aeso
ALBERTA ELECTRIC SYSTEM OPERATOR

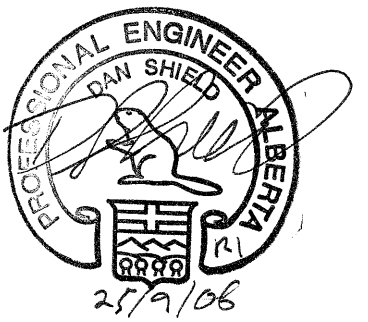
Generation and Load Interconnection Standard

OBSOLETE

Rev. 1

Final

September 19, 2006



	Name	Signature	Date
Prepared:	DAN SHIELD		25/9/06
Approved:	FRED RITTER		27/9/06
VP Acceptance	NEIL MILLAR		29/09/06

APEGGA Permit to Practice P-08200

OBSOLETE

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 Introduction

1.1 Purpose

The purpose of this Standard is to define the AESO's requirements for connecting load or generation facilities to the AIES. This includes all loads, generators, and Industrial Systems with generators regardless of net import or export levels, but does not include distribution connected generators. The Standard addresses the following requirements:

a) that system voltage, frequency and power quality are maintained within acceptable limits;
b) that the Facilities can be dispatched and operated within the physical limits of their capability;
c) that the Facilities and the AIES are operated safely and reliably; and
d) that the AESO remains compliant with WECC and NERC requirements.

The applicable TFO may also have some additional requirements for interconnection. Such requirements are typically addressed by the AESO Functional Specification for each interconnection project.

Other necessary technical considerations, such as SCADA, protection, metering, etc, are included in other AESO standards and these are incorporated by referenced into this Standard. Wind generation is addressed in Wind Power Facility Technical Requirements standard. AESO Operating Policies and Procedures (OPPs), which are part of the ISO Rules, are also referenced and can be accessed via AESO's website. Any contractual, tariff, market, ancillary service, operating agreements or other requirements to complete the interconnection are not covered within this Standard.

1.2 Application

Subject to the following, this Standard applies to all Facilities. Sections 2 and 4 will be applied on a ***go forward basis;*** that is the new requirements in this Standard shall not be used as justification to retrofit or change Facilities presently connected to the AIES that are not compliant. However, the AESO reserves the right, on a case-by-case basis, to require retrofitting, to this Standard of existing non compliant Facilities that the AESO deems critical to the AIES. Unless directed otherwise by the AESO, Facilities presently connected to the AIES must continue to meet the Interconnection Requirements at the time of their energization.

In order to maintain system reliability levels, Section 3 "Generation Interconnection Requirements" shall apply to all existing and new generating facilities.

The Standard supersedes the technical requirements of the following standards:

Technical Requirements for Connecting to the Alberta Interconnected Electric System (IES) Transmission System, Part 1: Technical Requirements for Connecting Generators, Rev 1.0, 1999-12-06

Technical Requirements for Connecting to the Alberta Interconnected Electric System (IES) Transmission System, Part 2: Technical Requirements for Connecting Loads, Rev 1.0, 1999-12-06

The Standard comprises the "Interconnection Requirements" as defined in the ISO Tariff.

1.3 Definitions

The following capitalized terms when used in the Standard have the following meanings:

"AESO Tariff" means the tariff of the AESO as described in section 30 of the EUA and approved by the EUB;

"AIES" means the "interconnected electric system" as defined in the EUA;

"Alberta Transmission System" or "ATS" means "transmission facilities" as defined in the EUA;

"Distribution Facility Owner" or "DFO" means in respect of a "electric distribution system" as defined in the EUA, the "owner" as defined in the EUA;

"EUA" means the Electric Utilities Act;

"Facilities" means load or generation facilities that are or are intended to be connected to the AIES pursuant to the ISO Tariff;

"External Dynamic Reactive Source" means a device that can quickly provide positive and negative VAr's in a continuously variable manner regardless of equipment terminal voltage.

"Generating Facility Owner" or "GFO" means in respect of a "generating unit" as defined in the EUA, the "owner" as defined in the EUA.

"Industrial System" means an industrial system as defined in the EUA;

"ISO Rules" means the rules mad by the AESO pursuant to section 20 of the EUA;

"P_{ST} " means the Short Term Flicker Limit severity based on a 10 minute interval as defined in the IEC Standard 1000-3-7 Electromagnetic Compatibility (EMC) – Part 3: Limits - Section 7[1]

"P_{LT} " means the Long Term Flicker Limit. severity based on a 2 hour sample period which is derived from groups of 12 consecutive P_{ST} values as defined in the IEC Standard 1000-3-7 Electromagnetic Compatibility (EMC) – Part 3: Limits - Section 7

[1] IEC standard 1000-3-7 Electromagnetic Compatibility (EMC) – Part 3: Limits - Section 7, 1996-10

"Point of Common Coupling" or "PCC" means the point of connection between the ATS and customers, DFO's, or GFO's. For DFO's this will be at the transformer secondary bus (typically 25kV), for industrial customers connecting directly to the transmission system this will be at the high voltage transformer terminals, for generators connecting directly to the transmission system this will be at the high voltage transformer terminals;

"Standard" means this document and the interconnection standards contained in it;

"Transmission Facility Owner" or "TFO" means in respect of a "transmission facility" as defined in the EUA, the "owner" as defined in the EUA;

"Under-Frequency Load Shedding" or "UFLS" has the meaning given in the ISO rules;

"Under-Voltage Load Shedding" or "UVLS" - has the meaning given in the ISO rules.

1.4 Modifications

AESO may be required to revise this standard from time to time in order to, among other things, remain compliant with NERC and WECC requirements as those requirements change from time to time.

In respect to modifying this standard the AESO will:

a) seek and consider the input and feedback of any affected parties prior to making changes or additions to the standard;
b) make and manage all changes to this standard;
c) make this standard publicly available via the AESO website.

1.5 Requirement For Review

This Standard expires and must be reviewed within five (5) years of the effective date shown on the cover page and given below. This standard shall stay in force during the review period, but shall automatically cease to have force twelve (12) months after the five (5) year expiry date.

The effective date of this standard is September 19, 2006.

1.6 Document Change History

VERSION	DISCRIPTION	DATE
Rev 0	Draft Issued for Stakeholder Comment	2005.11.01
Rev 0A	Stakeholder Comments addressed on the following topics: Power Quality, Voltage Regulation, and Reactive Power	2006-03-27
Rev 0B	Additional Stakeholder comments addressed.	2006-09-19
Rev 1	Final Issue	2006-09-19

2.0 General Interconnection Requirements

The technical requirements outlined in this section apply to both load and generation facility interconnections connected to the ATS.

2.1 Power Quality

2.1.1 Voltage Fluctuations (Flicker)

Facilities shall be designed to meet IEC standard 1000-3-7 Electromagnetic Compatibility (EMC) – Part 3: Limits - Section 7: Assessment of emission limits for fluctuating loads in MV and HV power systems - with short and long term flicker limit as identified in the following table:

Table 2-1: Short and long-term flicker limits

	≤25kV	>25kV
P_{st}	0.9	0.8
P_{lt}	0.7	0.6

This requirement shall be applied at the PCC.

2.1.2 Harmonics

Harmonic limits shall be as specified in IEEE Standard 519-1992 Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems - Section 11 and measured at the PCC.

2.1.3 Voltage Unbalance

Any new three-phase facility must not increase the phase-to-phase voltage unbalance of the system by more than 1%, as measured with no load and with balanced three-phase loading. The voltage unbalance on the electrical system under normal operating conditions is kept to a minimum and shall not exceed 3%.

The voltage unbalance is calculated as follows:

$$\text{Unbalance} = \frac{100 \times \text{deviation from average}}{\text{average}}$$

This calculation is defined by National Electrical Manufacturers Association (NEMA) standard MG1-14.33 and American National Standard for Electric Power Systems and Equipment – Voltage Rating (60Hz) ANSI 84.1.

This requirement shall be applied at the PCC.

2.2 System Grounding

The AIES is designed as an effectively grounded system, i.e. the X_o/X_1 ratio is less than or equal to three. The AIES shall remain an effectively grounded system even with equipment out of service.

In rare cases where the AIES is not effectively grounded or where operation of the AIES causes the system X_o/X_1 ratio to exceed three, consideration shall be given to the application of equipment rated line to line for the system voltage on that part of the AIES.

2.3 Insulation Coordination

Voltage stresses caused by lightning, switching surges, temporary over-voltage, islanding, and neutral shifts need to be protected against when adding new facilities to the AIES. This is accomplished through selecting equipment with an adequate Basic Impulse Insulation Level (BIL) and the use of surge arrestors. The addition of new facilities can also change the duty cycle of existing equipment by increasing their exposure levels. The minimum BIL levels for new facilities will be provided in AESO's project functional specification along with any requirements for upgrading existing facilities.

In addition to these minimum BIL levels the new facilities shall be designed for the average isokeraunic level (thunderstorm days per year or lightening flash density, available from Environment Canada) for the specific site location.

IEEE P998 provides additional background on direct stroke lightning protection.

2.4 AIES Disturbance Recording

To aid in system post-disturbance analysis, automatic disturbance oscillograms and event recorders must be installed at key locations throughout the AIES, and must be synchronized to Universal Coordinated Time. The primary recording devices, phasor measurement units (PMUs), must conform to the Western Electricity Coordinating Council's (WECC's) Wide Area Measurement System requirements. The need for a PMU will be determined by the AESO and identified in AESO's project functional specification.

Per AESO's Protection Standard all numerical protection systems shall be equipped with recording devices that record voltage, current and all relay operations during a fault condition. Further details are available in the Protection Standard.

2.5 Clearances and Access

Energized parts must maintain a safe vertical and horizontal clearance as dictated by the following standards, regulations and code requirements in effect at the time of facility construction:

Alberta Electrical and Communication Utility Code (AECUC)

Canadian Electrical Code 22.1 Part I

2.6 Voltage Level and Voltage Range

The nominal voltage, operating voltage range, and maximum and minimum voltages will be provided by the AESO in the AESO project functional specification for the interconnection. It is the applicant's responsibility to ensure the equipment complies with the AESO's specified voltage requirements. Typical operating voltages may be found in OPP 702 "Voltage Control".

2.7 Current Level and Ampacity Range

Minimum current-carrying capability (rated by voltage level) for major equipment and associated substation bus components is project specific and will be provided in the AESO project functional specification for the interconnection.

2.8 Resonance

The design of the facility shall avoid introducing resonant conditions into the AIES. Of particular concern are self-excitation of induction motors, transformer ferroresonance, and the possible resonant effects of capacitor additions.

2.9 Fault Levels

System fault levels at the point of interconnection will be provided in the AESO project functional specification for the interconnection. It is the responsibility of the facility owner to ensure that interconnected facilities are designed for these published fault levels. As fault levels change over time, the facility owner must ensure that the interconnected facilities are upgraded as required for the increased fault levels. To this end the AESO will include an estimate of future and ultimate fault levels in the AESO project functional specification for the interconnection.

2.10 Fault Interrupting Devices

The design of the interconnection facility must consider the fault contributions from both the transmission system and the proposed facility. The interconnecting facility must have fault interrupting and momentary withstand ratings that are adequate to meet the maximum expected fault levels, as specified in the AESO functional specification for the interconnection, with appropriate margin for future station and short circuit level growth.

Due to the reduced reliability, increased outage times, the possibility of single phasing, and possibility of ferroresonance, the use of high voltage fuses on the transmission system (69kV and above) is not permitted.

2.11 Isolating Devices

The customer or facility owner and the TFO will collaborate to define a point or points of isolation. The customer or facility owner will provide manually operated isolation devices at all points of isolation. The devices must permit visual verification of electrical isolation, and must be capable of being locked open with multiple locks. The isolating device must be under the control of a single control authority, as agreed between the customer, the GFO and the TFO, as applicable, in a Joint Operating Procedure (JOP).

3.0 Generation Interconnection Requirements

This section specifies the technical requirements for all generators (excluding wind farms and distribution connected generators) to be connected to the ATS. The requirements apply to generators connected directly to the ATS or load customer with generator facilities. The requirements in this section are in addition to the general technical requirements outlined in section 2.0.

Wind farms shall comply with the AESO's Wind Power Facility Technical Requirements which can be found on the AESO website.

3.1 Voltage Regulation

All generating units, whether synchronous or not, must at a minimum be dispatchable and capable of supplying continuous reactive power at any point within the limits of 0.9 power factor over-excited (lagging)[2] and 0.95 power factor under-excited (leading)[3] as measured at the generator unit terminals. The FULL range of the reactive power capability must be available over the entire MW operating range of the generator at rated generator terminal voltage as shown by the shaded area in Figure 3-1:

Each generating unit, under non-disturbance conditions, must be capable of maintaining a constant voltage at the generator terminals within ±0.5% of a set point by continuously modulating its reactive power output within the limits specified above. The voltage set point must be adjustable by the generating unit operator and dispatchable from the AESO System Controller within ±5% of the nominal generator interface voltage.

Unit transformers must have a tapped range such that maximum unit output can be achieved throughout the system operating voltage range as specified in the project functional specification. At a minimum, unit transformers shall be capable of a ±5% voltage range in 2.5% increments.

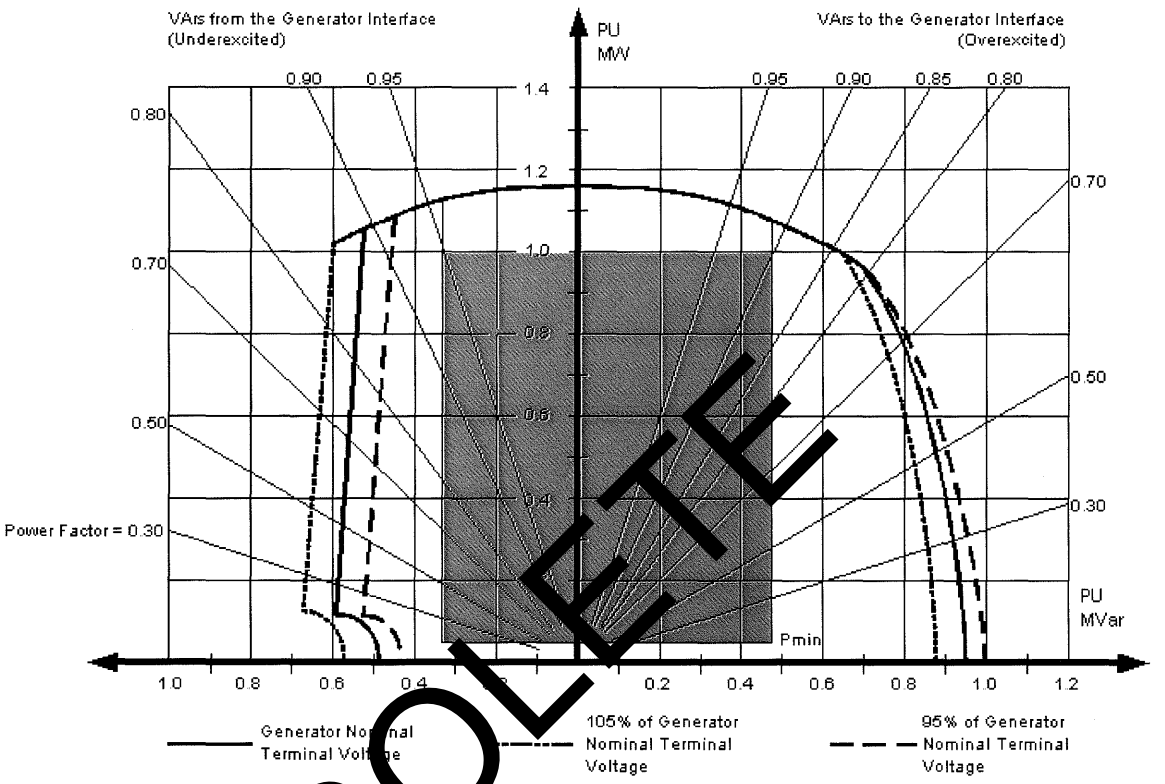
The combination of the generator and transformer capabilities shall allow for a total operating voltage range of ±10%.

Generators shall operate in automatic voltage control mode. Other operating modes such as Constant VAr regulation mode and power factor regulation mode are not acceptable for connection and operation on the AIES.

Excitation systems with stator current limiters are not acceptable for interconnection.

[2] VArs flowing to the AIES from the generating facility.
[3] VArs flowing from the AIES to the generating facility.

Figure 3-1: Generator Reactive Power Capability Requirements



The use of an external dynamic reactive source to compensate for a generator's inabilities to meet the above requirements will be considered by the AESO on a project by project basis.

3.2 Frequency and Speed-Governing Characteristics of Turbo/Generator Unit(s)

Synchronous generators and non-synchronous generators with stand-alone capability, with a capacity of 10 MW or more must have a speed governor. The governor droop setting must be set at 5% and total governor deadband (intentional plus unintentional) shall not exceed ±0.06%. Further, the generator must always be operated with the governor system free to respond to system frequency changes.

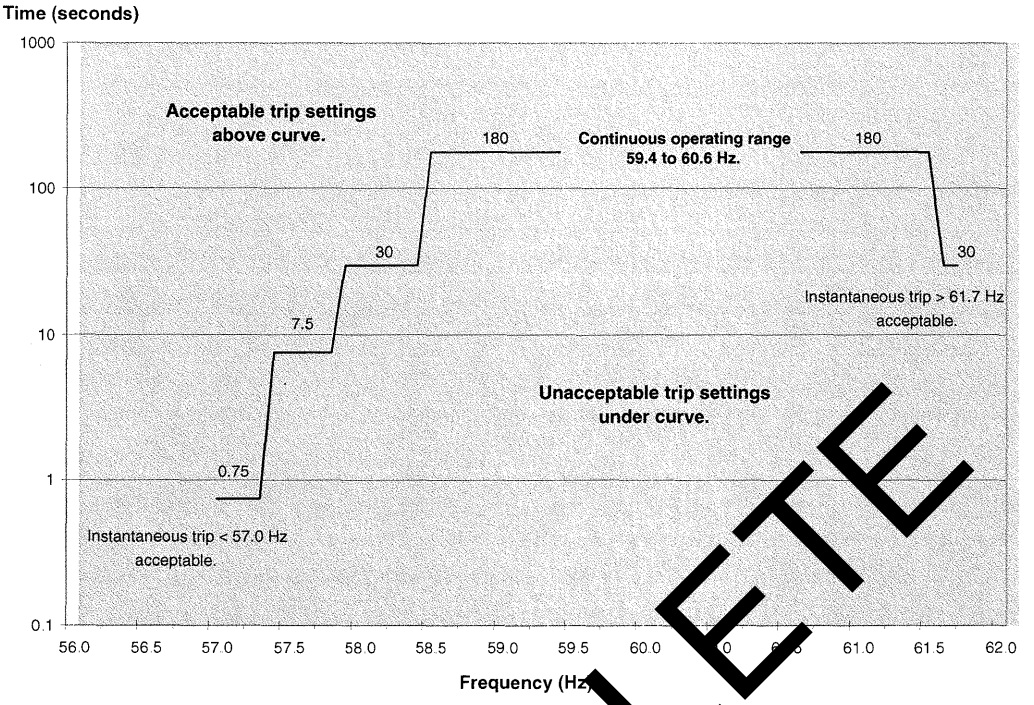
If a GFO wants to synchronously interconnect a generator that may become islanded with some portion of the AIES load, they must ensure that the generator is capable of performing its own speed governing. As a minimum, the islanded generator(s) must be able to maintain frequency within the 59.4 to 60.6 Hz range until the island can be synchronized to the main AIES grid. Potential electrical islands must be equipped to enable re-synchronizing with the main grid.

An interconnected generating facility must remain synchronously connected for frequency excursion, as specified in the WECC Off Nominal Frequency Requirements (effective December 5, 2003) and OPP 804 "Off-Nominal Frequency Load Shedding and Restoration". This means that generators connected to the grid that have off-nominal frequency protection must accommodate, as a minimum, under-frequency and over-frequency excursions for the time frames listed in Table 3-1: and illustrated in Figure 3-2.

Table 3-1: Frequency Ranges

Under-Frequency Limit (Hz)	Over-Frequency Limit (Hz)	Minimum Time
> 59.4 Hz	60.0 Hz to < 60.6 Hz	N/A (continuous operating range)
≤ 59.4 Hz	≥60.6 Hz	minutes
≤ 58.4 Hz	≥61.6 Hz	30 seconds
≤ 57.8 Hz		7.5 seconds
≤ 57.3 Hz		5 cycles
≤ 57.0 Hz	≥61.7 Hz	instantaneous trip

Figure 3-2: Generator Frequency Trip Setting



In accordance with WECC requirements, generators that trip off the grid in a shorter period than the minimum time described in Table 3-1: must automatically trip load simultaneously with the generator trip to match the anticipated generation loss at comparable frequency levels.

3.3 Power System Stabilizer

All synchronous generators must be equipped with power system stabilizers (PSS), as required by WECC policy[4,5]. The AESO will review the GFO's proposed design to ensure the damping requirements are sufficient.

3.4 Voltage Ride Through Capabilities

Per WECC's requirements[6] generator facilities larger than 10MVA are to remain in-service during system faults unless clearing the fault effectively disconnects the generator from AIES. Faults causing voltages as low as 0.15 per unit at the high side of the generator step-up transformer shall not cause or result in a generator trip within 625ms. In the post fault transient period generators shall remain in service for the low voltage excursions specified in

[4] WECC Policy Statement on Power System Stabilizers – Approved April 18, 2002
[5] WECC Power System Stabilizer Design and Performance Criteria – Approved April 23, 2004
[6] WECC Low Voltage Ride Through Standard – Approved June 17, 2005

WECC Table W-1 as applied to a load bus.[7] Generating units shall not trip for system voltage excursions within 0.9 to 1.1 per unit.

3.5 Transformer Connection

The interface transformer connection should be designed to provide a favorable circuit to reduce the transmission of harmonic currents, and to isolate transmission and generator side ground fault current contributions. Further, the configuration should provide an effective ground source to the transmission system. The preferred configuration is a delta connection on the generator side of the transformer, and a solidly-grounded wye connection on the line side of the transformer.

Generator transformer voltage ratio, tap changer type (load/off-circuit), range and step size must be such that:

- the reactive power requirements specified are fully complied with over the entire voltage range described in section 3.6, and
- the generating facility remains synchronized to the grid over the entire voltage range described in section 3.6.

3.6 Internal Generating Plant Event Log

In order for AESO to facilitate post event analysis and NERC/ WECC[8] reporting all plant trip events must initiate an event record that contains the initiating device (protection element) and be time stamped (synchronized to Universal Coordinated Time).

3.7 Generator Data Re-Validation

In order to ensure that the system modeled data matches the physical characteristics of the generating facility and to meet the NERC/WECC Planning Standard[9] the generating facility model data must be re-validated from time to time. The NERC/WECC Planning Standard presently states a minimum of every 5 years.

[7] NERC / WECC Planning Standards, Table W-1 – Revised April, 2005
[8] NERC Standard PRC-002-0, Define and Document Disturbance Monitoring Equipment Requirements
[9] NERC / WECC Planning Standards, Section II-B, System Modelling Data Requirements – Generation Equipment

4.0 Load Interconnection Requirements

This section specifies the technical requirements for connecting a new (or previously isolated) load to the AIES. These requirements are in addition to the general technical requirements outlined in section 2.0.

4.1 Power Factor Requirements

The entire load facility, regardless of load composition (rotating or static), must be capable of operating continuously at a power factor above 0.9 lagging. This will be measured at the Point Of Connection (POC).

4.2 Transformer Connection

The interface transformer connection should be designed to provide a favorable circuit to reduce the transmission of harmonic currents, and to isolate transmission and load-side ground fault current contributions.

For individual industrial loads directly connected to the transmission system, the preferred transformer configuration is a delta connection on the transmission supply side of the transformer, and a wye connection on the load side of the transformer.

For distribution loads connected to the transmission system, the preferred transformer configuration is wye wye and typically grounded solidly on both sides.

Other configurations will be considered on a project by project basis.

The need for load tap changing will be specified in the AESO project functional specification.

4.3 Under-Frequency Load Shedding

Under-frequency load shedding (UFLS) is used to ensure that a synchronously interconnected electric system continues to operate within an acceptable frequency range whenever generation suddenly becomes insufficient to meet the connected load of the system. When UFLS protection systems detect a decay of frequency following a significant resource loss, the system sheds sufficient load to maintain acceptable system frequency. The load shed sequence will be prioritized so that less critical loads are shed first to ensure uninterrupted service to essential loads.

The AIES complies with WECC requirements for coordinated under-frequency loadshedding.[10] Overall, AIES compliance with the WECC requirement is managed by AESO's OPP 804, which requires each Alberta distribution company and directly connected load customer to participate in

[10] *WSCC Coordinated Off-Nominal Frequency Load Shedding and Restoration Plan* 1997-11-25 http://www.wscc.com/files/uflsfina.pdf

the UFLS program, and to provide a proportion of the Alberta's under-frequency load shedding.

Customers must ensure that sufficient load is equipped with UFLS relays armed in each frequency band to meet the program specifications, and that the under-frequency protection scheme is properly installed, commissioned, and maintained.

4.4 Under-Voltage Load Shedding

During severe but infrequent situations, such as a simultaneous outage of multiple circuits, load shedding may be necessary to prevent cascading voltage collapse. The AESO will notify load customers of any under-voltage load shed (UVLS) requirements in the AESO project functional specification. As with UFLS, the UVLS sequence will be prioritized so that less critical loads are shed first to ensure uninterrupted service to essential loads.