



Transmission Reliability Criteria

Part III

Operating Criteria

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1.0 Introduction

One of the responsibilities of the Alberta Electric System Operator (AESO) is the reliable operation of the transmission system. The AESO must direct the operation of the transmission system within defined capabilities and limits to achieve the desired level of reliability. A well-defined transmission operating criteria is required to guide the studies used to determine system limits as well as for the procedures to be used for day-to-day operation of the transmission system. The purpose of this document is to define the AESO transmission operating criteria.

The AESO transmission operating criteria must recognize not only the operating reliability needs within Alberta, but also the obligations that arise from being connected to other electric systems in North America. The criteria must also be compatible with the capabilities of the Alberta system and with the criteria used to plan the system (described in Part II).

This document begins with a review of pertinent reliability requirements for the operation of the interconnected system. The AESO transmission operating criteria is then described.

2.0 Background

The North American Electric Reliability Council's (NERC) mission is to ensure that the bulk electric system in North America is reliable, adequate and secure. NERC has established operating policies and planning standards to ensure that the electric system operates reliably. NERC's operating policies are based on the concept that *"all control areas share the benefits of interconnected systems operation and, by their participation in NERC, they recognize the need to operate in a manner that will promote reliability in interconnected operation and not burden other interconnected Control Areas."*¹ The operating policies place the responsibility for operating reliably primarily on the Control Areas² that operate within the interconnected system. As operator of the Alberta Control Area, the AESO has the obligation to meet this responsibility for reliable operation.

NERC achieves its mission through its 10 regional councils. The Western Electricity Coordinating Council (WECC) is the Regional Council that coordinates and promotes reliable operation in the Western Interconnection. The Alberta system is part of the Western Interconnection. The WECC sets the reliability requirements for all entities that operate within the Western Interconnection. These requirements must meet the standards and requirements specified by NERC. The WECC requirements also include additional requirements specific to the Region and provide specific measures that meet NERC requirements. As a member of the WECC, the AESO chooses to meet the reliability requirements set by the WECC.

¹ NERC Operating Manual, Preamble to Operating Policies

² In this document, capitalized terms are used to indicate terms defined by either NERC or WECC

3.0 Overview of NERC Operating Policies

The NERC operating policies are described in the *NERC Operating Manual*³. The *NERC Operating Manual* consists of a number of policies that define operating Standards, Requirements, and Guides. All control areas are expected to adhere to the operating Requirements and Standards. The operating Guides are suggested operating practices that control areas may wish to consider, but they are not mandatory.

The *NERC Operating Manual* defines the following basic requirement for its operating standards and requirements:

*“All Control Areas shall operate so that instability, uncontrolled separation, or cascading outages will not occur as a result of the most severe single contingency.”*⁴

This is supplemented by the following requirement:

“Following a contingency or other event that results in an operating security limit violation, the control area shall return its transmission system to within operating security limits soon as possible, but no longer than 30 minutes.”

The overall emphasis is that each Control Area is expected to take actions necessary so that problems within its system will not cause problems for neighbouring systems. Each Control Area may operate to single contingency criteria but, following a contingency, must take action so that it can sustain a subsequent contingency. NERC provides that radial and local networks allow loss of firm load for single contingencies provided that problems in those areas will not affect the overall security of the interconnected system.

The operating Standards and Requirements most relevant to the Alberta transmission operating criteria are described in the Operating Manual in the following sections⁵:

- *Policy 2 – Transmission*
- *Policy 6 – Operations Planning*

The operating Standards and Requirements generally describe the level of transmission system reliability performance expected from the Control Areas. However, they do not identify specific criteria to be used to meet those expectations. This provides each Region with the flexibility to develop requirements specific to their areas. For Alberta, the regional requirements are defined by WECC Standards and Requirements.

³ The NERC Operating manual is available at <http://www.nerc.com/standards/>

⁴ NERC Operating Manual, Preamble, page I-1

⁵ The other Policy sections are: Policy 1 – Generation Control and Performance, Policy 3 – Interchange, Policy 4 – System Coordination, Policy 5 – Emergency Operations, Policy 7 – Telecommunications, and Policy 8 – Operator Personnel and Training

4.0 Overview of WECC Operating Policies

The WECC requirements for reliable operation are identified in a number of policy and procedure documents⁶. The overall philosophy of the WECC requirements is very similar to the NERC operating requirements. It could be summarized as:

- A member system must be able to sustain a specified single contingency without loss of firm load.
- A system must also be able to sustain a specified multiple contingency (or another contingency after system adjustment following the first specified single contingency) without causing cascading outages on the interconnected system. Planned or controlled curtailment of load and/or generation can be used to achieve this requirement.
- Following any contingency, adjustments to the system must be made so that the system could sustain another specified single contingency. These adjustments could include curtailment of load and/or generation.
- The contingency response requirements are not required for radial customers or Local Networks, providing that there is no impact to the reliability of the Interconnection.

Since Alberta is part of the Western Interconnection and has chosen to comply with NERC and WECC Reliability Criteria, the WECC operating requirements are a major influence on the AESO transmission operating criteria. The following discussion is intended to highlight portions of the WECC operating requirements that should be carefully considered when defining the AESO operating criteria.

The primary reference for the reliability requirements for the operation of the Alberta system is the WECC *Reliability Criteria*. The *Reliability Criteria* identifies Standards, Measures and Guides to be used to achieve reliable operation on the interconnected system. The Standards and Measures are mandatory for all Control Area operators. They provide specific indication of the operating criteria to be applied. Guides provide further suggestions on appropriate practices, but they are not mandatory.

The *Reliability Criteria* consists of five parts. The parts most relevant (in order of priority) to the AESO transmission operating criteria are:

- *Part III – Minimum Operating Reliability Criteria* (referred to as MORC) and
- *Part I – NERC/WECC Planning Standards*.
- *Part IV - Definitions*

These parts are discussed below. References to other pertinent policies and procedures are included in this discussion.

⁶ The WECC Policies and Procedures can be accessed at http://www.wecc.biz/docs_pubs.html. Many of the Policies are also included in the OC Handbook which is listed under Publications

4.1 Part III – Minimum Operating Reliability Criteria

The MORC outlines the overall Requirements for reliable operation of the system. *Section 2 – Transmission* states the Basic Criteria for reliable operation. These basic criteria are similar to the NERC basic requirements. Extracts of the MORC basic criteria that are most pertinent to the AESO operating criteria are:

“Continuity of service to load is the primary objective of the Minimum Operating Reliability Criteria”,

“The interconnected power system shall be operated at all times so that general system instability, uncontrolled separation, cascading outages, or voltage collapse will not occur as a result of any single contingency or multiple contingencies of sufficiently high likelihood.”

and

“The necessary operating procedures, equipment, and remedial action schemes shall be in place to prevent unplanned or uncontrolled loss of load or total system shutdown.”

Section 2 - Transmission also indicates the requirements for voltage control on the interconnected system. It includes the concept of under voltage load shedding to avoid cascading. The requirements include:

“Operating entities shall assess the need for and install undervoltage load shedding as required to augment other reactive reserves to protect against voltage collapse and ensure system reliability performance criteria as specified in the WECC Disturbance-Performance Table of Allowable Effect on Other Systems⁷ are met during all internal and external outage conditions.”

Overall system stability requirements are defined in MORC *Section 3 – Interchange*, which indicate:

“The interconnected power system shall remain stable upon loss of any one single element without system cascading that could result in the successive loss of additional elements. The system voltages shall be within acceptable limits defined in the NERC/WECC Planning Standards.

.... loss of either single or multiple elements should not cause uncontrolled, widespread collapse of the interconnected power system.”

The MORC provides some specific directions for operations planning studies in *Section 6 – Operations Planning*. The criteria for studies are not stated in this section. Instead, the MORC refers to the criteria in the *NERC/WECC Planning Standards*. Section 6 states: “To be considered acceptable, operating study results must be in compliance with the WECC Disturbance-Performance Table⁸ within the

⁷ Table W-1 of the NERC/WECC Planning Standards, page 13

⁸ See Part II Section 5.3

NERC/WECC Planning Standards.” Section 6 also provides direction on the use of automatic load shedding and system sectionalizing as a method to avoid system collapse.

4.2 Part I – NERC/WECC Planning Standards

This section is intended to illustrate the linkage between NERC/WECC Planning Standards and MORC.

Most of the NERC and WECC planning criteria applicable to operating purposes are indicated in *Part I – NERC/WECC Planning Standards*. In this document, WECC has merged its planning standards into the NERC Planning Standards. This conveniently places the NERC and WECC planning requirements into a single document. Section I of the Planning Standards deals with *System Adequacy and Security*. Two of the subsections – *A. Transmission Systems*, and *D. Voltage Support and Reactive Power* – are most relevant to the AESO transmission operating criteria.

The Standards and Measures in section *I.A. Transmission* define the criteria for operating studies. These criteria are conveniently summarized in *Table I. Transmission System Standards – Normal and Contingency Conditions*⁹. This table summarizes operating conditions that must be met under four categories of operating situations:

- A- No contingencies (System Normal)
- B- Events resulting in the loss of any single specified element
- C- Events resulting in the loss of two or more (multiple) specified elements
- D- Extreme event resulting in two or more (multiple) elements removed or cascading out of service

The standards require all systems to be able to meet firm load and firm transfers following a single contingency event (Category B). It should be noted that this standard is not expected of radial customers and customers on a Local Network¹⁰, provided that there is no impact to security of the interconnected system. Planned or controlled loss of firm load is permitted for the multiple contingency events (Categories C and D). Cascading outages (uncontrolled successive loss of system elements) that would affect the interconnected system are not permitted for Category B and C events.

In section *I.A. Transmission*, the WECC has added the requirements illustrated in *Table W-1 WECC Disturbance-Performance Table of Allowable Effects on Other Systems*.¹¹ This table provides voltage and frequency deviation criteria for the various categories mentioned above. It is emphasized that these performance standards are not required internal to a member system.

⁹ Table I of the NERC/WECC Planning Standards, page 25, See Part II Section 4.1 for copies.

¹⁰ Local Network is defined in *Reliable Criteria, Part IV Definitions*

¹¹ See Part II Section 5.3

The Standards required to avoid voltage instability and widespread system collapse are indicated in section *I.D. Voltage Support and Reactive Power*. The standards set requirements for all contingency levels described in Table I. This section promotes the use of P-V and V-Q analysis to ensure that appropriate reserves are available to maintain voltage stability. It suggests that undervoltage load shedding may be helpful in avoiding voltage collapse under Category C & D contingencies. The WECC provides two additional references to the support these standards. The *Undervoltage Load Shedding Guidelines* illustrate the need for automatic undervoltage load shedding to avoid cascading outages. The *Voltage Stability Criteria, Undervoltage Load Shedding Strategy, and Reactive Power Reserve Monitoring Methodology* provides detailed instructions on how to perform P-V and V-Q analysis to establish voltage reserve margins.

These policies illustrate the concept of a single contingency operating criteria supplemented with a backstop or Safety Net that enable the system to withstand more severe events. The *WECC Policy Regarding Extreme Events and Unplanned Events* reinforces this approach. It provides further information on Safety Nets and encourages the use of Safety Nets to reduce the severity of low probability and unforeseen events.

5.0 AESO Transmission Operating Criteria

5.1 Overall Philosophy of the AESO Transmission Operating Criteria

The AESO Transmission Operating Criteria is based on the *WECC Reliability Criteria*. In general, it adopts the requirements and standards identified by the WECC, and supplements them with requirements that recognize special situations on the Alberta system. Significant features of the AESO operating criteria include:

- The Alberta transmission system must be able to sustain any specified single contingency without loss of firm load with the exception of local networks and radial connected load.
- The Alberta transmission system must also be able to sustain a specified multiple contingency, or a subsequent contingency to the first contingency, without causing cascading outages on the interconnected system. Planned or controlled loss of load and/or generation may be used to achieve this requirement.
- Following any contingency, adjustments to the system must be made so that the system could sustain another contingency. These adjustments may include curtailment of load and/or generation.

5.2 Contingency Criteria

The system response requirements to contingency conditions are defined by the *WECC Reliability Criteria* with most requirements appearing in *Part I - NERC/WECC Planning Standards*. These requirements are summarized in *Table I. Transmission Standards – Normal and Contingency Conditions*¹². This table illustrates the

¹² Table I is reproduced in Figure 4.1-1 (Part II Section 4.2)

expected responses of the system to four categories of contingencies. These categories, which will be used in discussions in other sections, are:

- Category A - No contingencies (System Normal)
- Category B – Specified events resulting in the loss of a single element
- Category C – Specified events resulting in the loss of two or more (multiple) elements.
- Category D - Extreme event resulting in two or more (multiple) elements removed or cascading out of service

The *NERC/WECC Planning Standards* require that the transmission system must be able to sustain category B events without loss of firm or non-radial load and remain with the applicable ratings, prior to any operator adjustment. For application in Alberta, the applicable ratings immediately following a contingency are the emergency ratings. Operator actions are one of the options that may be required to bring the system within normal ratings. The required responses listed in Table I recognize that planned or controlled interruption of supply to radial customers or Local Network customers may occur in all contingency categories. This will apply to many situations in Alberta, and will be further discussed below.

The system response to category C events must meet the same limits as required by category B, except that planned or controlled loss of load and/or generation is permitted.

A fundamental operating requirement is that the system must be able to sustain any B or C contingency while avoiding cascading outages¹³. Following any contingency, adjustments must be made to the system so that the next Category B contingency will not cause cascading. The use of the Safety Net concept is an important part of preventing cascading on the Alberta system.

5.3 Application of the AESO Transmission Operating Criteria

The application of the contingency requirements to the Alberta transmission system is illustrated in Figure 1. Response to Contingencies. This diagram illustrates the desired response to WECC contingency categories under various operating conditions. The diagram also emphasizes the activities required to prepare for the next contingency.

As illustrated in Figure 1, the Alberta transmission system operating in the Normal state (all equipment in service) must be able to withstand a single contingency (Category B event) without cascading and without load curtailments. The system must continue to operate within all equipment limits. Operation of automatic Remedial Action schemes (RAS) may occur if part of the designed response. Following the contingency, action must be taken so that the system could sustain the next contingency and meet the response requirements shown for that contingency. A key requirement of this preparation is to ensure that another contingency would not cause cascading.

¹³ Level D requires an evaluation of the risks and consequences. A party may chose to accept the consequences.

The required single contingency (Category B event) response when the transmission system is operating with one element out of service is also shown in Figure 1. This case is similar to the required contingency response for the Normal state in that the contingency must not cause cascading. However, it differs from the Normal state response in that some loss of load may occur. Operation of Safety Net devices such as undervoltage load shedding (UVLS) may also occur. Additional detail provided in section 5.7

The required contingency responses to Category C and D events are also shown in Figure 1. The diagram illustrates that either event could result in loss of load, generation, and/or interchange and that operation of Safety Net devices may occur. A Category C event must not cause cascading. Following either event, actions must be taken to prepare for a subsequent contingency.

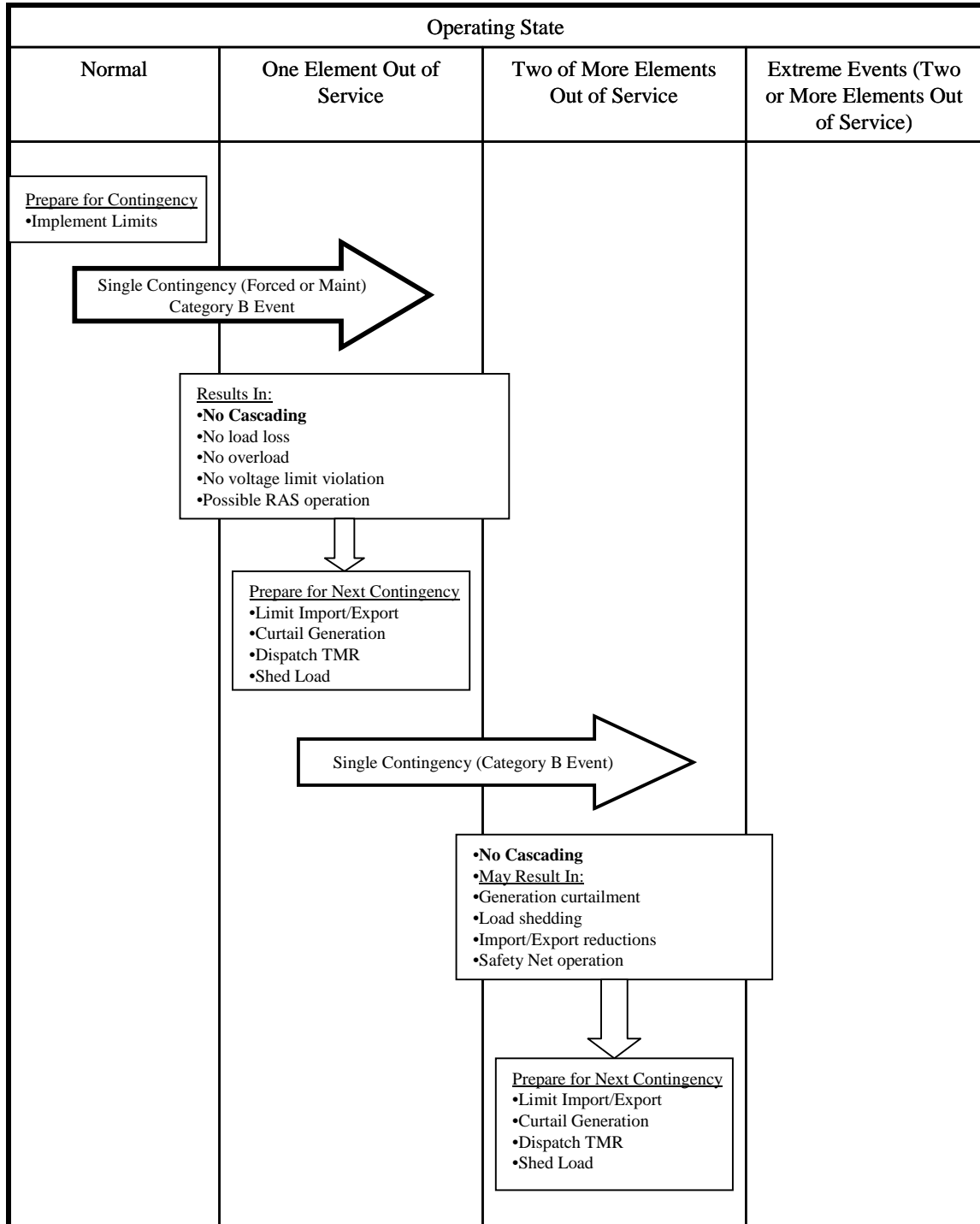


Figure 1. Response to Contingencies

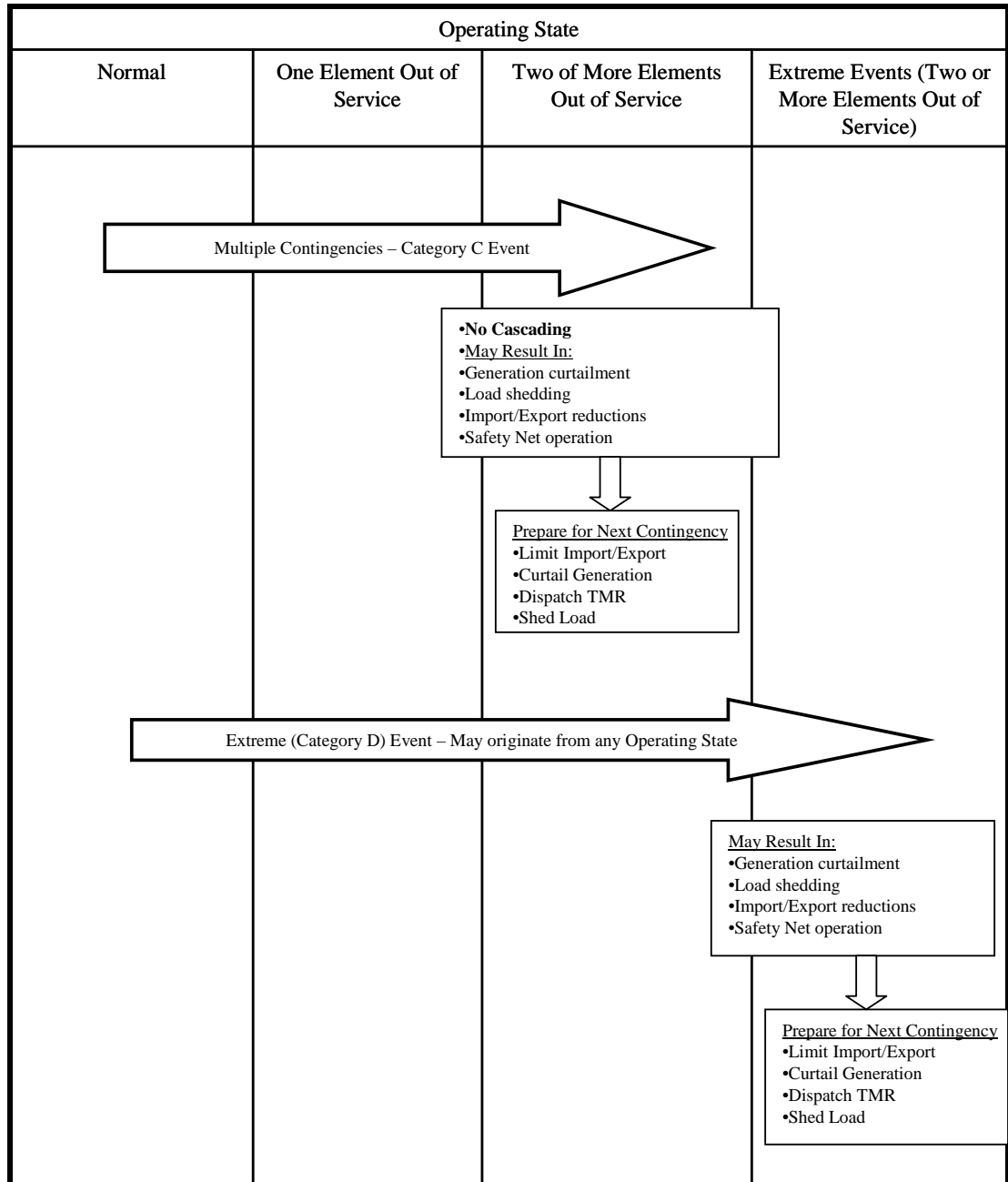


Figure 1. Response to Contingencies (Continued)

5.4 Local Networks and Radial Supply

The AESO Reliability Criteria provides, as does WECC Criteria, for Local Networks. (Part II Section 4.1) The AESO will designate Local Networks, from time to time, as necessary. The following discussion provides some clarification on how the Radial Systems and Local Networks will be identified for application of the AESO Transmission Operating Criteria.

The determination of the Alberta transmission facilities that would be considered a Radial System is a straightforward application of the WECC definition. However, some clarification on how to designate Local Networks would be helpful. The WECC provides the following definition of Local Network:

“A Local Network (LN) is a non-radial portion of a system and has been planned such that a disturbance may result in loss of all load and generation in the LN.

- 1) The LN is not a control area.
- 2) The loss of the LN should not cause a Reliability Criteria violation external to the LN.”

This definition does not place any limit on the size or voltage level of the facilities that could be considered a Local Network except that the whole Alberta system (a control area) could not be considered as a Local Network. A key requirement of facilities designated as a Local Network is that outages within the Local Network must be contained within that network.

The AESO Transmission Operating Criteria uses the WECC definition for a Local Network. The primary consideration in designating a Local Network is that there must be the capability to contain any disturbance within that Local Network. This requirement may be achieved through the normal response of the network (depends on configuration) or special protection may be required. Consequently, the boundaries of a Local Network may change as the system is developed.

5.5 Safety Nets

A fundamental aspect of the WECC Reliability Criteria (and the AESO Transmission Operating Criteria) is that all contingencies (except for Category D), or series of contingencies, must be controlled to prevent cascading of outages on the interconnected system. The WECC *Policy Regarding Extreme Contingencies and Unplanned Events* recognizes that “it is not feasible or even possible to predict or prevent all multiple contingency events. Therefore, Safety Nets are needed to minimize and reduce the severity of these low probability and unforeseen events to prevent cascading.” Examples of Safety Net schemes¹⁴ include direct load tripping schemes, undervoltage load shedding schemes, and controlled islanding schemes. Although Safety Nets are intended to operate for extreme disturbances, portions of these Safety Nets may be used to prevent more likely disturbances from escalating into a more severe disturbance.

¹⁴ The under-frequency load shedding scheme is a Safety Net scheme applied throughout the WECC to prevent cascading following loss of multiple generating units.

For many parts of the Alberta transmission system, the Safety Net concept is an important factor in providing capability to avoid cascading following multiple contingency events (as well as single contingency events for some Local Networks). Undervoltage load shedding can be particularly helpful form of Safety Net for the Alberta transmission system.

The application of undervoltage load shedding to the Alberta system must be carefully designed. Alberta has a high proportion of industrial load that is sensitive to low voltage. Some of this load is protected with customer-owned devices that are set to meet customer needs. These low voltage protection settings may not be compatible with transmission undervoltage load shedding requirements. In order to prevent an excessive amount of load shedding, the transmission undervoltage scheme must recognize that some customer load may trip before the transmission scheme operates.

5.6 Limits

Table I. Transmission Standards – Normal and Contingency Conditions includes columns showing the various limits that should be applied for the various operating situations. These appear as “Applicable Rating” in the table. The following sections indicate the “Applicable Ratings” that will be applied by the AESO Transmission Operating criteria¹⁵.

5.6.1 Thermal Limits

The steady state thermal ratings, specified by the Transmission Facility Owners, (TFO) will be the Applicable Ratings during Category A conditions. Following a contingency (Categories B, C and D), the Applicable Ratings will be the Emergency Limits specified by the TFOs.

5.6.2 Voltage Limits

The equipment voltage limits, for steady state and post-contingency situations will be provided by the TFOs.

5.6.3 Stability Limits

Several types of limits will be recognized in this category:

- The limits defined by the *NERC/WECC Planning Standards in Table W-1 WECC Disturbance –Performance Table of Allowable Effects on Other Systems*¹⁶ will not apply to the ATS with the exception that it will apply to the BC 500 kV Tie.
- The limits will also recognize voltage stability limits as defined by the WECC report *Voltage Stability Criteria, Undervoltage Load Shedding Strategy, and Reactive Power Reserve Monitoring Methodology*. The limits indicated in *Table*

¹⁵ The tables in this section showing post-contingency limits are based on tables that were proposed by the Electric Transmission Council (ETC) in January 1998.

¹⁶ Table W-1 is reproduced Part II Section 5.3 Figure 5.3-2

1 WECC Voltage Stability Criteria¹⁷ will generally apply to the Alberta system. Note that, as indicated by the table, controlled load shedding may occur within the Alberta system in order to meet these requirements. The AESO may identify Local Networks or Radial Systems where the voltage stability limits would not apply.

5.6.4 Point of Delivery Limits

In addition to the voltage limits described above, consideration must also be given to the impacts of contingencies and routine switching of transmission elements on the voltages at the transmission delivery points. The following table illustrates the limits on the voltage variations.

Acceptable Post Contingency Voltage Deviation at Low Voltage Bus	Time Period		
	Post Transient (Up to 30s)	Post Auto Control (30 sec to 5 min)	Post Manual Control (Steady State)
Voltage Deviation from Steady State at Low Voltage Bus	± 10%	± 7%	± 5%

5.6.5 Frequency Limits

Alberta complies with the WECC Coordinated Off-Nominal Frequency Load Shedding and Restoration Plan.

The WECC Plan is supplemented with additional underfrequency load shed to cover loss of tie line at maximum import and loss of 2 large generating units at the same time.

Category B and C events or the loss of the BC Tie shall not result in a system frequency over 61.0 Hz. The overfrequency must settle to less than 60.3Hz quickly enough to avoid uncoordinated generator tripping in Alberta.

5.7 Operating Criteria for Maintenance Conditions

The ATS will be planned to meet Category B performance standards during a planned maintenance outage of a single element, see Part II Section 4.2. This standard does not apply to Local Networks, areas of the system where meeting this standard is not deemed to be economic or prudent or areas where development does not yet meet the criteria.

¹⁷ This table is reproduced in Part II Section 5.2

All elements of the ATS must be maintained. To mitigate risks during maintenance the AESO has established a maintenance scheduling risk assessment process¹⁸ which includes the following:

- Choosing a time when loads are lower
- Choosing a season when the impact of load loss is lower
- Choosing a season (or day) when the contingency risks are lower
- Coordinating with load or generation turnarounds
- Consider live line maintenance techniques
- Use of probabilistic analysis to evaluate various strategies that could be employed to reduce the contingency consequences.
- Coordination with other maintenance activities.

5.8 Revisions to the Transmission Operating Criteria

This AESO is responsible for revisions to the Operating Criteria. These revisions may occur, from time to time, in response to changing industry needs (particularly WECC and NERC), as well as to respond to changing conditions on the Alberta transmission system. As a minimum, the AESO Transmission Operating Criteria will be reviewed every five years.

¹⁸ The maintenance scheduling process is described in AESO Operating Policy and Procedure OPP 602.