Direct Testimony of Frank Mezzanotte

Attachment A

NPCC Document A-2

NORTHEAST POWER COORDINATING COUNCIL

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Basic Criteria for Design and Operation Of Interconnected Power Systems

Adopted by the Members of the Northeast Power Coordinating Council September 20, 1967, based on recommendation by the Operating Procedure Coordinating Committee and the System Design Coordinating Committee, in accordance with paragraph IV, subheading (a), of NPCC's Memorandum of Agreement dated January 19, 1966 as amended to date.

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1.0 Introduction

The objective of these criteria is to provide a "design-based approach" to ensure the **bulk power system** is designed and operated to a level of reliability such that the loss of a major portion of the system, or unintentional separation of a major portion of the system, will not result from any design **contingencies** referenced in Sections 5.1 and 5.2. In NPCC the technique for assuring the reliability of the **bulk power system** is to require that it be designed and operated to withstand representative **contingencies** as specified in these criteria. Analyses of simulations of these **contingencies** include assessment of the potential for widespread cascading outages due to overloads, instability or voltage collapse. Loss of small portions of a system (such as radial portions) may be tolerated provided these do not jeopardize the reliability of the remaining **bulk power system**. (Terms in bold typeface are defined in the Glossary located in Document A-7, the *NPCC Glossary of Terms*).

Criteria described in this document are to be used in the design and operation of the **bulk power system.** These criteria meet or exceed the North American Electric Reliability Council (NERC) policies and standards. These criteria are applicable to all entities which are part of or make use of the **bulk power system**. The Council member whose system is used to connect a non-member system to the **bulk power system** shall assure that, whenever it enters into arrangements or contractual agreements with non-members whose system could have a **significant adverse impact** on service reliability on the interconnected **bulk power system** in Northeastern North America, the terms of such arrangements or contractual agreements are consistent with criteria established by the Council, NERC, or the Regional Reliability Councils established in areas in which the facilities used for such arrangements are located.

The characteristics of a reliable **bulk power system** include adequate **resources** and transmission to reliably meet projected customer electricity demand and energy requirements as prescribed in this document and include:

a. Consideration of a balanced relationship among the fuel type, capacity, physical characteristics (peaking/baseload/etc.), and location of **resources**.

b. Consideration of a balanced relationship among transmission system **elements** to avoid excessive dependence on any one transmission circuit, structure, right-of-way, or substation.

c. Transmission systems should provide flexibility in switching arrangements, voltage control, and other control measures.

It is the responsibility of each **Area** to ascertain that its portion of the **bulk power system** is designed and operated in conformance with these criteria. The Council provides a forum for coordinating the design and operations of its five **Areas**.

Through committees, task forces, and working groups the Council shall conduct regional and interregional studies, and assess and monitor **Area** studies and operations to assure conformance to the criteria.

2.0 General Requirements

Area, Member system or local conditions may require criteria which are more stringent than those set out herein. Any constraints imposed by these more stringent criteria will be observed. It is also recognized that the Basic Criteria are not necessarily applicable to those **elements** that are not a part of the **bulk power system** or in the portions of a member system where instability or overloads will not jeopardize the reliability of the remaining **bulk power system.**

2.1 Design Criteria

The design criteria will be used in the assessment of the **bulk power system** of each of the NPCC member systems and each NPCC **Area**, and in the reliability testing at the member system, **Area**, and Regional Council levels.

Design studies shall assume power flow conditions utilizing transfers, load and generation conditions which stress the system. Transfer capability studies shall be based on the load and generation conditions expected to exist for the period under study. All reclosing facilities shall be assumed in service unless it is known that such facilities will be rendered inoperative.

A **special protection system (SPS)** shall be used judiciously and when employed, shall be installed, consistent with good system design and operating policy.

A SPS may be used to provide protection for infrequent contingencies, or for temporary conditions that may exist such as project delays, unusual combinations of system demand and equipment outages or availability, or specific equipment maintenance outages. An **SPS** may also be applied to preserve system integrity in the event of **severe facility outages** and extreme **contingencies.** The decision to employ an **SPS** shall take into account the complexity of the scheme and the consequences of correct or incorrect operation as well as its benefits.

The requirements of **special protection systems** are defined in the NPCC *Bulk Power System Protection Criteria*, (Document A-5), and the *Special Protection System Criteria*, (Document A-11).

2.2 Operating Criteria

Coordination among and within the **Areas** of NPCC is essential to the reliability of interconnected operations. Timely information concerning system conditions shall be transmitted by the NPCC **Areas** to other NPCC **Areas** or systems as needed to assure reliable operation of the **bulk power system**.

The operating criteria represent the application of the design criteria to inter-**Area**, intra-**Area** (inter-system) and intra-system operation.

The operating criteria define the minimum level of reliability that shall apply to inter-**Area** operation. Where inter-**Area** reliability is affected, each **Area** shall establish limits and operate so that the **contingencies** stated in Section 6.1 and 6.2 can be withstood without causing a **significant adverse impact** on other **Areas**.

When adequate **bulk power system** facilities are not available, **special protection systems** (SPS) may be employed to maintain system security. Two categories of transmission transfer capabilities, normal and emergency, are applicable. Normal transfer capabilities are to be observed unless an **emergency** is declared.

2.3 System Analysis and Modeling Data Exchange Requirements

It is the responsibility of NPCC, its **Areas** and NPCC Members to protect the proprietary nature of the following information and to ensure it is used only for purposes of efficient and reliable system operation and design. Also, any sharing of such information must not violate anti-trust laws.

For reliability purposes, **Areas** shall share and coordinate forecast system information and real time information to enable and enhance the analysis and modeling of the interconnected **bulk power system** by security application software on energy management systems. Each member within an NPCC **Area** shall provide needed information to its **Area** representative as required. Analysis and modeling of the interconnected power system is required for reliable design and operation. Data needed to analyze and model the electric system and its component facilities must be developed, maintained, and made available for use in interconnected operating and planning studies, including data for fault level analysis.

Areas and member systems shall maintain and submit, as needed, data in accordance with applicable NPCC Procedures.

Data submitted for analysis representing physical or control characteristics of equipment shall be verified through appropriate methods. System analysis and modeling data must be reviewed annually, and verified on a periodic basis. Generation equipment, and its component controllers, shall be tested to verify data.

Areas shall install dynamic recording devices and provide recorded data necessary to enhance analysis of wide area system disturbances and validate system simulation models. These devices should be time synchronized and should have sufficient data storage to permit a few minutes of data to be collected. Information provided by these recordings would be used in tandem, when appropriate, with shorter time scale readings from fault recorders and sequence of events recorders (SER), as described in the *Bulk Power System Protection Criteria* (Document A-5), paragraph 2.7.2.

3.0 Resource Adequacy - Design Criteria

Each **Area's** probability (or risk) of disconnecting any **firm load** due to resource deficiencies shall be, on average, not more than once in ten years. Compliance with this criteria shall be evaluated probabilistically, such that the **loss of load expectation** [**LOLE**] of disconnecting **firm load** due to resource deficiencies shall be, on average, no more than 0.1 day per year. This evaluation shall make due allowance for demand uncertainty, scheduled outages and deratings, forced outages and deratings, assistance over interconnections with neighboring **Areas** and **Regions**, transmission transfer capabilities, and capacity and/or load relief from available operating procedures.

4.0 Resource Adequacy - Operating Criteria

Each **Area** shall have procedures in place to schedule outages and deratings of **resources** in such a manner that the available **resources** will be adequate to meet the **Area**'s forecasted load and reserve requirements, in accordance with the NPCC *Operating Reserve Criteria* (Document A-6).

For consistent evaluation and reporting of **resource** adequacy, it is necessary to measure the net capability of generating units and loads utilized as a **resource** of each Area on a regular basis.

5.0 Transmission Design Criteria

The portion of the **bulk power system** in each **Area** and of each member system shall be designed with sufficient transmission capability to serve forecasted loads under the conditions noted in Sections 5.1 and 5.2. These criteria will also apply after any critical generator, transmission circuit, transformer, series or shunt compensating device or HVdc pole has already been lost, assuming that the **Area** generation and power flows are adjusted between outages by the use of **ten-minute reserve** and where available, phase angle regulator control and HVdc control.

Anticipated transfers of power from one **Area** to another, as well as within **Areas**, shall be considered in the design of inter-**Area** and intra-**Area** transmission facilities. Transmission transfer capabilities shall be determined in accordance with the conditions noted in Sections 5.1 and 5.2.

5.1 Stability Assessment

Stability of the **bulk power system** shall be maintained during and following the most severe of the **contingencies** stated below, **with due regard to reclosing**. For each of the **contingencies** below that involves a fault, stability shall be maintained when the simulation is based on **fault clearing** initiated by the **"system A" protection group**, and also shall be maintained when the simulation is based on **fault clearing** initiated by the **"system B" protection group**.

a. A permanent three-phase fault on any generator, transmission circuit, transformer or bus section with **normal fault clearing**.

b. Simultaneous permanent phase to ground faults on different phases of each of two adjacent transmission circuits on a multiple circuit tower, with **normal fault clearing**. If multiple circuit towers are used only for station entrance and exit purposes, and if they do not exceed five towers at each station, then this condition is an acceptable risk and therefore can be excluded. Other similar situations can be excluded on the basis of acceptable risk, provided that the Reliability Coordinating Committee specifically accepts each request for exclusion.

c. A permanent phase to ground fault on any transmission circuit, transformer, or bus section with **delayed fault clearing**.

d. Loss of any **element** without a fault.

e. A permanent phase to ground fault on a circuit breaker with **normal fault clearing**. (**Normal fault clearing** time for this condition may not always be high speed.)

f. Simultaneous permanent loss of both poles of a direct current bipolar facility without an ac fault

g. The failure of a circuit breaker to operate when initiated by an SPS following: loss of any **element** without a fault; or a permanent phase to ground fault, with **normal fault clearing**, on any transmission circuit, transformer or bus section.

5.2 Steady State Assessment

a. Each **Area** shall design its system in accordance with these criteria and its own voltage control procedures and criteria, and coordinate these with adjacent **Areas** and **control areas.** Adequate reactive power resources and appropriate controls shall be installed in each **Area** to maintain voltages within normal limits for predisturbance conditions, and within **applicable emergency limits** for the system conditions that exist following the **contingencies** specified in 5.1.

b. Line and equipment loadings shall be within normal limits for predisturbance conditions and within **applicable emergency limits** for the system conditions that exist following the **contingencies** specified in 5.1.

5.3 Fault Current Assessment

Each **Area** shall establish procedures and implement a system design that ensures equipment capabilities are adequate for fault current levels with all transmission and generation facilities in service for all potential operating conditions, and coordinate these procedures with adjacent **Areas** and **Regions**.

6.0 Transmission Operating Criteria

Scheduled outages of facilities that affect inter-**Area** reliability shall be coordinated sufficiently in advance of the outage to permit the affected **Areas** to maintain reliability. Each **Area** shall notify adjacent **Areas** of scheduled or forced outages of any facility on the NPCC Transmission Facilities Notification List and of any other condition which may impact on inter-**Area** reliability. Work on facilities which impact inter-**Area** reliability shall be expedited.

Individual **Areas** shall be operated in a manner such that the **contingencies** noted in Section 6.1 and 6.2 can be sustained and do not adversely affect other **Areas**.

Appropriate adjustments shall be made to **Area** operations to accommodate the impact of **protection group** outages, including the outage of a **protection group** which is part of a Type I **special protection system**. For typical periods of forced outage or maintenance of a **protection group**, it can be assumed, unless there are indications to the contrary, that the remaining **protection** will function as designed. If the **protection group** will be out of service for an extended period of time, additional adjustments to operations may be appropriate considering other system conditions and the consequences of possible failure of the remaining **protection group**.

6.1 Normal Transfers

Pre-**contingency** voltages, line and equipment loadings shall be within normal limits. Unless specific instructions describing alternate action are in effect, normal transfers shall be such that manual reclosing of a faulted **element** can be carried out before any manual system adjustment, without affecting the stability of the **bulk power system**.

Stability of the **bulk power system** shall be maintained during and following the most severe of the **contingencies** stated below, **with due regard to reclosing.** For each of the **contingencies** stated below that involves a fault, stability shall be maintained when the simulation is based on **fault clearing** initiated by the **"system A" protection group**, and also shall be maintained when the simulation is based on **fault clearing** initiated by the **"system B" protection group**.

a. A permanent three-phase fault on any generator, transmission circuit, transformer or bus section, with **normal fault clearing**.

b. Simultaneous permanent phase to ground faults on different phases of each of two adjacent transmission circuits on a multiple circuit tower, with **normal fault clearing**. If multiple circuit towers are used only for station entrance and exit purposes, and if they do not exceed five towers at each station, then this condition is an acceptable risk and therefore can be excluded. Other similar situations can be excluded on the basis of acceptable risk, provided that the Reliability Coordinating Committee specifically accepts each request for exclusion.

c. A permanent phase to ground fault on any transmission circuit, transformer, or bus section with **delayed fault clearing**.

d. Loss of any **element** without a fault.

e. A permanent phase to ground fault on a circuit breaker, with **normal fault clearing**. (**Normal fault clearing** time for this condition may not always be high speed.)

f. Simultaneous permanent loss of both poles of a direct current bipolar facility without an ac fault.

g. The failure of a circuit breaker to operate when initiated by an SPS following: loss of any **element** without a fault; or a permanent phase to ground fault, with **normal fault clearing**, on any transmission circuit, transformer or bus section.

Reactive power resources shall be maintained in each **Area** in order to maintain voltages within normal limits for predisturbance conditions, and within **applicable emergency limits** for the system conditions that exist following the **contingencies** specified in the foregoing. Adjoining **Areas** shall mutually agree upon procedures of inter-Area voltage control.

Line and equipment loadings shall be within normal limits for predisturbance conditions and within **applicable emergency limits** for the system conditions that exist following the **contingencies** specified in the foregoing.

Since **contingencies** b, c, e, f, and g, are not confined to the loss of a single **element**, individual **Areas** may choose to permit a higher post **contingency** flow on remaining facilities than for **contingencies** a and d. This is permissible providing operating procedures are documented to accomplish corrective actions, the loadings are sustainable for at least the anticipated time required to effect such action, and other **Areas** will not be subjected to the higher flows without prior agreement.

6.2 Emergency Transfers

When **firm load** cannot be supplied within normal limits in an **Area**, or a portion of an **Area**, transfers may be increased to the point where pre-**contingency** voltages, line and equipment loadings are within **applicable emergency limits**. Emergency transfer levels may require generation adjustment before manually reclosing faulted **elements**.

Stability of the **bulk power system** shall be maintained during and following the most severe of the following **contingencies**, and **with due regard to reclosing**:

a. A permanent three-phase fault on any generator, transmission circuit, transformer or bus section, with **normal fault clearing**.

b. The loss of any **element** without a fault.

Immediately following the most severe of these **contingencies**, voltages, line and equipment loadings will be within **applicable emergency limits**.

6.3 Post Contingency Operation

Immediately after the occurrence of a **contingency**, the status of the **bulk power system** must be assessed and transfer levels must be adjusted, if necessary, to prepare for the next **contingency**. If the readjustment of generation, load resources, phase angle regulators, and direct current facilities, is not adequate to restore the system to a secure state, then other measures such as voltage reduction and shedding of firm load may be required. System adjustments shall be completed as quickly as possible, but in all cases within 30 minutes after the occurrence of the **contingency**.

Voltage reduction need not be initiated and firm load need not be shed to observe a post **contingency** loading requirement until the **contingency** occurs, provided that adequate response time for this action is available after the **contingency** occurs and other measures will maintain post **contingency** loadings within **applicable emergency limits**.

Emergency measures, including the pre-contingency disconnection of **firm load** if necessary, must be implemented to limit transfers to within the requirements of 6.2 above.

6.4 Operation Under High Risk Conditions

Operating to the **contingencies** listed in Sections 6.1 and 6.2 is considered to provide an acceptable level of **bulk power system** security. Under certain unusual conditions, such as severe weather, the expectation of occurrence of some **contingencies**, and the associated consequences, may be judged to be temporarily, but significantly, greater than the long-term average expectation. When these conditions, referred to as high risk conditions, are judged to exist in an **Area**, consideration should be given to operating in a more conservative manner than that required by the provisions of Sections 6.1 and 6.2.

7.0 Extreme Contingency Assessment

Extreme **contingency** assessment recognizes that the **bulk power system** can be subjected to events which exceed, in severity, the **contingencies** listed in Section 5.1. One of the objectives of extreme **contingency** assessment is to determine, through planning studies, the effects of extreme **contingencies** on system performance. This is done in order to obtain an indication of system strength, or to determine the extent of a widespread system disturbance, even though extreme **contingencies** do have low probabilities of occurrence.

The specified extreme **contingencies** listed below are intended to serve as a means of identifying some of those particular situations that could result in widespread **bulk power system** shutdown. It is the responsibility of each **Area** to identify additional extreme contingencies, if any, to be assessed.

Assessment of the extreme **contingencies** listed below shall examine post **contingency** steady state conditions, as well as stability, overload cascading and voltage collapse. Pre-**contingency** load flows chosen for analysis shall reflect reasonable power transfer conditions within **Areas**, or from **Area** to **Area**

Analytical studies shall be conducted to determine the effect of the following extreme **contingencies**:

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

b. Loss of all transmission circuits emanating from a generating station, switching station, dc terminal or substation

c. Loss of all transmission circuits on a common right-of-way.

d. Permanent three-phase fault on any generator, transmission circuit, transformer, or bus section, with **delayed fault clearing** and **with due regard 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 Council's interconnected systems.

g. Failure of a **special protection system**, to operate when required following the normal **contingencies** listed in Section 5.1.

h. The operation or partial operation of a special protection system for an event or condition for which it was not intended to operate.

i. Sudden loss of fuel delivery system to multiple plants, (i.e. gas pipeline contingencies, including both gas transmission lines and gas mains.)

Note: The requirement of this section is to perform extreme contingency assessments. In the case where extreme contingency assessment concludes there are serious consequences, an evaluation of implementing a change to design or operating practices to address such contingencies must be conducted, and measures may be utilized where appropriate to reduce the likelihood of such contingencies or to mitigate the consequences indicated in the assessment of such contingencies.

8.0 Extreme System Conditions Assessment

The **bulk power system** can be subjected to wide range of other than normal system conditions that have low probability of occurrence. One of the objectives of extreme system conditions assessment is to determine, through planning studies, the impact of these conditions on expected steady-state and dynamic system performance. This is done in order to obtain an indication of system robustness or to determine the extent of a widespread adverse system response. Each **Area** has the responsibility to incorporate special simulation testing to assess the impact of extreme system conditions.

For example, analytical studies shall be conducted to determine the effect of design contingencies under the following extreme conditions:

a. Peak load conditions resulting from extreme weather conditions with applicable rating of electrical elements.

b. Generating unit(s) fuel shortage, (i.e. gas supply adequacy)

After due assessment of extreme system conditions, measures may be utilized, where appropriate, to mitigate the consequences that are indicated as a result of testing for such system conditions.

Lead Task Force:	Task Force on Coordination of Planning
Reviewed for concurrence by:	TFCO, TFSP, TFSS and TFIST Chairman
Review frequency:	4 years
References:	*Bulk Power System Protection Criteria* (Document A-5)
	Operating Reserve Criteria (Document A-6)
	NPCC Glossary of Terms (Document A-7)
	Special Protection System Criteria (Document A-11)