

FERC Form No. 715
Part 4

TRANSMISSION PLANNING RELIABILITY CRITERIA

The following information submitted for this Part 4 of FERC Form No. 715 consists of PJM's current Planning Criteria, and each member transmitting utility's additional detailed planning criteria document.

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PUBLIC SERVICE ELECTRIC & GAS COMPANY

**CRITERIA FOR PLANNING THE DEVELOPMENT
OF THE ELECTRIC TRANSMISSION SYSTEM**

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I INTRODUCTION

A. PURPOSE

With the changes to the electric transmission systems regulations promulgated by FERC under orders 888, 889, and 2000, the planning process has expanded and is led by the PJM Regional Transmission Expansion Plan. This document is intended to identify the PSE&G specific planning principles, interaction between the transmission and distribution systems, and additional requirements that are needed to assure consistent, safe, and reliable service to transmission customers in the PSE&G service territory.

B. APPLICATION

These criteria are intended to state broad principles or policies rather than design specifications. All connections to the transmission and distribution system whether they are utility owned or not, should adhere to these principles. Arbitrary or unreasonable application of the criteria is to be avoided, and modifications will at times be found justified in unusual situations. For example, higher than average service reliability is usually called for in high load density business areas or for critical loads; and conversely, some lower level of service reliability may be justified in areas of very low load density or when specifically requested by a large customer for reasons of economy. Where more than one criteria covers a given situation, or where both Public Service Electric & Gas Co. (PS) Planning Criteria and the Mid-Atlantic Area Council (MAAC) Criteria (MAAC Reliability Principles and Standards) cover the same situation, the criteria resulting in the highest reliability of service is to be applied.

Enhancements to the power system should balance system reliability, ease of operation, environmental concerns, and economics. In order to accomplish these long-term goals operating conditions and procedures should be taken into account in both the design and analysis of the bulk power system. This will ensure the operation of the system is not compromised when changes are made to the power system design. Close attention should be paid to the environmental impact of all changes to the power system. All system enhancements should work in harmony with their surroundings. Each system change should be made with the intention of improving the reliability and/or the economics of the bulk power system. The economics of each option should be considered before a decision is made. A balance of all of these factors will ensure a prudent system enhancement.

C. BASIS

The MAAC Reliability Principles and Standards, Document A-1, rev 1/27/95, shall be the basis for PSE&G Transmission System planning. The facilities that are to be used in the analysis are contained in the MAAC facility list. Although these criteria are for the most part deterministic, the allowed consequences are more severe for those contingencies with a relatively lower probability of occurrence. The development of the criteria is based partly on a balancing of service quality, cost of service and environmental impact.

Other criteria are based on experience; for example, the boundary between acceptable and unacceptable voltage variations. It is recognized that many of the contingencies specified in these criteria occur very infrequently at the specified load levels and system conditions. However, the facilities installed to meet these criteria should provide an overall system capable of meeting the contingencies that do occur in actual operations.

D. ORGANIZATION OF MATERIAL

The ratings required for planning purposes are defined in Section II. The methods used to determine these ratings are consistent with the methods used by the PJM, LLP Regional Transmission Organization. Section III describes the nominal and acceptable voltages at connections to transmission system customers and acceptable load drop levels and durations. Section IV addresses power quality issues including harmonics and transients. Section V covers the basis for documenting generation, Merchant Transmission, and Special Protective Systems requirements.

The specific contingencies which the system must be able to withstand in order to provide adequate service are defined in the MAAC Reliability Principles and Standards, Document A-1, rev 1/27/05, for generation, transmission, and switching stations. Each element of the system must be adequate for any of the contingencies in any other element of the system; for example the sub-transmission system must be adequate for criteria established for transmission contingencies. Provision for outages in other companies' systems that affect PS facilities is made through the MAAC Criteria.

For each element of the electric system, the quality of service required for various load levels is given. The acceptable load interruptions and acceptable voltages for the various load levels and contingencies are also stated. All other items are intended to be in accordance with applicable MAAC requirements.

II APPLICABLE RATINGS

Loadings of facilities should be within appropriate ratings submitted to PJM and documented on their web site as indicated in these criteria. Normal and applicable emergency thermal ratings are required for summer and winter seasons. The transfers of load, by readjustment of system facilities following outages, are acceptable means of providing adequate service with the remaining facilities, as defined by PJM operations manuals. Special ratings other than those listed below should not be used except under emergency conditions.

A. TRANSMISSION FACILITIES

1. Normal Rating:

This rating, based on the specified ambient air or soil temperature, and time of day, shall be used in both the planning and operation of the system. All loads

and transactions that are loaded on the system shall not cause these ratings to be exceeded.

2. Long Term Emergency Rating:

The Long Term Emergency rating is the four hour rating based on the specified ambient air or soil temperature, and time of day, that shall be used in both the planning and operation of the system. Contingency loading of the applicable element should not exceed these ratings for more than fifteen (15) minutes. It is assumed that within that time, either generation will be applied or switching shall occur to reduce the contingency loading below the LTE rating.

3. Load Dump Rating:

This is the rating that shall not be exceeded for any period of time. If an event occurs on the system that the loading reaches or exceeds this rating, immediate load dump shall be implemented. This rating shall not be implemented during the planning process but only in operation.

B. DISTRIBUTION FACILITIES

1. Very Short-Time Rating:

This rating is for rapidly decaying loadings to provide for the time interval necessary during the inrush period immediately following the sudden outage of a large generator, transmission line or load. Very short-time ratings will be requested only as required for special cases.

2. 30-Minute Rating:

This rating is for continuous loadings and provides for the time interval necessary to load up operating reserve or do any necessary switching including phase shifters to relieve overloads, at attended stations or stations using supervisory control.

3. 4-Hour Rating:

This rating is for continuous loadings and provides time to start generation to relieve the overloads during succeeding peak periods and to allow switching when it must be accomplished at unattended locations.

4. 1-Day Rating:

This rating is at normal load factors and provides for the emergency outage of facilities that can be restored to service in one day.

5. 1-Week Rating:

This rating is at normal load factors and provides for multiple generator contingencies and the relocation and substitution of spare transformers when up to one week is required.

6. **300-Hour Rating:**
This rating is at 100% load factor for the entire outage period and provides for emergency outages of pipe-type cables and the relocation and substitution of spare transformers when more than one week and up to three weeks is required.

C. **GENERATING EQUIPMENT**

Normal and emergency net ratings for winter and summer are required along with maximum peaking megawatt ratings for the summer period.

1. **Manufacturer's maximum rating for the generator (kW and kVA) and the turbine (kW)**
2. **Summer Normal Net Rating**
This rating is a guide for normal system conditions during the summer period.
3. **Summer Emergency Gross and Net Rating**
This rating can be used under emergency generation, transmission or sub-transmission conditions as applicable during the summer period.
4. **Summer Maximum Peaking Rating**
This rating only applies to gas turbines during the summer period. This rating can be used, under special circumstances, under extreme emergency generations, transmission or sub-transmission conditions beyond any condition covered in these criteria.
5. **Winter Normal Rating**
This rating is a guide for normal system conditions during the winter period.
6. **Winter Emergency Gross and Net Rating**
This rating can be used under emergency generation, transmission or sub-transmission conditions as applicable during the winter period.

III VOLTAGES

A. NOMINAL VOLTAGES (60 Hertz, AC Volts)

Secondary: 120; 208; 240; 265; 277; 460; 480

Primary: 4,160; 13,200

Sub-transmission: 13,200; 26,400; 69,000

Transmission: 138,000; 230,000; 345,000; 500,000

B. ACCEPTABLE VOLTAGES

1. Steady state voltages at transmission stations that are connected to transmission customers shall be in accordance with ANSI C84.1-1989 American National Standard for Electric Power Systems and Equipment - Voltage Ratings (60Hz). At stations that do not have directly connected customers, such as switching stations, the PJM, LLC standard voltage range shall apply. The ANSI values are contained in Table 1, Voltage Limitations, except for contingencies for which interruptions are acceptable. In certain special cases, such as service to tall buildings where meters are on upper floors, voltages shall be considered acceptable if within limits at the point of service connection.
2. Customer voltages outside the limits of **Table 1, Voltage Limitations**, are acceptable if that customer's power factor is less than 0.85 and if the power factor was corrected to a minimum of 0.85 the resulting voltages would be within acceptable limits.
3. Voltage dips, attributable to the start-up and operation of large customer loads such as motors or arc furnaces, shall be limited as indicated on **Figure 1, Permissible Voltage Fluctuations**. Special study is required if:
 - a. The effect on substation or switching station buses exceeds 0.4% of nominal, or
 - b. The effect on 138-, 230-, 345-, or 500- kV buses exceeds 0.2% of nominal.
4. Voltage schedules are not included here as they are not criteria. They are, rather, intermediate targets to help meet criteria. As the system develops, revised voltage schedules will be issued from time to time so that the criteria may be met in the most economic manner.
5. These voltage criteria will not be applied during imposed voltage reductions.
6. Under normal conditions, the range of voltage variation is not intended to represent the maximum variation as a result of a sudden load increase or the single correction by a voltage regulating device. Rather the range represents an acceptable

bandwidth within which customer equipment should operate properly. Single step changes in voltage level either as a result of load changes or voltage regulating devices should be limited to as small an incremental change as can be reasonably obtained with commercially available techniques. Typically, limiting single step changes to 2% or less of nominal voltage is recommended.

C. ACCEPTABLE LOAD DROP LEVELS AND DURATIONS

Transmission facilities shall be required to be constructed if the criteria in the below table are violated.

The Maximum Load Drop shall be the estimated load that is expected at a system peak load level. It shall apply to stations supplying native load or for Merchant Transmission facilities that are supplying native load in another control area.

<u>MAAC Contingency</u>	<u>Facility Type</u>	<u>Maximum Load Drop</u>	<u>Duration</u>
IIA	All	175 MW	Momentary
IIB	Only overhead circuits	350 MW	24 Hours
	All underground circuits in a designated urban area	175 MW	Momentary
	All or partial underground not in designated urban area	350 MW	24 Hour
IIC	All	300 MW	24 Hours

For loss of loads that are less than the above criteria, distribution facilities shall be available to supply the load within 24 hours for an IIB or IIC contingency.

TABLE 1

VOLTAGE LIMITATIONS

	<u>Normal</u>			<u>Emergency</u>		
	<u>Max.</u>	<u>Min.</u>	<u>Variation</u>	<u>Max.</u>	<u>Min.</u>	<u>Variation</u>
<u>Secondary Customers</u>						
% of Nominal	104	96	8	106	95(a)	11
<u>Primary Customers</u>						
% of Nominal	105	98	7	106	95(a)	11
<u>Sub-Transmission Customers</u>						
% of Nominal	105(b)	98(b)	6 (b)	105 (b)	95 (a)(b)	8
<u>Transmission Customers</u>						
% of Nominal	105(b)	98(b)	5 (b)(c)	105 (b)	95 (a)(b)	5 (c)
<u>Transmission Nodes (d)</u>						
% of Nominal	105	95	5 (c)	105	95	5 (c)

Notes:

- (a) Minimum voltages 3% below these values are acceptable when switching operations not dependent on availability of a traveling operator can be performed to correct the voltage to meet the emergency criteria within 30 minutes. Further voltage reductions are acceptable if automatic switching operations or automatic controls will correct the voltage to applicable minimum values within 2 seconds.
- (b) If the cost to supply a customer from sub-transmission or transmission could be substantially reduced by rendering service outside the prescribed voltage limits, service outside these limits may be rendered under a special agreement with the customer.
- (c) The post transient voltage drop should be consistent with the voltage criteria currently used in actual system operation (i.e. no more than 5% voltage drop and a post contingency voltage of 0.95 per unit or higher).
- (d) Transmission Nodes are those MAAC facilities that do not have any wholesale customers directly connected. Example of such facilities is Deans Switching station. Those locations shall be governed by the PJM standard voltage criteria.

IV POWER QUALITY

A. HARMONICS DISCUSSION

Increased customer usage of non-linear types of loads, such as switched mode power supplies, can create increased harmonic distortion in utility and customer electrical systems. Unrestricted harmonic propagation can result in a variety of electrical and telecommunications problems including increased equipment heating, resonance conditions, fuse and capacitor failures, and telephone interference conditions. At very high levels, harmonic distortion may result in misoperation or random drop-out of customer systems.

Typically, harmonics are a function of load conditions where non-linear devices draw electrical power in a non-sinusoidal manner. The resulting current waveform consists of various multiples of 60 Hz power. In electrical systems having a high source impedance, current distortion will affect the voltage waveform more significantly. In addition, harmonic currents being of an unbalanced nature will add in the neutral thus impacting other systems referencing the common neutral system.

Ideally, harmonics can be prevented through utilization of power conversion devices that draw power in as near a sinusoidal fashion as possible. Alternatively, damaging harmonics can be managed by maintaining a low impedance electrical source. Where a low impedance source cannot be provided, various filtering and conditioning techniques are commercially available.

Although PSE&G maintains a fairly low impedance source affording suitable short circuit availability to avoid harmonic distortion of the electrical supply, proper design should include adherence to set harmonic limitations. Institute of Electrical and Electronic Engineers (IEEE) Standard 519-1992, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems, or its latest version, is the definitive utility industry guideline regarding harmonics for both utility and customer systems. PSE&G recognizes this standard and utilizes it in applying appropriate limitations at the point of connection to utility customer's service equipment.

B. TRANSIENT DISTURBANCE DISCUSSION

While system planning criteria traditionally addresses the prevention and minimization of momentary and long term outage contingencies, the resulting redundancy typically increases exposure to transient disturbances. The physics and nature of electrical phenomena dictates that during a short circuit or drastic system reconfiguration, undesirable voltage sags, surges, and swells will occur.

Mitigation and protection from these types of events involves complex review and analysis of the utility system, customer electrical infrastructure and affected equipment and systems.

Ongoing preventive maintenance, maintaining a utility source with low source impedance and fast fault clearing times, and the use of sound design practices are the most effective means of

minimizing the impact of transient events. The protection and/or de-sensitization of affected customer equipment and systems has generally been recognized and accepted by both utility and customer segments as the most effective and economic technique of assuring continuous process and equipment up-time. Coordination of designs between utility and customer systems will ensure the highest degree of service quality and continuity based on economic justification.

The use of an equipment susceptibility curve such as the CBEMA (Computer and Business Equipment Manufactures Association) curve depicted in IEEE Standards 446-1995 and 1100-2005, is recommended as a guide in determining vulnerability of customer equipment and systems to transient events originating from within the utility system.

V. SYSTEM RESERVE REQUIREMENTS

A. MEGAWATT RESERVE

Sufficient megawatt generating capacity shall be contracted, and sufficient transmission to provide emergency transfer capability to meet PS reliability criteria. These criteria require that for the PS system the probability of load exceeding the available capacity sources shall not be greater, on the average, than one day in ten years. The installed generation capacity is based on both PS studies and joint PJM studies.

The Capacity Emergency Transfer Objective (CETO) is the capacity transfer which PS or any designated zone within PS must have in a given year and for a given generation configuration to provide sufficient emergency assistance to meet the reliability criteria stated above. In any given year when the Capacity Emergency Transfer Limit (CETL) is less than the CETO it is necessary to install either additional transmission, demand side management, or additional internal generation. In any given year when there is insufficient generating capacity in interconnected systems for emergency assistance it is necessary to install additional generation.

The basic elements involved in planning the generating capacity reserve requirements of a system include the characteristics of load and generating capacity and capacity benefit of ties. The analysis of system reserve includes consideration of load forecast uncertainty. The analysis of system generating capacity, which consists of units of different sizes and types, includes the following characteristics affecting reliability:

1. Summer emergency rating
2. Seasonal changes in capability
3. Forced outage rate
4. Planned outage rate
5. Maintenance outage rate.

Ties provide the capacity transfer required in an emergency. The available tie capacity is specified as the CETL as defined in Section VII-B of the MAAC Criteria.

B. MEGAVAR RESERVE

Sufficient reactive capacity must be provided to maintain adequate bulk power system reliability and to meet customer voltages as described in the various voltage and reliability criteria included throughout these Planning Criteria.

Both load and Merchant Transmission facilities shall not absorb significant amounts of MVAR's from the transmission system. The minimum power factor from a load or Merchant transmission facility shall be 0.98.

The type of reactive to be installed is to be based on an evaluation of the overall system reactive requirements and available reactive sources.

C. SPECIAL PROTECTIVE SYSTEMS

Special Protective Systems (SPS) shall be used only to achieve reliability criteria during maintenance outages. They shall not be used as a substitute for constructing or reinforcing the transmission system. The specific criteria as to type of SPS shall be in accordance with MAAC documents.

D. MERCHANT TRANSMISSION FACILITIES

Merchant transmission facilities shall be planned in accordance with the PJM, LLC RTEP process. Specific modifications to that process are:

1. Load dump magnitudes and durations for IIA, IIB, and IIC criteria shall be the same as in section IIIC of this document
2. Torsional analysis of local generation shall be conducted with the exact same software control system as will be used on the facility.
 - a. Changes in software revisions will be re-certified prior to field installation.
 - b. Identification of any interactions will be remedied by trip of the merchant facility
 - c. All modes of operation of the merchant facility will be studied
3. Harmonic analysis and negative sequence injections shall not result in exceeding recommended limits on any existing generator or load with existing sources taken as the base line
4. Impact on the cathodic protection of existing underground systems shall be predicted and verified after installation

VI PLANNING CRITERIA FOR SUBSTATION CONTINGENCIES

		CONTINGENCIES									
FOR THESE CONTINGENCIES APPLY THESE CRITERIA		<u>A.</u> The outage of any single transformer in a distribution station						<u>B.</u> The outage of any substation bus or section of such a bus			
								(1). With the proper operation of breakers and relays		(2). With failure of first line relaying or breakers	
<u>ACCEPTABLE CUSTOMER VOLTAGES</u> If contingency occurs at any load level		Emergency						Emergency		Emergency	
<u>APPLICABLE RATINGS</u> If contingency occurs at any load level		1 - Day Emergency						1-Day Emergency		1-Day Emergency	
<u>ACCEPTABLE LOAD INTERRUPTIONS</u>		Secondary <u>Networks</u>			Radial <u>Primaries</u>						
Maximum allowable load interrupted		0 to 10 MVA	10 to 24 MVA	Above 24 MVA	0 to 96 MVA	96 to 175 MVA	Above 175 MVA	0 to 45 MVA	Above 45 MVA	0 to 350 MVA	Above 350 MVA
<i>Acceptable duration of interruption</i>		<i>60 sec.</i>	<i>5 sec.</i>	<i>None</i>	<i>60 sec.</i>	<i>5 sec.</i>	<i>None</i>	<i>24 hours</i>	<i>None</i>	<i>24 hours</i>	<i>None</i>
COMMENTS:		1, 2, 3, 4						2		2	

- (1) A single radial primary may be interrupted for up to six hours if its planned backup is an available mobile transformer
- (2) In special situations, 30-minute Emergency Ratings may be applied
- (3) Radial Primaries no greater than 10 MVA may be interrupted for up to three (3) hours
- (4) See Section XIII for rationale on Acceptable Load Interruptions

**VII PLANNING CRITERIA FOR SUB-TRANSMISSION
CONTINGENCIES**

		CONTINGENCIES			
		<u>A.</u>	<u>B.</u>	<u>C.</u>	<u>D.</u>
FOR THESE CONTINGENCIES	APPLY THESE CRITERIA	The outage of any single circuit	The outage of a double-circuit open-wire pole line	The outage of any two circuits (aerial cable and open wire), which are on a single pole line and which are the sole supply for any load	The overlapping outage of any single subtransmission circuit and any generator or transformer outage lasting more than three weeks
<u>ACCEPTABLE CUSTOMER VOLTAGES</u> If contingency occurs at:	91 to 100% of Peak Load	Emergency	Emergency	Not Applicable	Emergency
	90% or less of Peak Load	Normal	Normal	Not Applicable	Emergency
<u>APPLICABLE RATINGS</u> If contingency occurs at:	81 to 100% of Peak Load	1-Day Emergency	1-Day Emergency	Not Applicable	1-Day Emergency
	80% or less of Peak Load	Normal	Normal	Not Applicable	1-Day Emergency
<u>ACCEPTABLE LOAD INTERRUPTIONS</u>	Secondary Radial	<u>For Each Circuit</u> Radial			Radial

	<u>Networks</u>			<u>Secondary Networks</u>			¹ <u>Primaries</u>		<u>Secondary Networks</u>			<u>Primaries</u>
	0 to	10 to	0 to	0 to	10 to	0 to	0 to	Above	0 to	10 to	0 to	
Maximum allowable load interrupted	10 MVA	24 MVA	24 MVA	10 MVA	24 MVA	24 MVA	45 MVA	45 MVA	10 MVA	24 MVA	24 MVA	
<i>Acceptable duration of interruption</i>	<i>60 sec.</i>	<i>5 sec.</i>	<i>60 sec.</i>	<i>60 sec.</i>	<i>60 sec.</i>	<i>60 sec.</i>	<i>24 hours</i>	<i>None</i>	<i>60 sec.</i>	<i>5 sec.</i>	<i>60 sec.</i>	
COMMENTS:	1, 2			1, 2					1, 2			

- (1) Radial Primaries no greater than 10 MVA may be interrupted for up to three (3) hours
(2) A Single Line Customer may have their Peak Load interrupted for the duration of the restoration

VIII PLANNING CRITERIA FOR DISTRIBUTION CONTINGENCIES

CONTINGENCIES

FOR THESE CONTINGENCIES	<u>A.</u>	<u>B.</u>
	The outage of any single radial distribution circuit or any part of such a circuit except service runs	The outage of a single distribution circuit which supplies a secondary network
APPLY THESE CRITERIA		
 <u>ACCEPTABLE CUSTOMER VOLTAGES</u>		
If contingency occurs at:	<u>been transferred</u>	<u>been transferred</u>
91 to 100% of Peak Load	Emergency	Emergency
90 % or less of Peak Load	Normal	Normal
<u>APPLICABLE RATINGS</u>		
If contingency occurs at:	<u>been transferred</u>	<u>been transferred</u>
81 to 100 % of Peak Load	1 - Day Emergency	1 - Day Emergency
80% or less of Peak Load	Normal	Normal
<u>ACCEPTABLE LOAD INTERRUPTIONS</u>		
	<u>Radial Primary</u>	<u>Radial Primary</u>
	0 to	Above
Maximum allowable load interrupted	5 MVA	5 MVA
		<u>Primary Throwover</u>
		Peak
		Load
		<u>Single Customer</u>
		Peak
		Load
		<u>Secondary Network</u>
		0 to
		Above
		10 MVA
		10 MVA
<i>Acceptable duration of interruption</i>	<i>3 hours</i>	<i>60 sec.</i>
		<i>60 sec.</i>
		<i>3 hours</i>
		<i>60 sec.</i>
		<i>None</i>

NOTES:

- (a) In general, a 13-kV circuit is limited by the loop loading. All interstation capacity tie loop and circuits providing back-up to a 13-kV Unit, must be limited to 16 MVA. Other loops can be loaded to 20 MVA if a normally open head end tie switch equipped with SCADA is installed.
- (b) Networks supplied by gas filled cables with protective alarms should be limited to 50 MVA. Networks supplied by solid cables without an alarm should be limited to 24 MVA.

