Stability Analysis and Determination of Stability-Based Transfer Limits. For a stability simulation to be deemed stable, oscillations in angle and voltage must exhibit positive damping within ten seconds after initiation of the disturbance. If a secondary mode of oscillation exists within the initial ten seconds, then the simulation time shall be increased sufficiently to demonstrate that successive modes of oscillation exhibit positive damping before the simulation may be deemed stable.

b.) All simulations assume that generators with an angle separation greater than 300 degrees from the rest of the system will trip during post-contingency transient. The 300 degrees is measured from the system average angle.

c.) The stability of the system shall be maintained during and following the most severe design criteria contingencies (refer to Tables A-1 and A-2 for all contingencies and applicable facilities, and NERC TPL-001-4 for additional BES Criteria), with due regard to successful and unsuccessful reclosing.

10. Short Circuit Assessment

Circuit breaker fault (three phase, phase-to-phase-to-ground, and single line-to-ground) duty studies shall be conducted annually. All resulting breaker duties are required to be within their rated interrupting capability. Fault duty is calculated by following the NYISO Transmission Expansion and Interconnection Manual, Attachment I, NYISO Planning Guideline #4-1, Guideline for Fault Current Assessment.

All circuit breaker capacitive and inductive interrupting duties shall be within rated capability.

11. Extreme Events / Contingencies

Studies shall be performed to assess the impact of the extreme events outlined in the NERC Transmission Planning Reliability Standard (Transmission System Planning Performance Requirements; TPL-001-4) Table A, NPCC Directory 1 and NYSRC Reliability Rules which are expected to produce more severe system impacts. Assessment of the extreme events shall examine post-contingency steady state conditions as well as stability, overload, cascading outages and voltage collapse. If the analysis concludes there is cascading caused by the occurrence of extreme events, an evaluation of possible actions designed to reduce the likelihood or mitigate the consequences and adverse impacts of the event(s) shall be conducted.

Criteria/methodology used in the analysis to identify system instability for conditions such as cascading, voltage instability, or uncontrolled islanding shall consider the following:

- Per the NERC Transmission Planning Reliability Standard, the evaluation of extreme events will identify the possibility of cascading. Cascading is defined as the uncontrolled successive loss of system elements triggered by an incident at any location. Cascading results in widespread electric service interruption that cannot be restrained from sequentially spreading beyond an area predetermined by studies. For extreme event assessments, BES elements are evaluated against their STE rating.

- The NYISO Transmission Expansion and Interconnection Manual, NYISO Transmission Planning Guideline #3-1, Guideline for Stability Analysis and Determination of Stability-Based Transfer Limits addresses system stability, including dynamic voltage stability.
- Uncontrolled islanding would occur when generation is isolated with load due to some system condition that is not planned. Uncontrolled islanding will be assessed as part of NYISO / NPCC SS-38 Working Group UFLS studies.

12. Consideration of Non-Consequential Load Loss

For scenarios where the LIPA Transmission System cannot meet the BES performance requirements outlined in this document, a transitional period is allotted in order to allow for compliance with the criteria. Non-consequential load loss may be considered as a corrective action plan during this timeframe. In addition, non-consequential load loss may be considered as a solution for scenarios where a limited portion of the BES system is isolated from the rest of the system and no longer possesses BES characteristics according to the NERC BES definition.

For BES violations under Extreme Weather system conditions, non-consequential load loss may be implemented as a corrective action plan. Non-consequential load loss may also be considered for the severe contingency event in Table A-2.2.

With the exception of the above, LIPA will not consider non-consequential load loss as a permanent design solution, consistent with good utility practice.

13. Special Protection Systems / Remedial Action Schemes

According to the NERC definition, Special Protection Systems are automatic protection systems designed to detect abnormal or predetermined system conditions, and take corrective actions other than and/or in addition to the isolation of faulted components to maintain system reliability.

Special Protection Systems shall not be considered in the planning/design of the LIPA transmission system.