TRANSMISSION DESIGN STANDARDS
(Revision 13)

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REVISION TABLE			
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11th Revision		6/2020	- Included provisions from NERC Standard TPL-001 in the planning criteria (Section III). -Included End-of-Life (EOL) Criteria (Section IV). - Revised interconnection procedures for new facilities (Section VII).
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I. INTRODUCTION

Orange and Rockland Utilities' Transmission Planning has the task of ensuring the reliability and adequacy of the local transmission system while meeting system load growth. Transmission Planning conducts annual comprehensive studies that result in local transmission system plans. In developing these plans, Transmission Planning uses the principles and guidelines mentioned in this document to ensure that the Orange and Rockland ("O&R") local transmission system is capable of serving current and projected distribution loads during normal and emergency conditions. These planning design standards are meant to supplement the New York Independent System Operator ("NYISO") and Pennsylvania Jersey Maryland Interconnection ("PJM") current planning process.

II. BULK POWER SYSTEM

A. Definition

For the New York Control Area ("NYCA"), all facilities at 230 kV and above are considered as bulk power system (BPS), as known as Northeast Power Coordinating Council ("NPCC") A-10 Facilities, including lines, transformer banks where both high and low side terminals at are least 230 kV, shunt devices and generators at 300 MW and above. Planning guidelines and criteria for these facilities are defined by North American Electric Reliability Corporation ("NERC"), NPCC and the New York State Reliability Council ("NYSRC"). These facilities are determined as bulk power by the application of the methodology defined by NPCC's A-10. Bulk power transmission planning is covered by NYISO's planning process. The analysis and studies performed by the NYISO include, but not limited to, thermal, voltage, stability, short circuit and breaker duty and transfer limits. O&R covers Bulk Electric System ("BES").

For the New Jersey Control Area ("NJCA"), the Bulk Electric System is defined as all:

(1) Individual generation resources larger than 20 MVA or a generation plant with aggregate capacity greater than 75 MVA that is connected via a step-up transformer(s) to facilities operated at voltages of 100 kV or higher,
(2) Lines operated at voltages of 100 kV or higher,
(3) Transformers (other than generator step-up) with both primary and secondary windings of 100 kV or higher, and
(4) Associated auxiliary and protection and control system equipment that could automatically trip a BES facility, independent of the protection and control equipment's voltage level.

Planning guidelines and criteria for these facilities are defined by NERC and Reliability First Corporation ("RFC"). BES transmission planning is covered by PJM Interconnection's ("PJM") planning process. The analysis and studies performed by the PJM include, but not limited to, thermal, voltage, stability, short circuit and breaker duty and transfer limits.

B. Reliability

The reliability criteria, guidelines and policies for the NYCA facilities shall be defined by NERC, NPCC and NYSRC. The NJCA facilities shall be covered by NERC, RFC and PJM standards and guidelines.

C. Contingencies

All contingencies shall be defined by NERC, NPCC and NYSRC for the NYCA facilities; the NJCA facilities shall be under the NERC, RF and PJM guidelines.

III. LOCAL TRANSMISSION SYSTEM

A. Definition

The local transmission system consists of all electric facilities operated at 34.5 kV system up to 345 kV system. O&R's transmission system includes BPS and BES Facilities as well as 69 kV and 34.5 kV systems (facilities in Eastern Division) and their supply transformers. However, facilities operating at 34.5 kV in O&R's Central and Western Divisions are considered part of the distribution system.

The basic functions of the local transmission system are:

(1) To deliver generation from remote sites to load centers while operating within the electrical limitations of existing transmission facilities, and supplying service at the desired time and amounts in a reliable manner;

(2) To accommodate system emergencies including outages of generation or transmission facilities without disruption of service; and,

(3) To dispatch generation from the most economical resources available while maintaining system reliability.

B. Reliability

1. No Loss of Load

The Transmission System will be designed and operated to a level where no loss of load will be allowed during reasonably foreseeable contingencies. Loss of small portions of a system, such as radial portions, will be tolerated provided these do not jeopardize the integrity of the overall transmission system.

2. Maintenance Outages

The Transmission System will be designed to allow for maintenance outages. In cases where a substation or customers are supplied from two sources, loss of load will be accepted for reasonably foreseeable contingencies with one supply out for maintenance.

3. **Sufficient Capability**

The Transmission System will be designed with sufficient capability as can be economically justified. Losses will be reduced where possible, optimum economic generation will be provided for and the ability to purchase or sell capacity and energy through various interconnections with other utilities will be maintained.

4. **New Facilities**

New facilities will be designed to provide physical separation so that a single occurrence will not cause simultaneous loss of two supplies to the same distribution substation or load center.

5. **Restoration of Service**

The transfer of load by rearrangement of lines and busses via supervisory control and field switching and readjustment of generator outputs following outages are acceptable means to restore service.

C. Operating Conditions

1. **Normal Operating Conditions(N-0)**

The Transmission system shall be designed to serve load when the system is in normal configuration and the following criteria will be based on *NERC Standard TPL-001-4 Table 1 Category P0 - No contingency condition*:

Thermal Ratings Criteria

No transmission facility exceeded its Normal Thermal ratings and no thermal violations observed in all divisions under normal operating conditions.

Voltage Limit Criteria

All bus voltages should be within 0.95 to 1.05 per unit of their nominal voltage. No voltage violations observed in all divisions under normal operating conditions.

Study results with proposed mitigations are summarized annually in the Transmission System Operating Summer Peak Study ('Annual Summer Study") report.

2. **Single Contingency Operating Conditions (N-1)**

The O&R transmission system shall be designed to sustain single contingency conditions such as outage of a single transmission circuit, transformer or a bus section without loss of load based on *NERC Standard TPL-001-4 Table 1 Category P1 - Single contingency condition*. During any of the above contingencies, **no facility will be loaded above its Normal rating**. When the Normal rating is exceeded during the above single contingencies, T&S Engineering shall propose system reinforcements and/or improvements to mitigate the violation(s). The objective of these corrective measures, whether traditional transmission project or non-wires alternative (NWA) project, is to reduce the MW flow on the affected equipment below its corresponding Normal thermal rating. The maximum acceptable voltage deviation of busses in contingency conditions, after Load Tap Changers (LTCs) of transformers have operated, should not be less than 95% nor greater than 105% of the nominal bus voltage. Study results with proposed mitigations are summarized in the Annual Summer Study report.

3. **Double Contingencies Operating Conditions (N-2)**

The occurrences of the following specific double contingencies are to be examined for the consequences and possible solutions. However, in no case should they result in a system outage affecting more than 10% of total system peak for duration greater than four (4) hours.

a. Transmission circuit and transformer within same substation or load area;
b. Generator and either a transformer or a transmission circuit within the same substation or load area;
c. Two transmission circuits on the same structure
d. Two transformers within same substation
e. Two adjacent bus sections.

Results of the study are summarized in the Annual Summer Study report but for information purposes only.

4. Two Overlapping Single Contingency Operating Conditions (N-1-1)

O&R's 138 kV facilities include twenty-four (24) 138 kV lines, seven (7) 345/138 kV transformer banks and three (3) capacitors designated as BES by NPCC. O&R had been registered as a Transmission Planner ("TP") with NERC, a summary of findings was included in this report using "*NERC Standard TPL-001-4 Table 1 – Steady State & Stability Performance Planning Events", Category P6 - Multiple Contingency (Two Overlapping Singles*). The standard allows the interruption of both firm transmission service and non-consequential load loss (i.e. load shedding) and should bring the power flow on the affected equipment **below their normal ratings and + 5% of the nominal bus voltage**. Results are summarized in the annual TP Assessment Report.

5. Extreme Contingency Operating Conditions

Extreme contingencies are the occurrence of multiple contingency events especially in the BPS that will subject the whole Transmission system to severe conditions and were based on *NERC Standard TPL-001-4 Table 1- Steady State and Stability Performance Extreme Events"*. The occurrences of the following extreme contingencies, per NPCC criteria, are to be examined for possible consequences and solutions:

a. Loss of the entire capability of a generating station;

b. Loss of all lines emanating from a generating station, switching station or substation;
c. Loss of a Right-of-Way ("ROW");
d. Permanent three-phase fault on any generator, transmission circuit, transformer, or bus section, which delayed fault clearing and with due regarding to reclosing;
e. The sudden dropping of a large load or major load center;
f. The effect of severe power swings arising from disturbances outside the NPCC's interconnected system; and,
g. Failure of a special protection system, to operate when required following the normal contingencies.

Results of the study are summarized in the Annual Summer Study report but for information purposes only.

D. Voltage

The Transmission System shall have supervisory or automatic controls capable of maintaining voltages at levels, which will not exceed limits of the connected equipment during both normal and contingency conditions and will allow for meeting the criteria for customer voltage as defined in the Distribution Planning Criteria.

1. Operating Range

1.1. Normal Operating Conditions

The voltages on the Transmission System will be maintained within ± 5% of nominal voltage under normal conditions.

1.2 Single Contingency Operating Conditions

The maximum acceptable voltage deviation during single contingency conditions after LTC transformers have operated within ± 5%, but not less than 95% or greater than 105% of nominal voltage.

2. **Reactive Requirements**

Capacitors banks are installed in the distribution system for voltage support and loss reduction. On the transmission system, capacitor banks will be installed to provide voltage support during normal operating conditions and post-contingency conditions.

E. Generating Unit Stability

With all transmission facilities in service, generator unit stability shall be maintained on those facilities not directly involved in clearing the fault for:

1. A permanent three-phase fault or phase-to-ground fault on any generator transmission circuit, transformer or bus section cleared in normal time;
2. A permanent phase-to-ground fault on any generator transmission circuit, transformer or bus section with delayed clearing.

IV. THERMAL RATINGS AND METHODOLOGIES

The methodology and criteria used by O&R in rating its transmission line facilities are in accordance with the latest report of the New York Transmission Owner ("NYTO") Task Force on Tie Line Ratings. Southwire Ratings Program based on latest version of IEEE 738 Standard was utilized to calculate of the thermal ratings for the overhead conductors.

The transformer thermal ratings are derived from the latest version of EPRI's Power Transformer Loading Program ("PT LOAD"), which is based on the latest version of IEEE's "Guide for Loading Oil-Immersed Distribution and Power Transformer "(IEEE C57.91).

A. Overview

It is the responsibility of Engineering to calculate and issue the thermal ratings of O&R's overhead and underground transmission facilities. Engineering shall issue ratings for all O&R transmission facilities operated at nominal voltages of 69 kV or greater; and certain facilities operated below 69 kV including the 34.5 kV system in the Eastern Division, which operated as a transmission system. Thermal ratings are also calculated for 34.5 kV system which are operated as distribution system including the Harriman-Highland Falls/West Point 34.5 kV loop in the Central Division and the 34.5 kV Western Division system.

The purpose of this section is to describe the methodologies used to rate all equipment which may in any way impose loading constraints on transmission circuits, and thus, the ratings are referred to as "thermal ratings." Three thermal ratings will be computed, namely, Normal rating, Long-term Emergency ("LTE") rating and Short-time Emergency ("STE") rating. However, non-thermal restrictions, such as those imposed by relay settings or design sag limitations, are also recognized and included where appropriate.

The focus of this section is on the capabilities of the transmission circuits, therefore, station equipment not associated with specific transmission circuits will not be included. However, all transmission circuit ratings include the ratings of substation equipment where the equipment terminates and/or limits the specific circuit.

B. Transmission Circuit Methodology and Derivation of Ratings

The methodology and criteria used by O&R in rating its transmission facilities are largely derived from latest version of the "NYTO Task Force on Tie Line Ratings." From the report, the conductor ratings are thermal and the prime consideration in thermal rating determination is that the conductor should not sustain more than ten percent (10%) loss of strength due to annealing over its useful life.

1. Thermal Ratings Definition

The operating conditions for which each circuit is rated are defined in the following manner:

1.1 Normal Rating

This refers to the maximum loading that the conductor can carry continuously.

1.2. LTE Rating

This refers to the maximum loading, which may be carried by a conductor up to four (4) hours following a contingency, totaling not more than 300 hours for the life of the line.

1.3. STE Rating

This refers to the maximum loading, which may be carried by a conductor up to fifteen (15) minutes following a contingency totaling not more than twelve and a half (12-½) hours for the life of the line.

2. Calculation Assumptions for Overhead Conductors

Southwire Ratings Program was used in the calculation of the overhead conductors' thermal ratings with the following assumptions:

2.1. Maximum Overhead Conductor Temperature

Conductor Type*	SUMMER			WINTER		
	Normal	**LTE**	**STE**	**Normal**	**LTE**	**STE**
ACSR	95°C	115°C	125°C	95°C	115°C	125°C
Copper	75°C	100°C	125°C	75°C	100°C	125°C
HTLS**	180°C	200°C	220°C	180°C	200°C	220°C

**Double conductor derate factor: 90%*
***High Temperature Low Sag conductors*

***Table 1*: Maximum Allowable Overhead Conductor Temperature**

2.2. Weather Conditions

The weather provides cooling by means of convective heat loss to the surrounding air. The degree of cooling mainly depends on air temperature, wind speed and wind direction.

a. Ambient Air Temperature

The ambient air temperatures for summer and winter operating conditions are 35 °C (95°F) and 10°C (50°F), respectively.

b. Wind Speed

The wind speed used is **3 feet per second**.

c. Wind Direction

For given wind speed, winds blowing parallel to the conductor result in a 60% lower convective heat loss than winds blowing perpendicular to the conductor. Thermal ratings for bare conductors are traditionally calculated for perpendicular wind even though this is not a conservative assumption. (Perpendicular wind is adopted for the calculations).

2.3. Solar Heating

Five data are used solely in calculating the solar heat input to the conductor, namely, Altitude/Latitude, Date, Solar Time, Conductor Orientation and Atmosphere. The conductor's solar absorptivity and emissivity are also used. Elevation above sea level affects both solar heat input and convection heat loss since air density also depends on elevation.

***a*. Elevation above Sea Level**

The solar heat intensity increases with altitude being about 15% higher at 1500 m (5000 ft) than at sea level. (Assumed elevation above sea level is 0 ft).

b. Latitude (deg)

Latitude of the line determines both the solar azimuth and solar altitude angles. (Assumed 45 degree Latitude).

c. Date

Summer months are June through September while winter months are December through February.

d. Solar Time

Solar heating is at its maximum between noon and 3 pm.

e. Atmosphere

The solar heating in a heavily polluted air is reduced from 20% to 50% depending on the solar altitude. (Assumed most conductors are in industrial area).

f. Absorptivity and Emissivity

Absorptivity and Emissivity factors range from 0.3 to 0.9 depending on the conductor's years of service. For new installations, a factor of 0.5 was used for both absorptivity and emissivity.

3. Calculation Assumptions for Underground Cables

In 2021, O&R Underground Engineering updated the Underground cable ratings to utilize cable manufacturer recommended ratings. In 2022, UG Engineering had all Underground cable ratings reviewed by a consultant for increased consistency across the different manufacturer calculations. The methodology now utilizes a new cable rating program, CYMPCAP. The calculations have been performed with updated constants and assumptions to provide a consistent approach. This modeling included evaluating the cables with a consistent load factor and emergency ratings conditions as well as incorporating as-built constraints and depth into the calculations.

4.2. Other Substation Terminal Equipment including Circuit Breakers, Line Traps, Current Transformer and Disconnect Switches *(As a percentage of nameplate ratings):*

Equipment Type	SUMMER			WINTER		
	Normal	**LTE**	**STE**	**Normal**	**LTE**	**STE**
Circuit Breakers	104%	116%	133%	122%	134%	149%
Line Traps	101%	111%	141%	107%	118%	150%
Current Transformer	100%	128%	150%	122%	148%	150%
Switches 30°C Rise	108%	153%	200%	141%	178%	200%
53°C Rise	105%	127%	160%	125%	144%	174%

Table** 2: Other Substation Terminal Equipment** *(Percentage of Nameplate Rating)*

C. Transformer Ratings Methodology

1. Overview

The methodology and criteria used by O&R in rating its power transformers and distributions substation transformers are derived from EPRI's PT LOAD Program, which was based on the latest version of the IEEE "Guide for Loading Oil – Immersed Distribution and Power Transformers" (IEEE Standard C57.91). Like its earlier versions, the recommendations developed in the IEEE C57.91 used the thermal aging of the winding insulation as the basis for its criteria. The aging of the transformer winding insulation is a major factor in the life expectancy of a transformer, commonly referred to as the "Loss of life" of a transformer.

Transformer life and loading are primarily dependent upon the thermal characteristics of a transformer. Life curves of insulation systems have been established which relate loss of life with the absolute temperature of the insulation (hot spot) and time. The effects of temperature and time are cumulative. The rating factors have been selected so that the total loss of life for the insulation system will be approximately 10% over a 40-year life.

Ambient temperatures have a significant effect on transformer load ability. IEEE Standard C57.91 recommends that the average ambient temperature be used when determining normal ratings and average maximum ambient temperature be used in determining ratings with some loss of life.

PT Load Program utilizes the "Top Oil" Model with various specific test data and physical characteristics as input, and then computes the summer and winter loading capability as a function of loss of life and preloading conditions. Typical input data are enumerated in the succeeding pages.

2. EPRI'S Power Transformer Loading (PTLOAD) Program

This program implements calculations from the latest version of the IEEE Standard C57.91-, "Guide for Loading Mineral-Oil Immersed Transformers," as well as the IEC Standard 354, "Loading Guide for Oil-Immersed Power Transformers." The guide covers general recommendations for loading 65° C rise mineral-oil-immersed power transformers as well as recommendations for the 55° C rise transformers still in the system. PT LOAD calculates transformer temperatures, ratings, loss of insulation life, and gas bubble formation based on user-specified physical parameters for the transformer and user-specified load and air temperature data. Although PT LOAD offers a choice between the conventional "top oil" rating algorithm, based on IEEE Standard C57.91, and the new "bottom oil" rating algorithm also from the same standard, the calculations here were only based on the "top-oil" concept.

Top Oil

The "Top Oil' model assumes a linear temperature distribution from the bottom bulk oil to the top bulk oil and a parallel rise in the winding temperatures. These temperatures are assumed to vary as a function of the losses.

Bottom Oil

The "Bottom Oil" model is more complex than the top oil model. This model takes into account the faster-rising duct oil-temperatures, as well as a more complex calculation of bottom and top oil temperatures as a function of loss.

2.1. Input Data

PTLOAD utilizes operating conditions, specific test data and physical characteristics as input to determine the loading capability of the transformer:

- Coincident load for each distribution substation bank for 24-hour period during the summer peak days.
- Ambient Temperature Cycle over a 24-hour period on the corresponding peak day.
- Assumed 90% preloading.

Typical transformer data consists of the following information from the nameplate or final test reports.

- Top-oil temperature rise over ambient temperature at rated load.
- Average conductor temperature rise over ambient temperature at rated load.
- Winding hot-spot temperature rise over ambient temperature at rated load.

- Load loss at rated load.
- No load (core loss).
- Total loss at rated load.
- Confirmation of oil flow design (that is, directed or non-directed).
- Weight of core and coil assembly.
- Volume of oil in the tank and cooling equipment (excluding LTC compartments, oil expansion tanks, etc.).

2.2. Transformer Loading

Applications of loads in excess of nameplate rating involve some degree of risk. While aging and longtime mechanical deterioration of winding insulation have been the basis for the loading of transformers, it is now recognized that there are additional factors that may involve greater risk for transformers of higher mega-volt-ampere (MVA) and voltage ratings.

Power transformer life expectancy at various operating temperatures is not accurately known, but the information given regarding loss of insulation life at elevated temperatures is the best that can be produced from present knowledge of the subject. Loads in excess of nameplate rating may subject insulation to temperatures higher than the basis of rating definition. To provide risk associated with higher operating temperature, three (3) basic loadings have been included in this report.

2.2.1. Normal Loading

The basic loading of a power transformer for normal life expectancy is continuous loading at rated output when operated under usual conditions. It is assumed that the operation under these conditions is equivalent to operation in an average ambient temperature of 30°C for a cooling air or 25°C for cooling water. Normal life expectancy will result from operating with continuous hottest-spot temperature of 110°C (or equivalent variable temperature with 120°C maximum in any 24-hour period). The 110°C hottest-spot temperature is based on the hottest-spot rise of 80°C plus the standard average ambient temperature of 30°C (105°C for an average ambient of 25°C).

This loading should entail normal winding insulation loss of life for a 24-hour period with a load cycle of 90% preloading or about **0.0133%**. For a 55°C Rise and 65°C Rise transformers, the top oil temperature and hottest-spot temperatures are:

Temperatures	**55°C Rise**	**65°C Rise**
Top Oil	95°C	105°C
Hottest spot	105°C	120°C

Table 3: **Normal Loading Top Oil & Hottest Spot Temperatures**

2.2.2. Long Term Emergency (LTE) Loading

Long term emergency loading results from the prolonged outage of some system element and causes either the conductor hottest-spot or the top-oil temperature to exceed those suggested for normal loading beyond nameplate rating. This is not normal operating condition but may persist for some time. It is expected that such occurrences will be rare. This loading assumes a **0.25%** loss of insulation life per occurrence not to exceed 4 hours, also with a 90% preloading. This is equivalent to approximately 19 days loss-of life for the one day in which the emergency occurs.

The LTE top oil temperature and hottest-spot temperatures used in the calculations for 55°C rise and 65°C rise transformers are:

Temperatures	55°C Rise	65°C Rise
Top Oil	100°C	110°C
Hottest spot	140°C	140°C

Table 4: **LTE Loading Top Oil & Hottest Spot Temperatures**

2.2.3. Short Time Emergency (STE) Loading

Short time emergency (STE) loading is unusually heavy loading brought about by the occurrence of one or more unlikely events that seriously disturb normal system loading and cause either the conductor hottest-spot or top-oil temperature to exceed the temperature limits suggested for normal loading beyond nameplate rating. Unlike during long-term emergency, the 0.25% loss of insulation life per occurrence **will not be reached** for this type of loading given the short 15 minutes time period and other limiting criteria.

The top oil temperature and hottest-spot temperatures used in the calculations for 55°C rise and 65°C rise transformers are:

Temperatures	55°C Rise	65°C Rise
Top Oil	100°C	110°C
Hottest spot	150°C	150°C

Table 5: **STE Loading Top Oil & Hottest Spot Temperatures**

PT LOAD's provision for Bubble Avoidance as suggested by the IEEE Standard was not applied in the calculations.

V. SYSTEM FREQUENCIES

A. Standard Frequency

The standard frequency on the O&R system is nominally 60 hertz. A sustained frequency excursion of $\pm$0.2 hertz is an indication of a major load-generation unbalance and possible formation of an island. A load shedding program has been developed in order to provide selectivity and flexibility. Most generators are incapable of sustained operation below a specified minimum frequency, typically less than 58.5 hertz.

B. Automatic Underfrequency Load Shedding

Underfrequency ("UF") relays are installed at various locations throughout the system to provide protection against widespread system disturbances. The Underfrequency Load Shedding Program ("UFLS") is updated each year for the NYISO and PJM.

1. Circuit Weight

A circuit weight is calculated annually for each circuit based on the priority of the customers that are located on the circuit. For example,

(a) A circuit contains a hospital (150), a nursing home (25) and a prison (2) would have a circuit weight of 177.

(b) An artificial weight is given for the two circuits that feed the O&R Spring Valley Operating Center building.

The available circuits with UF relays are then prioritized by circuit weight. Excluding circuits with high priority customers, such as hospitals and malls, the UF relays are then turned on for the higherweighted circuits until the cumulative load for these circuits reaches the requirement for each level. The UF relays for the remaining circuits are turned off.

2. UF relays:

2.1. The **NPCC** requirements are for two frequency settings based on the previous year's peak. The first setting requires 10% of the previous year's peak plus 25% of the curtailable load and co-generation used during the previous year's peak to be shed at 59.3 hertz. The second setting requires 15% of the previous year's peak to be shed at 58.8 hertz.

2.1. **RFC** requirements are for three frequency settings based on forecasted peak. The first setting requires 10% of the year's forecasted peak to be shed at 59.3hertz. The second setting requires 10% of the year's forecasted peak to be shed at 58.9 hertz. The third setting requires 10% of the year's forecasted peak to be shed at 58.5 hertz.

C. Manual Load Shedding:

The Manual Load Shed Program is updated every year based on the new circuit weights and the circuits selected for the underfrequency program. Excluding the high priority customers, such as hospitals and malls (public place for heat and air), the circuits that do not have underfrequency relays and the circuits in which the UF relays are turned off are grouped together and prioritized by circuit weight in ascending order. When these circuits are completed, the circuits with underfrequency relays turned on are prioritized by circuit weight in ascending order. Finally, after these circuits are completed, the remaining circuits (high-prioritized circuits) are prioritized by circuit weight in ascending order as well.

VI. INTERCONNECTION PROCEDURES FOR NEW FACILITIES

This Section will cover the interconnection process for integrating new generation, merchant transmission and end-user facility into the transmission system of Orange Rockland Utilities/Rockland Electric Company ("O&R/RECO"). For more details, please refer to **ORU-ENGR-06A – FACILITY INTERCONNECTION INFORMATIONAL KIT.**

A. NYISO AND PJM Interconnection Processes

O&R's service territory and RECO's Central Division are located in the NYISO; RECO's Eastern Division is located in the PJM. All proposed connections to the ORU/RECO transmission system are governed by the NYISO OATT and PJM OATT, as applicable**. Table 1** summarizes the various types of project interconnections and the applicable NYISO/PJM Manual References.

The NYISO OATT and PJM OATT both require a number of technical system studies to evaluate the potential impact of a new facility's interconnection to the NYISO or PJM transmission system. These system studies are performed so that the proposed interconnection project does not have an adverse impact on the performance of the NYISO/PJM bulk power system, as well as the underlying O&R/RECO transmission system. These studies are also used to allocate cost responsibility for the necessary system upgrades to mitigate any potential adverse impact to the bulk power system, as well as the O&R/RECO transmission system.

The NYISO or PJM is responsible for performing these technical studies, although the NYISO may subcontract to O&R and PJM may subcontract to RECO the performance of certain aspects of a particular study. Studies performed on previous projects may be obtained from the NYISO or PJM.

Below are high-level flow charts of NYISO's Standard Large Facility Interconnection Procedures (Attachment X – **Figure 1**), NYISO's Transmission Interconnection Procedures (Attachment P – **Figure 2**) and PJM's Generation Interconnection Requests (Manual 14G – **Figure 3**).

Table 6: GENERATING FACILITIES AND TRANSMISSION PROJECT INTERCONNECTIONS

Regional Transmission Operator	TYPE OF INTERCONNECTION	APPLICABLE NYISO/PJM MANUAL REFERENCES
NYISO[1]	Generating Facilities, No Larger than 20 MW	Small Generator Interconnection Procedures (NYISO OATT 32 **Attachment Z**)
	Generating Facilities that Exceed 20 MW and Merchant Transmission Facilities	Standard Large Facility Interconnection Procedures (NYISO OATT 32 **Attachment X**)
	Transmission Load Interconnection	Transmission Interconnection Procedures (NYISO OATT 32 **Attachment P**)
PJM[2]	Customer Owned Generator Request (Under 20 MW)	Generation Interconnection Requests (PJM **Manual 14G**)
	Customer Owned Generator Request (Over 20 MW)	Generation Interconnection Requests (PJM **Manual 14G**)
	Customer-Owned Merchant Transmission Facilities Request	Upgrade and Transmission Interconnection Requests (PJM **Manual 14E**)
	Customer-Funded Upgrade to Transmission Facilities Request	Upgrade and Transmission Interconnection Requests (PJM **Manual 14E**)

[1]In the NYISO, Generating Facilities include Photo-Voltaic ("PV"), Energy Storage and other Renewable Projects.

[2]In PJM, Customer Owned Generator Requests include PV, Energy Storage and other Renewable Projects.

These charts are intended to serve as a general guide to the Interconnection Processes. Developers and/or representatives should consult the most current NYISO OATT or PJM OATT or contact NYISO's Interconnection Office or PJM's Interconnection Department for details and/or updates on the interconnection procedures and manual references.

Figure 1: *NYISO's Attachment X Process (high-level flow chart)*

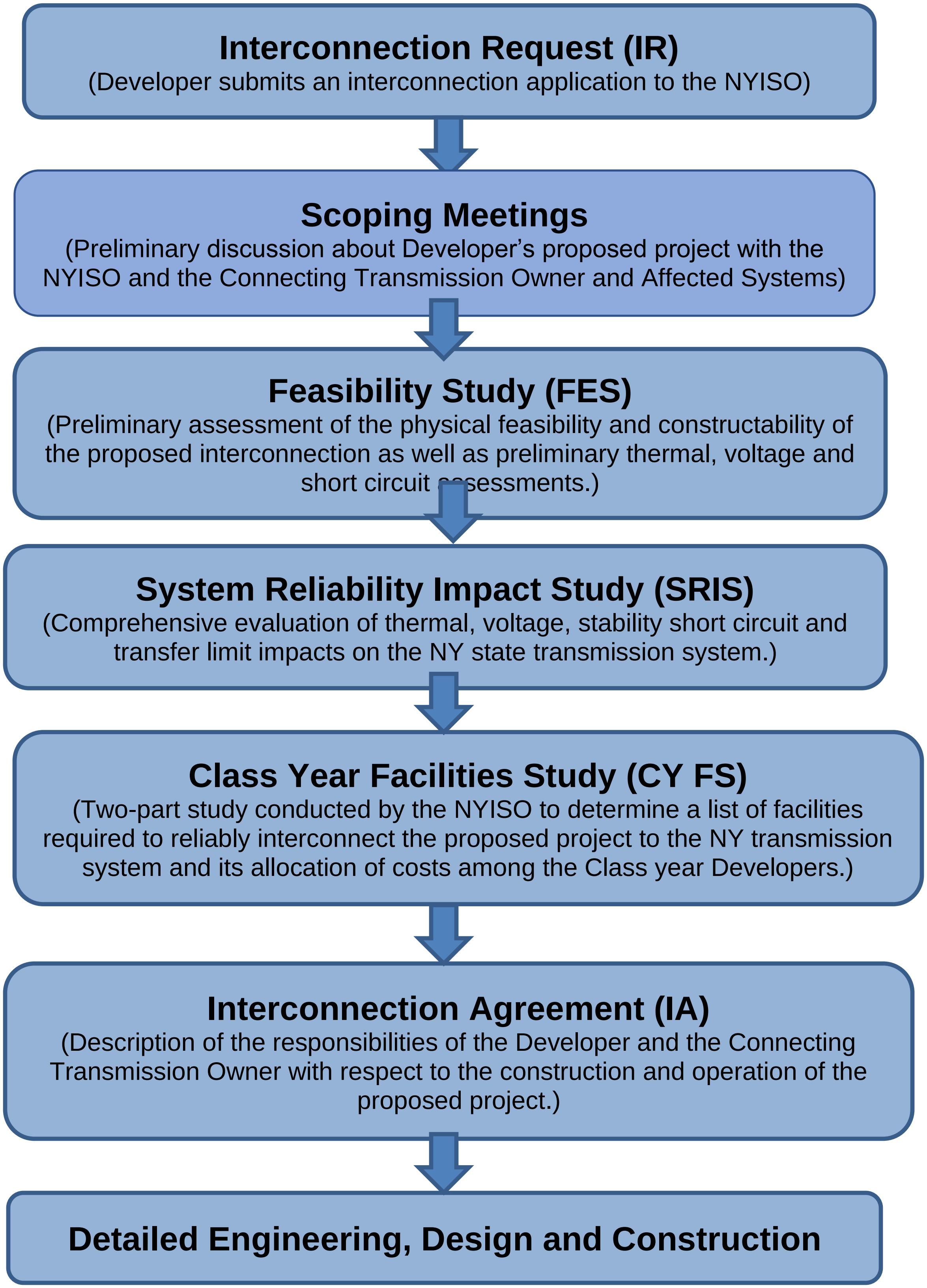


Figure 2: *NYISO's Attachment P Process (high-level flow chart)*

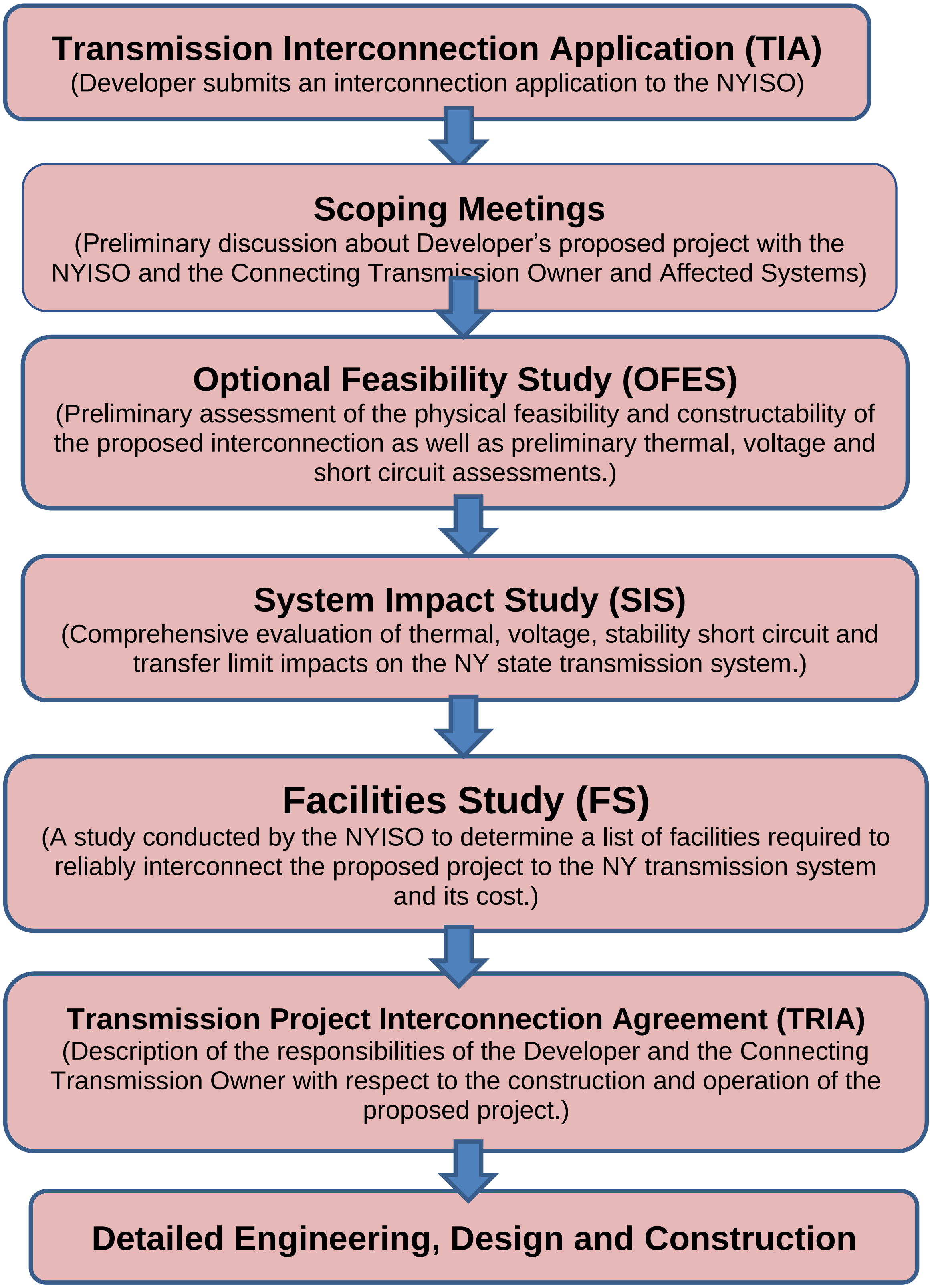
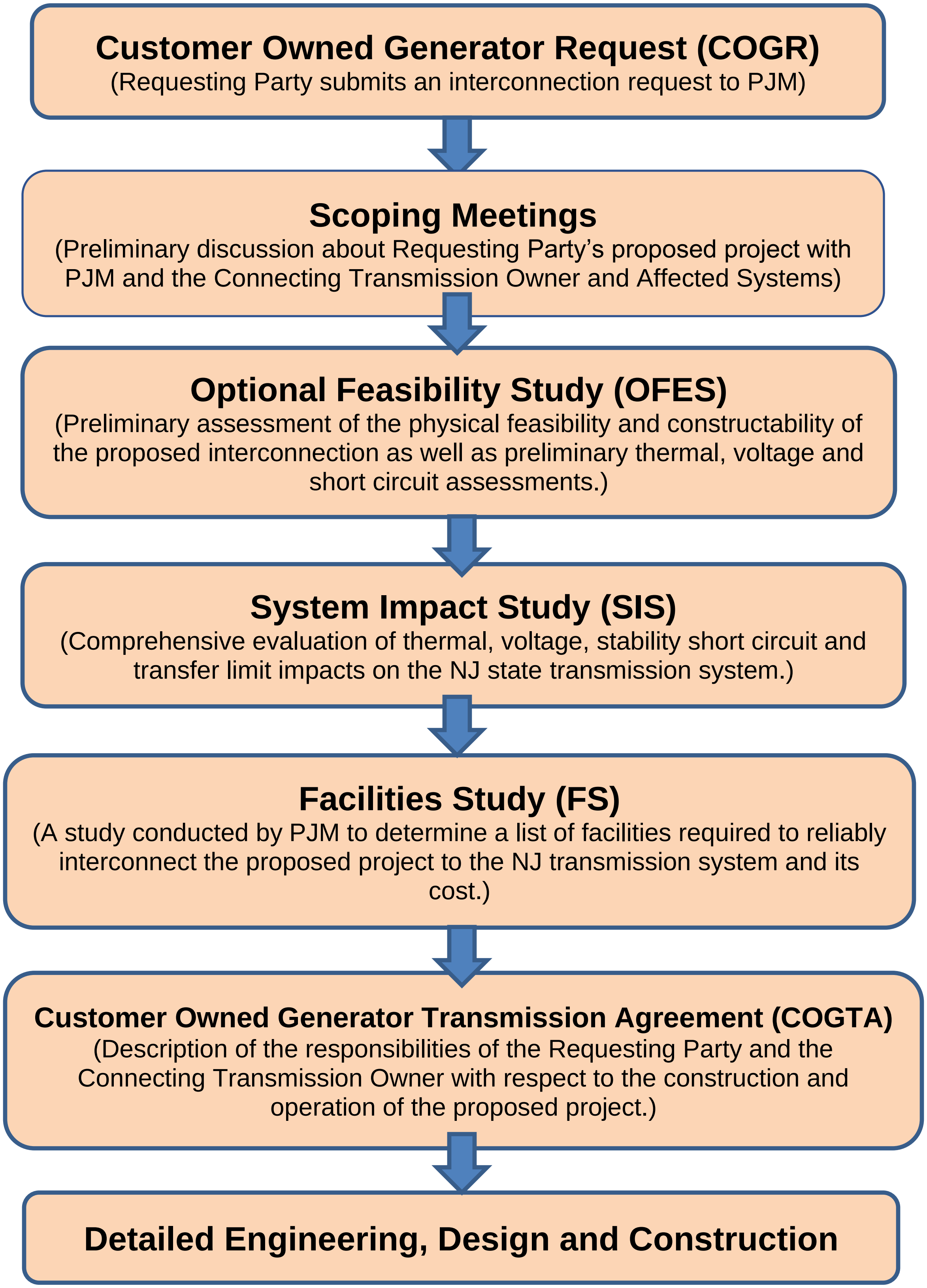


Figure 3: *PJM's Manual 14G Process (high-level flow chart)*



B. General Requirements

Interconnection of a proposed project to the O&R/RECO electric transmission system must meet all currently established reliability, operational, environmental and safety standards. All interconnection requests shall comply with the requirements of NERC, NYSRC, NPCC, NYISO, RFC and PJM, as applicable. These requirements are publicly available and can be obtained by contacting the relevant organization.

Developers and/or representatives shall comply with all applicable safety laws, building and construction codes including provisions of applicable Federal, State or local safety, health or industrial regulations or codes, as well as all applicable O&R/RECO safety practices and requirements

C. Substation Configurations (Breaker Arrangement)

At the 69 and 138 kV voltage levels, a proposed project can interconnect to an existing substation, or to a new substation at the location of the developer's/representative's choice.

Interconnection at an Existing Substation

The existing substations at the 69 kV and 138 kV voltage levels are primarily designed with straight bus, breaker and a half, or ring bus configurations. The type of connection to an existing substation would depend on the existing substation configuration which will be determined on a case-by-case basis. All modifications and additions performed shall be designed to comply with the applicable O&R/RECO Transmission and Substation Design Standards and system operational requirements.

O&R/RECO shall specify the relay protection, metering and control systems design at the interconnecting substation as well as upgrades at remote terminal substations including all settings for protective systems that protect O&R/RECO equipment.

Interconnection at a New Substation and Transmission Connections

The developer and/or representative may elect to build interconnection facilities, such as new substations and transmission lines, on Greenfield sites. Under this option, the developer or representative will engineer, design, procure, construct and commission the Greenfield interconnection facilities that will be owned by O&R/RECO. The developer and/or representative shall hire contractors and vendors that will adhere to O&R/RECO's standards/specifications with O&R's/RECO's oversight and approval.

For a proposed project, O&R/RECO shall specify the protection system design and provide all settings for protective systems that will protect the O&R/RECO equipment.

The developer and/or representative shall coordinate the schedule for its work with O&R/RECO so that its requests for oversight/approval are matched with available O&R/RECO resources.

Connection to the O&R/RECO 138 kV system shall be made using ring bus configuration. A four (4) breaker ring bus shall be used when interconnecting to a single transmission line (see **Figure 4**). If more than one transmission line is affected, the number of circuit breakers in the ring bus will be adjusted accordingly.

A proposed project's connection to the O&R/RECO 69 kV system shall be made using a three (3) circuit breaker configuration (see **Figure 5**). If two (2) or more lines are affected, a ring bus configuration shall be used (see **Figure 6**).

Figure 4: Generating Facilities and Transmission Projects Connecting to a 138-kV Transmission Line

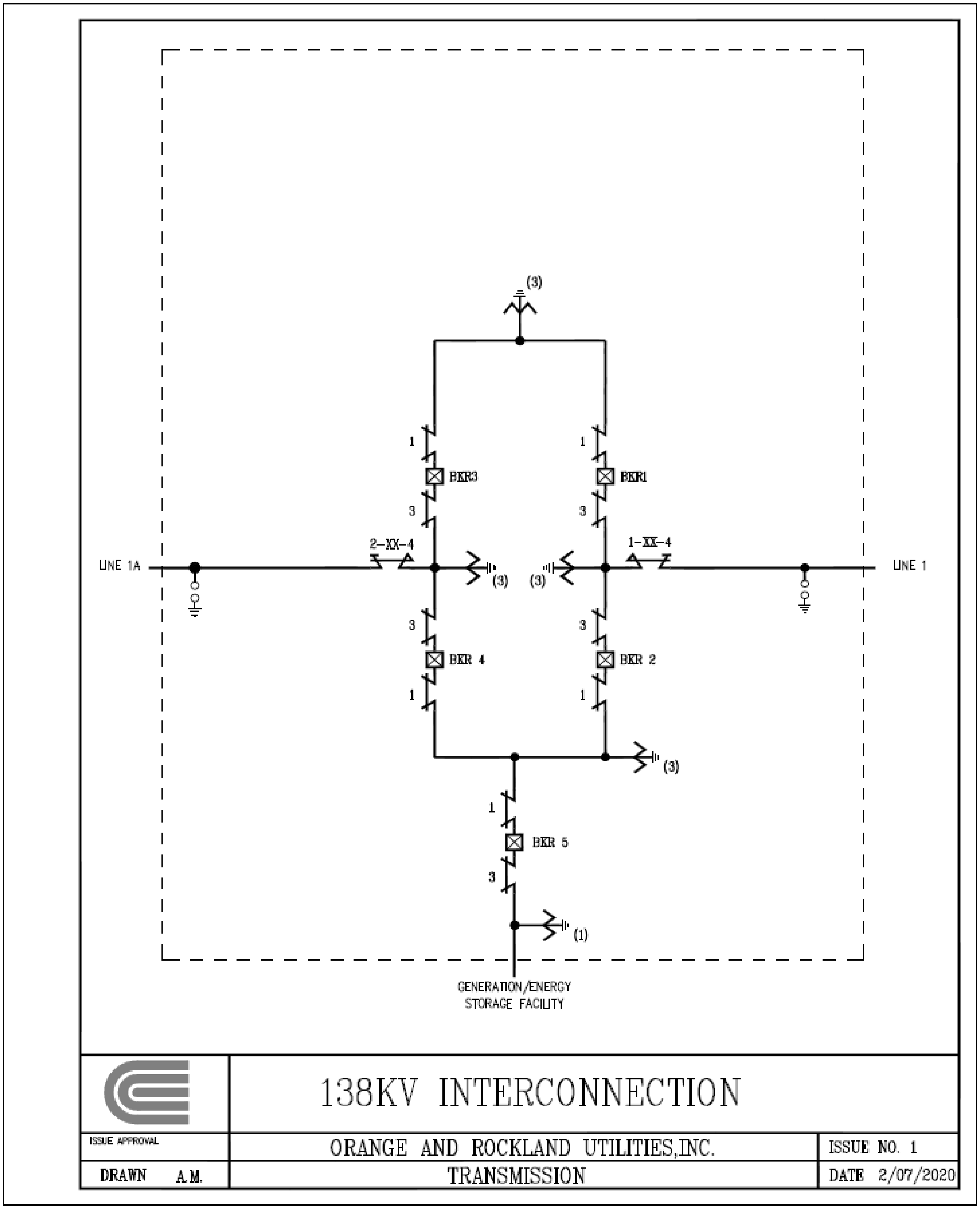


Figure 5: Generating Facilities and Transmission Projects Connecting to a 69 kV Transmission Line

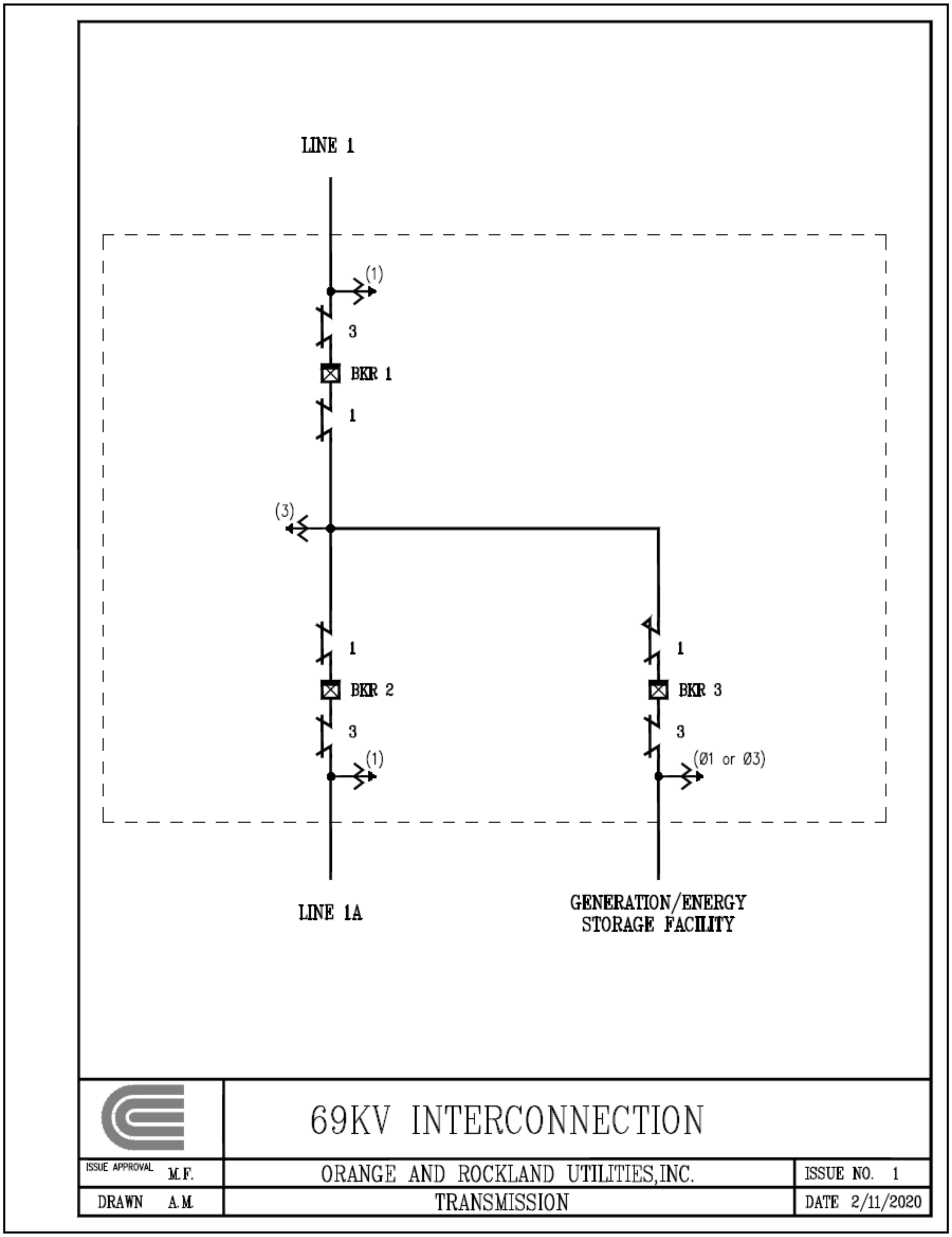
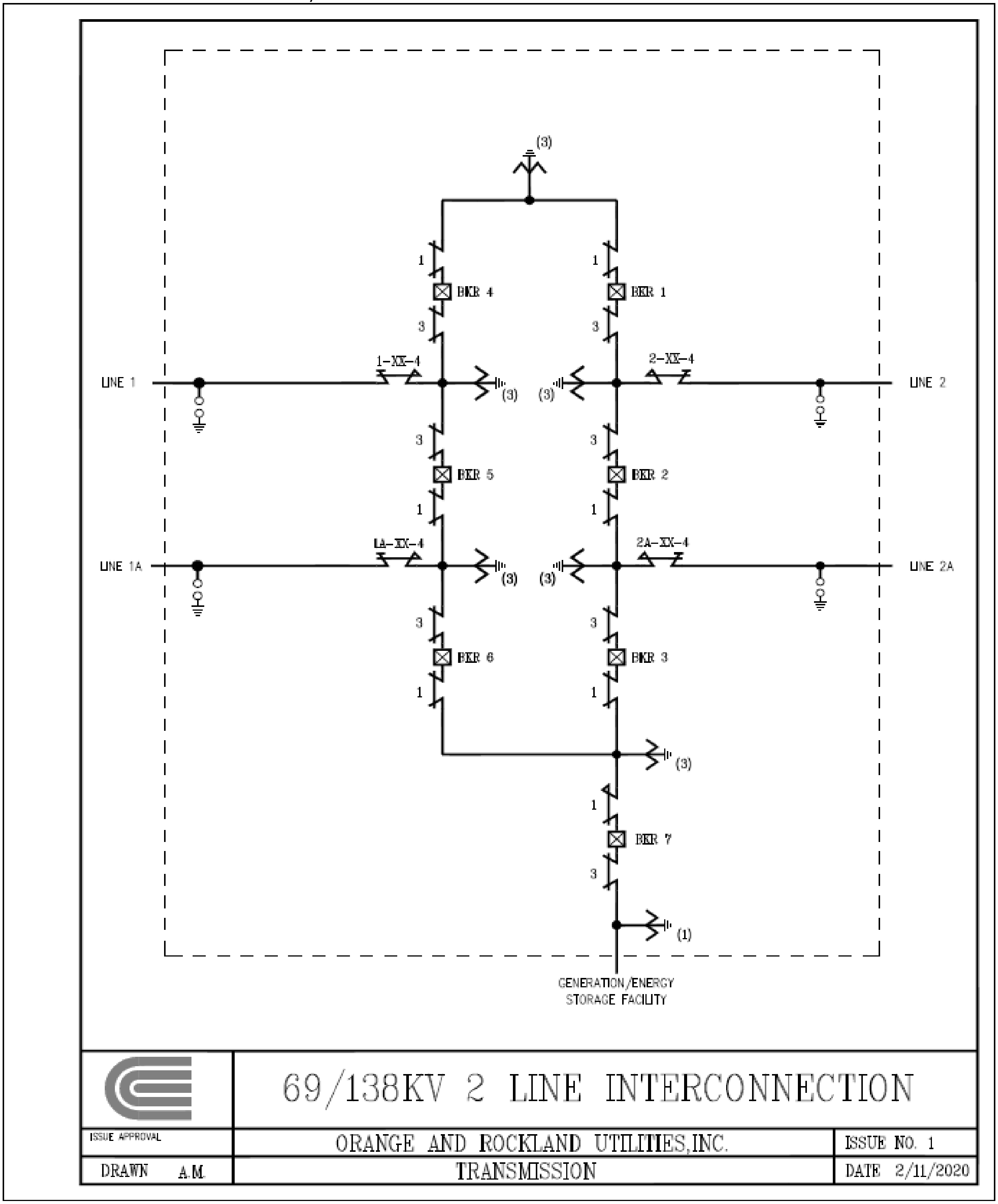


Figure 6: Generating Facilities and Transmission Projects Connecting to a Double 69 kV/138 kV Transmission Line



D. Developer Responsibilities

For a proposed project, the developer and/or representative shall suggest one or more points of interconnection ("POI") for evaluation. O&R/RECO will review the feasibility of the suggested POIs but will not be obligated to recommend a particular POI. One-line diagrams provided by the developer and/or representative shall show the transmission lines on the one-line diagrams by following the above substation configurations.

Any developer and/or representative proposing to expand an existing O&R/RECO substation shall clearly identify the bus section to which their Attachment Facilities will be connected, the isolating circuit breakers and disconnect switches. Any developer and/or representative proposing to expand or modify an existing substation shall identify the existing equipment in black and the new equipment in red. There may be instances when O&R/RECO considers expansion of an existing substation impractical due to a limited available additional footprint area (*e.g.*, the site is surrounded by wetlands).

The final substation design shall also consider the possibility that a device or piece of equipment proposed to be installed may fail. The design of the interconnection, and construction and installation of the associated equipment, shall be done so that a potential failure will disrupt the station to the least possible extent and will not jeopardize the station or system reliability. Particular attention should be given to the space requirements for on-site repair, maintenance activities of existing equipment, and safe removal of any failed equipment.

The technical requirements for transmission substation design can be found in the latest version of **ORU-ENGR-06B – FACILITY INTERCONNECTION REQUIREMENTS**

E. ORU/RECO Additional Requirements

Upon submission of a valid interconnection request to either the NYISO or PJM, O&R/RECO will allow a developer or representative supervised access to the desired interconnecting substation for the purpose of a site visit and technical evaluation. O&R/RECO will grant access only after a developer or representative has executed the Non-Disclosure Agreement ("NDA").

In some instances, O&R/RECO will provide the developer and/or representatives of substation equipment photographs that will assist them in developing their lay-out and equipment design at the POI. These photographs constitute confidential information and should be treated as such.

F. Requirements for Inverter Based Resources

In September 2018, NERC issued a Reliability Guideline on BPS-Connected Inverter Based Resource Performance. In that document, NERC mentioned that the North American bulk electric system and underlying electric grids are undergoing rapid changes in generation mix with increasing amounts of renewable generation such as wind, solar and energy storage power plants. These resources are asynchronously connected to the electric grid and are either completely or partially interfaced with the BPS through power electronics, hence referred to as Inverter-Based Resources ("IBR").

Like many any other utilities, O&R has experienced the influx of these IBRs in recent years. This document describes O&R's general performance requirements for these types of resources connecting to 69 kV and above transmission system. It should be noted that only the general performance guidelines are included (see **ORU-ENGR-008 – Inverter Based Resources**

Performance Requirements). For specific requirements, the developer and/or requesting party should utilize NERC's Reliability Guideline document.

Momentary Cessation

Momentary cessation, also referred to as "blocking", is when no current is injected into the grid by the IBRs during low or high voltage conditions outside the continuous operating range. This occurs because the power electronic firing commands are blocked, and the inverter does not produce active or reactive current (and therefore no active or reactive power).

IBRs connected to the O&R transmission system are expected to continue to inject current inside the "No Trip" zone of the frequency and voltage ride through curves of PRC-024-2 (see **Figure 1** and **Figure 2** below). Existing and newly interconnected IBRs should eliminate the use of momentary cessation to the possible extent.

Frequency Control

IBRs connected to the O&R transmission system should ensure that the frequency measurement and protection settings are set such that these resources are able to ride-through and not trip for grid disturbances and should be within the frequency ride-through capability curve (see **Figure 2**). FERC Order No. 842 recommends that new generation is expected to adjust its output to follow its droop of 5% whenever the frequency is at least outside of ± 0.36 Hz.

Voltage Control

IBRs connected to the O&R transmission system should operate in automatic voltage control at all times in order to support voltage regulation and voltage stability. The automatic voltage control shall be continuously enabled to control reactive power injection in all expected operating conditions. IBRs should be designed to provide reactive power 0.85 lagging to 0.95 leading at all active power outputs at the Point of Interconnection (POI).

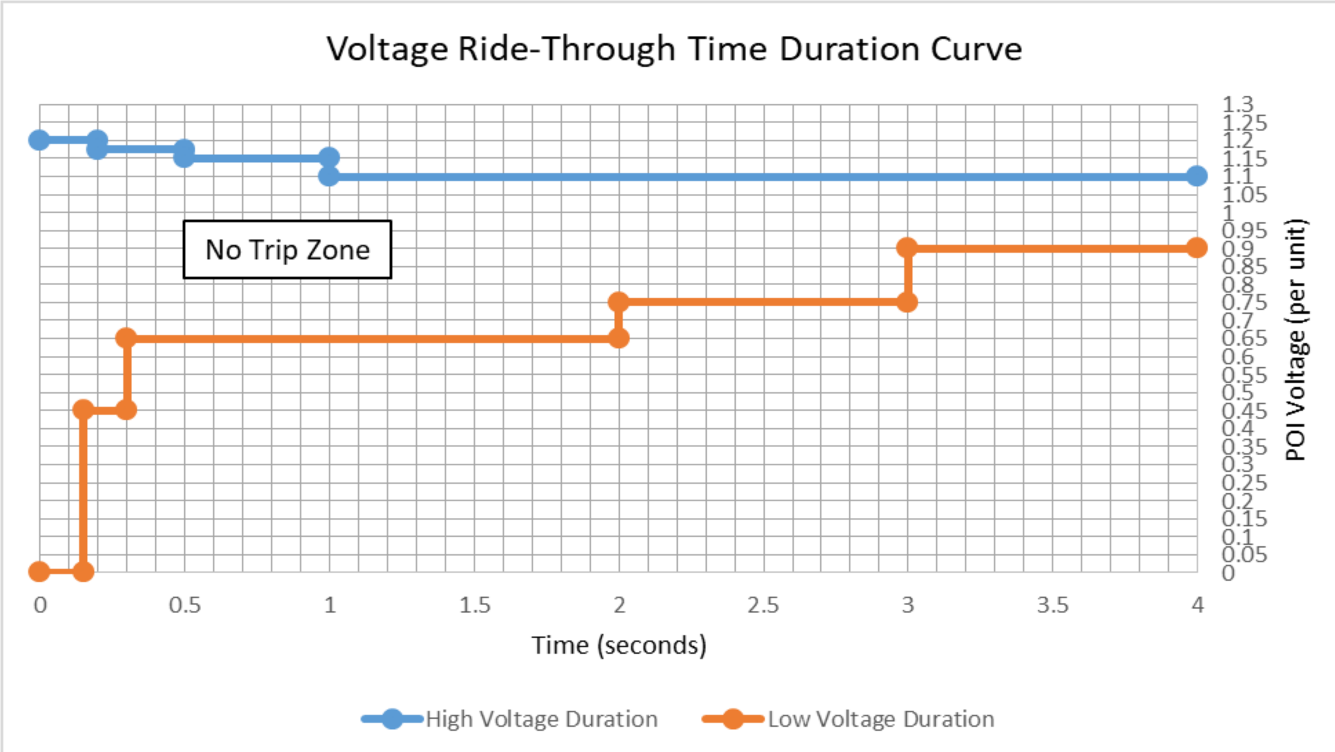


Figure 7: NERC Standard PRC-024 Voltage Ride-Through Duration Curve

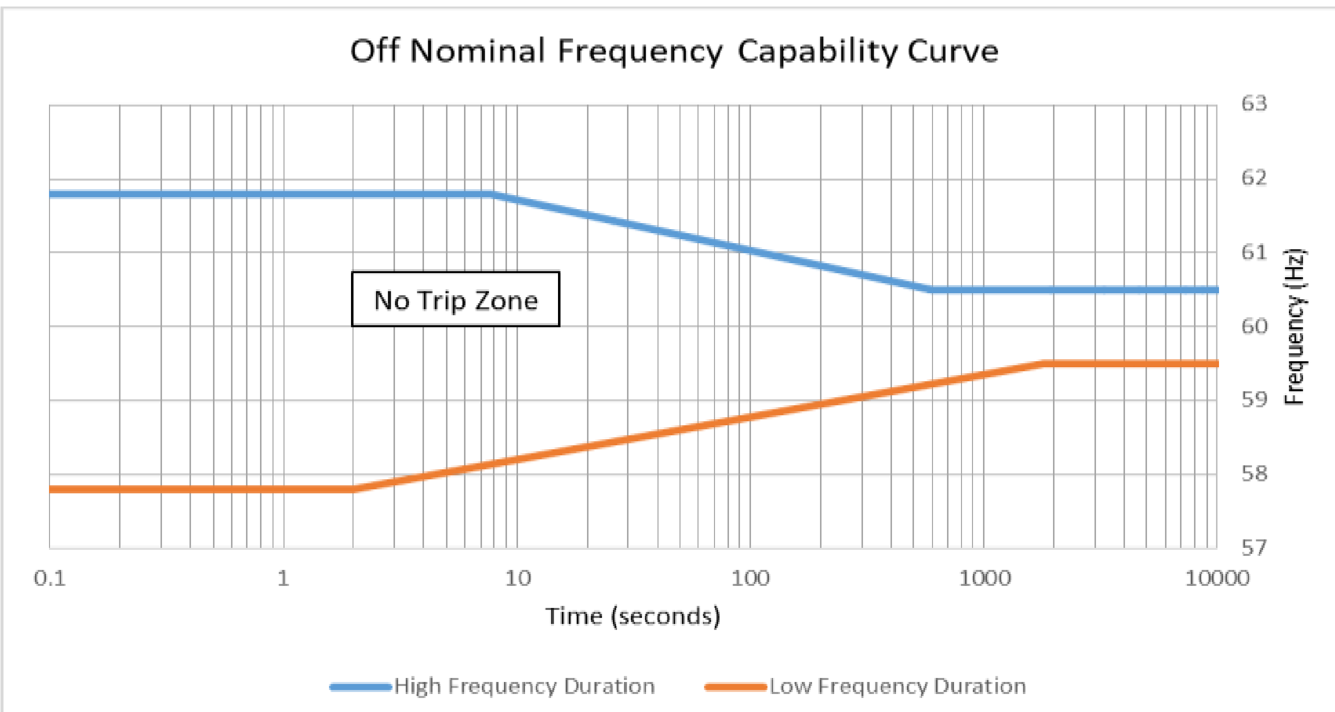


Figure 8: NERC Standard PRC-024 Frequency Ride-Through Capability Curve

G. Considerations for New York's State Climate Leadership Community Protection Act (CLCPA)

In June 2019, New York State Senate enacted the Climate Leadership Protection Act (CLCPA) that commits New York to reaching net zero greenhouse gas emissions. This mandate covers all sectors of the economy and includes electricity and fuels that are imported from other states. The specific targets include:

- 70 percent of the state's electricity must come from renewable energy by 2030, and 100 percent of the state's electricity supply must be emissions free by 2040.
- 9,000 MW of offshore wind must be installed to serve New Yorkers by 2035.
- 6,000 MW of solar energy must be installed to serve New Yorkers by 2025.
- 3,000 MW of energy storage capacity must be installed to serve New Yorkers by 2030.

In preparation for the CLCPA targets, the O&R system should be further studied to incorporate the proposed PV, Energy storage and other renewables in its transmission and distribution system. O&R will be collaborating with outside agencies to determine its specific needs and requirements to fully integrate and successfully operate these renewable projects. Depending of the outcome of several system studies and evaluations, additional system standards and criteria may be included in future versions of the Transmission Design Standards document.

VII. REFERENCES

1. **Bare Overhead Transmission Conductor Ratings.** Transmission and Substation Design Subcommittee (TSDS). PJM Interconnection, LLC.

1. **Determining Priority for Load Shed.** Orange and Rockland Utilities, Inc. Distribution Engineering Department.

2. Latest version of **IEEE Guide for Loading Mineral Oil-Immersed Transformer** (IEEE Standard C57.91).

3. Latest version of **IEEE 738 IEEE Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors**

4. Latest version of **NYTO Tie-Line Ratings Task Force Final Report**.

5. **PT LOAD User Manual**. Electric Power Research Institute. Power Transformer Loading Program.

6. Latest version of **EPRI's Underground Transmission Design Tools (UTDT**) with ACE Program.

7. **Underground Transmission Systems.** Electric Power Research Institute. Jay A. Williams and Anthony Ernst.

8. **NYISO Attachment X – Standard Large Facility Interconnection Procedures**

9. NYISO Attachment Z – Small Generator Interconnection Procedures

10. PJM's Manual 14G – Generation Interconnection Requests

11. **PJM's Manual 14E -** Upgrade and Transmission Interconnection Requests

12. Latest version of **ORU-ENGR-006A – Facility Interconnection Informational Kit** and **ORU-ENGR-006B - Facility Interconnection Requirements**

13. Latest version of **the NERC Standard TPL-001**

14. **NERC's Reliability Guideline on BPS-Connected Inverter Based Resource Performance** (September 2018).

15. Latest version of **ORU-ENGR-008 – Inverter Based Resources Performance Requirements**

16. New York State's **Climate Leadership Community Protection Act (CLCPA)**, June 2019