TECHNICAL GUIDELINE FOR INTERCONNECTION OF GENERATORS TO DISTRIBUTION SYSTEMS



FOREWORD

This Guideline was prepared by a Task Force sponsored by the Electric Transmission Council Planning and Operating Committee.

At the time this Guideline was completed, the Task Force had the following membership:

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1. INTRODUCTION

1.1 Intent

- Inform and Guide those wishing to connect a power producing facility to the Alberta Interconnected Electric System through Distribution facilities.
- Give guidance to the Power Producer's and the Wires Owners' operators, technical staff, consultants and contractors who must determine the technical and operating requirements of the facility.
- Allow industry participants to collaborate in developing their standards to apply to interconnecting to the distribution facilities. While guidelines cannot cover every contingency, they are designed to cover most situations that participants would have to deal with to interconnect.
- Respect that each individual Wires Owner will be responsible for maintaining their own guidelines and standards which will change from time to time to reflect the changing nature of the technical and regulatory environment. This document is designed to provide a common starting point for discussion between the Wires Owners and the Power Producer.

This document does **not**:

- Establish commercial or cost-sharing agreements.
- Cover the interconnection to transmission at voltages above 25kV. For interconnection to the transmission system see *Technical Requirements for Connecting to the Alberta Interconnected Transmission Grid* at **www.eal.ab.ca/document/ConnectionPolicy.html**.

For a description of the electric power industry in Alberta under the new Electric Utilities Act, please reference the Department of Energy's website at **www.energy.gov.ab.ca/electric**.

1.2 Guiding Principles

The following principles underlie this guideline:

- The interconnection does not pose a safety hazard to other customers, the public or operating personnel.
- The interconnection does not compromise the reliability or restrict the operation of the electric system.
- The interconnection does not degrade power quality below acceptable levels.
- The interconnection is no more costly or complicated than necessary.
- The interconnection process provides competitive, fair and equitable access for all Power Producers.
- The interconnection process, recognizing that a generator interconnection may be much more complex than a similar-sized motor load connection on a distribution system, should aspire to approach the time and difficulty required to connect similarly sized motor loads.

2. TERMS AND DEFINITIONS

Accredited Certification Organization: an organization that has been accredited by the Standards Council of Canada to operate a certification program for electrical equipment, such as the Canadian Standards Association (CSA).

AEUB: the Alberta Energy and Utilities Board.

CEA: the Canadian Electrical Association

Distribution Facility: any power-line facility under the operating authority of the Distribution Wires Owners. Distribution Facilities generally operate at or below voltages of 25kV nominal, line to line.

AECUC: the Alberta Electrical and Communication Utility Code.

Electric Utilities Act: an act passed in the Province of Alberta that introduces competition in the generation of electric energy.

Exporters: someone who sells, outside the Province of Alberta, electric energy that is produced within the province.

IEEE: the Institute of Electrical and Electronics Engineers, Inc.

Importers: someone who sells, in the Province, electric energy that is produced outside the province.

Inverter Type Voltage Following Generating Equipment: generating equipment that uses power electronic devices to produce a voltage waveform, using the external voltage of the Distribution Facility to control the electronic devices, in such a way that if the external voltage ceases, the electronic devices instantaneously stop producing the waveform.

Islanded Operation: the operation of a generating unit that provides the sole source of production on an electric power system.

Operating Authority: the person responsible for the safe and orderly operation of electrical facilities. The Producer and the Wires Owner will each name an Operating Authority.

Parallel Operation: the operation of a generating unit while connected to the Alberta Interconnected System or a smaller separate electric power grid and in parallel with other sources of electric power generation.

Point of Interconnection: the point at which the ownership and responsibility for the electric system facilities change from the wire owner to the producer.

Power Pool: the market for all energy bought or sold in Alberta and provides the market for Power Producers to sell their electric energy.

Power Pool Participant: someone who has executed an agreement with the Power Pool of Alberta for the sale or purchase of electric energy.

Power Producer or Producer: someone who produces electric energy from an unregulated facility.

Standby Power: power consumed by a producing facility when the onsite generator is not operating.

System Controller: a provincially appointed authority responsible for dispatching load and generation of the Alberta Interconnected System in real time.

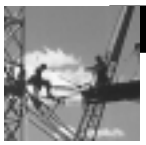
Tariffs: published rates for the sale of electric energy and energy services regulated by the AEUB.

Transmission Administrator: a provincially appointed authority providing access to the province-wide transmission grid. The TA's role is to provide system access service on the interconnected electric system in a manner that gives all eligible persons wishing to exchange electric energy through the power pool a reasonable opportunity to do so.

Transmission Facility: any power-line facilities under the authority of the Transmission facility owner. Transmission facilities generally operate at voltages above 25kV nominal, line to line.

Wires Owners: in this document the term refers to the owners of the distribution facilities. The duties of the Wire Owners are to use reasonable efforts to operate the facilities in cooperation with the other wire owners, and to be responsible for maintaining the integrity and reliability of the facilities.

WSCC: The Western Systems Coordinating Council



3. RESPONSIBILITIES

APPENDIX I summarizes, in a block diagram, the responsibilities which must be fulfilled in order to interconnect with the power system.

3.1 Power Producer Responsibilities

- Become a Power Pool Participant and comply with any power pool requirements (unless all energy produced at the site is to be consumed at the site).
- Provide technical information to the Wires Owner and to the Transmission Administrator, as specified in Appendix II of this document.
- Design, install, operate and maintain the Interconnection Facilities. All necessary designs and drawings shall be signed and stamped by a Professional Engineer; or shall be certified by an accredited certification organization and conform to the current edition of Part I of the Canadian Electrical Code.
- Obtain all required permits and licenses, which includes:
- ensuring that the local inspection and code enforcement authorities accept the installation.
- obtaining an operating agreement with the Wires Owner as specified in Appendix VI. The content of this agreement will be the technical and operating requirements.
- obtaining Alberta Energy and Utilities Board approval and order to connect. This approval requires an operating agreement to be in place between the Power Producer and the Wires Owner.
- obtaining an agreement on tariffs with the Transmission Administrator as specified in the Transmission Administrator's document, ***Terms and Conditions: Generation Pool Access Service*** or subsequent replacement documents.
- obtaining written approval from the Wires Owner before parallel operation and before any modification is made to the Power Producer system.
    - negotiate the timing and any testing requirements for the commission process for new generation being brought into the interconnected system with the Wires Owners, Transmission Administrator and/or the System Controller.

3.2 Distribution Wires Owner Responsibilities

The Wires Owner shall:

- Within a reasonable period, perform all relevant planning studies.
- Prepare an operating agreement with the Power Producer as specified in Appendix VI.
- Inform the Power Producer of the Wires Owner's current standards and practices.
- Provide to the Power Producer the information specified in Appendix III.

4. METERING

Responsibility for the electric meter installation to measure active energy and reactive energy flowing from the producing facility to the Distribution Facility lies with the Power Producer. The Wires Owner retains the right to obtain the metering data for internal use.

Responsibility for the electric meter installation to measure power, active energy and reactive energy flowing from the Distribution Facility to the producing facility lies with the Distribution Wires Owner. The Power Producer retains the right to obtain the metering data for internal use.

Where agreeable between the Distribution Wires Owner and the Power Producer, one physical bi-directional metering device may be used to fulfill both responsibilities.

Metering of power production must be submitted to the Transmission Administrator and the Power Pool in the format specified in the Transmission Administrator's document ***Practices for Management and Transfer of Metering Data*** or subsequent replacement documents. Metering shall conform to the Transmission Administrator Metering Standard.

The Transmission Administrator or the Wire Owner may arrange with the Power Producer to have the metering equipment tested and/or calibrated by the proper official.

5. TECHNICAL REQUIREMENTS

The following three sections, 5.1, 5.2, and 5.3, define respectively:

- the technical requirements to be met by the Distribution system. The Power Producer's equipment must be able to operate within the ranges specified in this section.
- the technical requirements to be met by the Power Producer.
- the technical requirements to be met by the facilities interconnecting the producing facility and distribution system.

5.1 Distribution System

5.1.1 System Frequency

The Alberta Interconnected Electric System operates at 60 Hertz (Hz.) Alternating Current (AC). Frequency deviations on the Alberta system are typically:

- 59.7 Hz. to 60.2 Hz. for small contingencies, for example where the Alberta Interconnected System remains intact and connected to the Western System.
- 58 Hz. to 61 Hz. for large contingencies, for example involving islanding of portions of the Alberta Interconnected System or the Western System.

5.1.2 Voltage Regulation

The Power Producer shall be responsible for ensuring that the voltage levels at the point of interconnection are as follows:

- maintained within the standards prescribed by the Wires Owner and/or
- at least equal to the voltage levels, during feeder peak load conditions, prior to the interconnection.

The CSA Standard CAN3 C235 83 Preferred Voltage Levels for AC Systems 0 to 50,000V provides general guidance as to appropriate performance.

5.1.3 Power Quality

All interconnected equipment must comply with the wire owner's standards for power quality. The following two industry standards may provide guidance as to appropriate performance.

Voltage Flicker IEEE Std. 519-1992 IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

Harmonics The individual Wires Owners' Guide for the Connection of Non-Linear Load (which are partly based on IEEE Std. 519 - 1992)

There are two industry standards currently under review (IEEE 519 and CSA standards based on IEC standards for Electro magnet Compatibility). Based on a review of the revised standards by the various Alberta Wires Owners, their respective operating guidelines may be revised.

5.1.4 Voltage Unbalance

Distribution Facilities are typically three-phase systems incorporating single-phase distribution taps. The voltage unbalance on the Distribution Facility under normal operating conditions may reach 3%, due to the unbalanced loading and single-phase regulation. Voltage unbalance will be calculated using:

$$\text{Unbalance (\%)} = \frac{100 \times (\text{deviation from average})}{(\text{average})}$$ as derived from NEMA MG1-1993 14.35.

5.1.5 Fault Levels

Fault levels, and maximum allowable fault levels, vary significantly through the Distribution Facility and must be considered in the design of the interconnection. Fault levels and X/R ratios must be evaluated for the equipment selected.

5.1.6 System Grounding

Distribution Facilities are typically operated as effectively (solidly) grounded and Wye-connected at the source substation bus. Alternate configurations as may be found at existing installations must be evaluated during the design of the facility.

Distribution Facility grounding must conform to the Alberta Electrical and Communications Utility System Regulation 44/1976 or future amendments.

5.1.7 Resonance

Resonance must be considered in the design of the facility. Of particular concern are self-excitation of induction generators, transformer ferro-resonance, and the resonant effects of capacitor additions on the Distribution Facility and harmonic-producing customers.

5.1.8 Networked Distribution Facilities

Networked Distribution Facilities are equipped with reverse-current relays to control circulating currents, and are characterized by very high fault currents. The special character of networked systems must be considered when connecting a generator to such a system.

5.2 Generating Facility

5.2.1 Customers Not Adversely Affected

The addition of the **Generating Facility** may adversely affect the electric service to existing or future electric customers. The Power Producer shall work with the Wires Owner to mitigate any adverse affects.

The Wires Owner may, in the case where the generating facility is causing adverse impact to Wires Owner's customers, disconnect the facility in question until such a time as the concern has been mitigated.

Responsibility for costs that are incurred, as a result of these actions will be identified through the routine contractual negotiations between the Power Producer and the Wires Owner.

5.2.2 Synchronism

Any Generating Facility that can create a voltage while separate from the electric system must have synchronization facilities to allow connection of the Generating Facility to the electric system.

Inverter-type, voltage-following, generating equipment cannot create a voltage while separate from the electric system and therefor is not required to have synchronization facilities.

Induction generators that act, as motors during start-up, drawing power from the electric system before they themselves generate power, are not required to have synchronization facilities.

The Power Producer shall be responsible for protecting his own facility from the distribution and transmission system switching elements. Distribution and transmission facilities typically allow for automatic reclosing of electrical circuits after a variable time delay. Where the Wires Owner deems that changes to the distribution system protection will not decrease system reliability below existing levels, the Wires Owner will work with the Power Producer

to make these changes. The Wires Owner will review the operation of the upstream distribution and transmission switching elements, and will determine what additional protection changes or additions are required to prevent inadvertent reclosing on the Generating Facility.

Generators less than 100 kW total capacity may automatically restart following automatic reclosing of Distribution Facility electrical equipment. Generators that automatically restart must have time delay on restart adjustable in the range of 1 - 60 minutes. The Wires Owner will coordinate the settings of generator restart time-delays such that generators on any feeder restart in staggered order.

5.2.3 Voltage Regulation and Power Factor

Synchronous generators connected to the Distribution Facility shall be equipped with excitation controllers capable of controlling voltage. The generator-bus voltage setpoint shall be stable at and adjustable to any value between 95% and 105% to permit the Wires Owner to maintain CSA voltage limits on their system.

Induction generators do not have voltage or reactive power control. In the case of an induction generator, reactive power (VAr) is consumed by the generator. Reactive compensation shall be provided at the Generating Facility to correct the power factor to – 0.90 at the Point of Interconnection, unless other terms are negotiated with the Wires Owner.

Inverter type generating equipment can control the power factor over a wide range, typically – 0.75. The inverter type generator connected to the Distribution Facility shall be capable of adjusting the power factor in the range of +/- 0.9. The Power Producer may operate outside that range by agreement with the Wires Owner.

The system studies performed by the Wires Owner will define voltage and reactive power control requirements on a project-by-project basis.

The Power Producer will agree jointly with the Wires Owner to identify the exact transformer ratio that will allow best voltage regulation on the system, and whether an on-load tap-changer is needed.

5.2.4 Frequency Control

An interconnected Generating Facility must remain synchronously connected for frequency excursions between 58 Hz and 61 Hz unless otherwise agreed.

Generators that are intended for islanded operation must be capable of controlling the frequency of the islanded system to between 59.7 Hz to 60.2 Hz for normal operation.

The frequency of the electric system is controlled by all synchronous generator governor systems that connect to the electric system. The governor system will respond automatically to changes in system frequency to prevent further deviation. Synchronous generators and other generator with stand-alone capability and capacity of 10 MW or more must have a speed droop governor. The droop setting of the governor shall be 5%, and the governor system must be operated at all times with the governor system free to respond to system frequency changes. If a 5% droop setting is not possible, the Power Producer must obtain Transmission Administrator acceptance of some other droop setting.

WSCC off-frequency requirements specify as follows:

> "Generators connected to the grid that protect for off-nominal frequency operation should have relaying protection that accommodates, as a minimum, underfrequency and overfrequency operation for the specified time frames:

Underfrequency Limit	Overfrequency Limit	Minimum Time
60.0 - 59.5 Hz	60.0 - 60.5 Hz	N/A (continuous operating range)
59.4 - 58.5 Hz	60.6 - 61.5 Hz	3 minutes
58.4 - 57.9 Hz	61.6 - 61.7 Hz	30 seconds
57.8 - 57.4 Hz		7.5 seconds
57.3 - 56.9 Hz		45 cycles
56.8 - 56.5 Hz		7.2 cycles
less than 56.4 Hz	greater than 61.7 Hz	instantaneous trip

> "Systems that have generators that do not meet the above requirements must automatically trip load to match the anticipated generation loss, at comparable frequency levels."

5.2.5 Voltage Unbalance

Any three-phase Generating Facility shall have a phase-to-phase voltage unbalance not exceeding 1%, as measured both with no load and with balanced three-phase loading. Voltage unbalance will be calculated using:

$$\text{Unbalance (\%)} = \frac{100 \times (\text{deviation from average})}{(\text{average})}$$ as derived from NEMA MG1-1993 14.35.

Single-phase generators must not adversely unbalance the three-phase system.
When connected in multiple units

- an equal amount of generation capacity must be applied to each phase of a three-phase circuit, and
- the group of generators must maintain balance when one unit trips or begins generating before or after the others.

A single one-phase generator may be connected alone only if it does not cause voltage unbalance on the Distribution Facility in excess of 2%.

5.3 Interconnection

5.3.1 Safety

Safety of personnel, the public and of equipment is of primary concern in the design of the interconnection.

5.3.2 Point of Interconnection

The point of interconnection will be defined in the design. The Wires Owner shall be responsible for the design, construction, maintenance and operation of the facilities on the distribution side of the point of interconnection. The Producer shall be responsible for the design, construction, maintenance and operation of the facilities on the generation side of the point of interconnection

A visible isolating switch or switches is required for the purpose of power system isolation for work on the facilities. Appendix V shows an example configuration.

5.3.3 Phasing

Phasing is not standardized across Distribution Facilities. The phase sequence and the direction of rotation must be coordinated between the Distribution Facility and the generator.

5.3.4 Interconnection Grounding

Grounding configurations shall be designed to provide:

- solidly grounded Distribution Facilities,
- suitable fault detection to isolate all sources of fault contribution including the generator, from a faulted line or distribution element,
- a favourable circuit to block the transmission of harmonic currents and voltages, and
- protection of the low voltage side from high fault current damage.

The preferred configuration is delta connection on the generator side of the transformer and wye configuration on the wire's side of the transformer. Where this configuration is not possible or practicable, the configuration chosen shall none-the-less address the above concerns.

5.3.5 Interrupting Device Ratings

The design of the Generating Facility must consider the fault contributions from both the distribution facility and the Generating Facility, to ensure that all circuit fault interrupters are adequately sized. The Wires Owner shall inform the Producer of the present and anticipated future fault contribution from the interconnected electric system.

5.3.6 Phase and Ground Fault Protection

The Producer must install protective devices to detect and promptly isolate the Generating Facility for faults occurring in the Generating Facility and on the Distribution Facility. "Virtual devices", that is, computer or programmable-logic-controller systems providing protective capability, will be acceptable provided that they meet standard utility practice for system protection.

The Generating Facility's protective devices must fully coordinate with the electric system protective relays unless otherwise agreed. The Generating Facility shall calculate the protective device settings, and submit the relay characteristics and settings to the Wires Owner for the Wires Owner's review and approval.

However, when

- the total generation on a distribution line is less than 2500kva, and
- the total generation on a distribution line is also less than 50% of the minimum distribution line load, and
- the generator maximum size is less than 100kW, and
- the generator is an inverter-type voltage-following systems; then

the detection of ground faults on the Distribution Facility by the Producer's equipment is not required.

Notwithstanding the preceding paragraph, the Generating Facility must be able to detect and isolate itself from the Distribution Facility should a short circuit occur on the Generating Facility between any phase(s) and ground or between phase(s); or upon loss of any phase(s).

5.3.7 Overvoltage and Undervoltage Protection

Should the Generating Facility or Distribution Facility require protective schemes to satisfy voltage requirements, the Producer shall install overvoltage and/or undervoltage relays to trip the circuit breaker when the voltage is outside predetermined limits. Undervoltage relays should be adjustable and should have a settable time delay to prevent unnecessary tripping of the Generating Facility on external faults. Overvoltage relays should be adjustable and may be instantaneous.

5.3.8 Overfrequency and Underfrequency Protection

Should the Generating Facility require protective schemes to satisfy frequency requirements the Generating Facility will be required to use frequency selective relays to separate the generator(s) from the electric system in cases of extreme variations in frequency.

5.3.9 Anti-Islanding

If there is a chance of inadvertent islanding of the generator, the Generating Facility must use teleprotection signals from the electric system or other reliable means to separate the generator from the electric system upon islanding.

Responsibility for damages that are caused, as a result of failure to safely separate during a potential islanding event, in non approved islanded operations will be identified through the routine contractual negotiations between the Power Producer and the Wires owner.

5.3.10 Telemetry and Targeting

Where a generator could adversely affect the power system, for example by providing inflow into a fault, the Producer must have systems in place such that he is able to report to the Wire Owner on request, what protection operations occurred or failed to occur.

As required by the Compliance Monitoring and Operating Practices Subcommittee of the WSCC, the Distribution and Transmission facilities owners and System Controller requires telemetry of MW, MVAr, and breaker-status of all significant generation (present defined as generators greater than 5MW capacity.)

5.3.11 Special Interconnection Protection

In some cases it will be necessary to provide for special generator specific protection and controls such as out-of-step or loss of synchronism. Similarly, special interconnection and system protection may be required to provide additional protection on some facilities, or on upstream facilities.

6. OPERATING REQUIREMENTS

6.1 Operating Authority

The Wires Owner and the Producer must each identify, by name or by job title, the individual within their organizations who is their "Operating Authority". The Operating Authority is responsible to establish operating procedures and standards within their organization. The Operating Authority shall negotiate and sign the Joint Operating Agreement described below. The Operating Authority shall ensure that the Operator in Charge is competent in the operation of their system and are aware of the provisions of any operating agreements and any regulations that may apply.

6.2 Operator in Charge

The Wires Owner and the Producer must each identify the individual, by name or by job title, who is the "Operator in Charge" of their facilities. The Operator in Charge shall operate their portion of the interconnection facility. The Operator in Charge must be familiar with the operating agreement. In addition the Operator in Charge must be aware of the provisions of any other operating agreements and any regulations that may apply. The Operating Authority and the Operator in Charge may be the same person.

6.3 Joint Operating Agreement

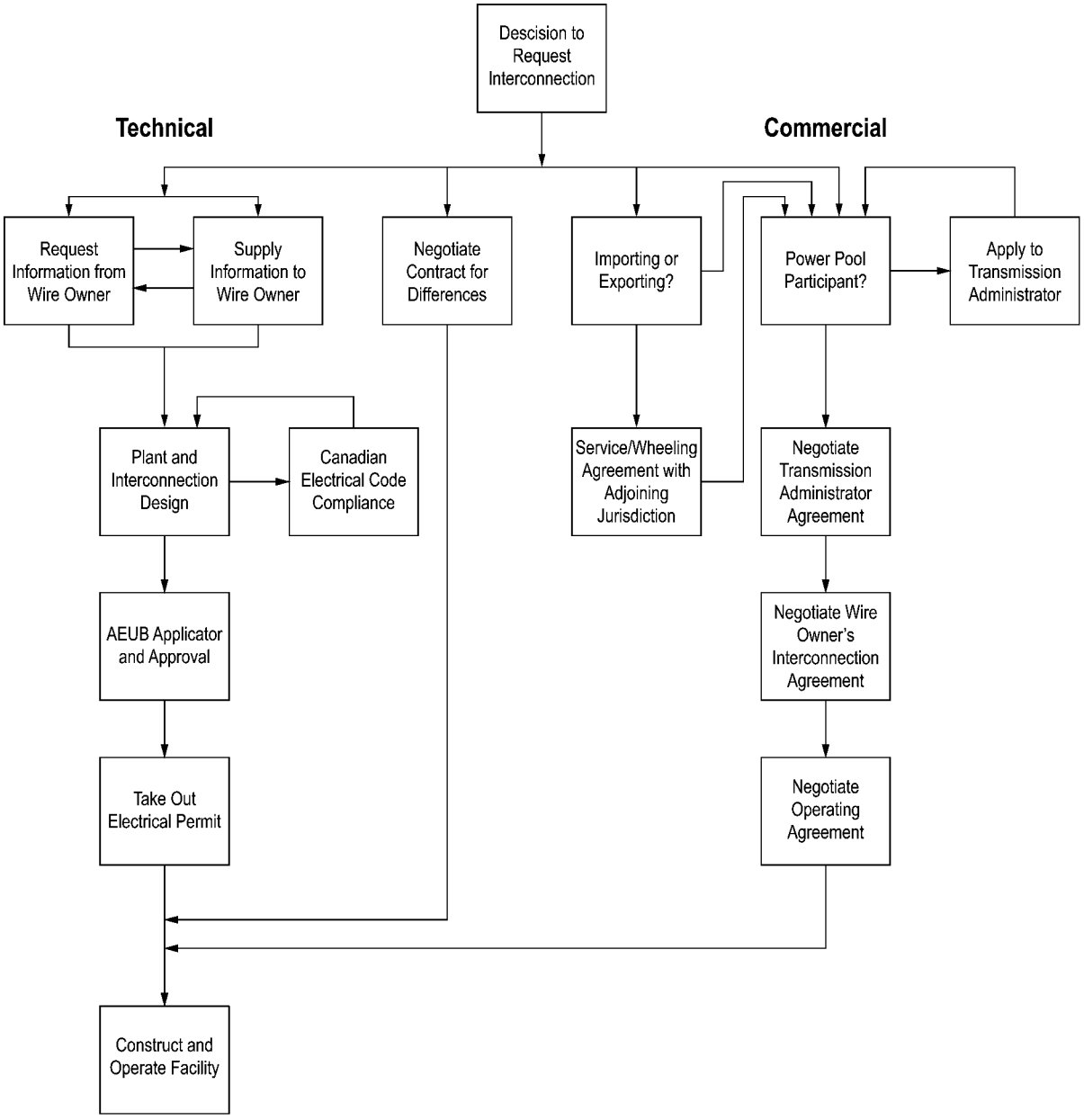
A joint operating agreement will be developed, the purpose of which is to provide for the safe and orderly operation of the interconnection facilities. The agreement will include, but not necessarily be limited to, the following:

- a high-level technical description of the Producer's facilities, equipment and protection
- a high-level technical description of the Distribution system and protection
- a description of how the Generating Facility will operate (interconnected, islanded, etc.)
- the name, title and phone number of the Operating Authority and the Operator in Charge of the Generating Facility and of the Wires Owner system.
- provision for disconnection by the Wires Owner for failure to meet technical and/or power quality requirements or if the operation of the facility may be or become dangerous to life or property.

- a revision date
- reference to safety procedures for joint work
- responsibility for maintaining current operating information such as Single Line Diagrams.
- isolation procedures for work on the facilities
- a description of what notification if any is required before synchronization
- any control setting parameters that could affect the interconnection, for example voltage and frequency
- approval by both the Producer and by the Wires Owner

The operating agreement should form an amendable appendix to a contract or commercial agreement. A sample operating agreement incorporating the above points is included as Appendix VI.

APPENDIX I: APPROVAL PROCESS BLOCK DIAGRAM



Approval Process Block Diagram

1.0 Power Pool

To sell electric energy through the Power Pool, a Producer must become a Pool Participant. This involves signing a participant contract, paying trading charges and signing an agreement with the Transmission Administrator. Importers and exporters must also demonstrate that they have service agreements for transmission between Alberta and the adjoining Province, State or Territory.

There are no direct energy purchases between producers and distributors. However, contracts may be put in place directly as a guarantee for a price of energy. These agreements would generally be Contracts for Differences (CFD's) to fix the price of the energy sold. Generally, the difference between the pool price and the guaranteed price for a quantity of energy specified in the Contract during a period of time specified in the Contract, would be settled between the Producer and the Distributor.

2.0 Grid Access

The Transmission Administrator is responsible for

- prudent financial arrangements with facility owners so that transmission system access may be provided
- setting tariffs for the use of the transmission system,
- setting reasonable standards and requirements for system support services such as operating reserves, and
- contracting for system support services.

3.0 Location or Loss Credits

Location or loss credits may be available to a Producer in an area of the electric system that would benefit the Transmission Administrator in the operation of the transmission system.

Location or loss credits may be available to a Producer in an area of the electric system that would benefit the Distribution Wire Owner in the operation of the distribution system.

4.0 Transmission Administrator Interconnection Agreement

For details of Transmission Administrator procedures, access the Transmission Administrator's website at **www.eal.ab.ca**.

5.0 Wire Owner Interconnection Agreement

An example Wires Owner Agreement is included in Appendix VI. The Power Producer should contact the individual Wires Owner to negotiate an individual Interconnection Agreement.

6.0 AEUB Approval

For AEUB procedures, access the AEUB website at **www.ercb.gov.ab.ca**.

APPENDIX II: INFORMATION REQUIRED FROM PRODUCER

1.0 Design and Operating Information

The Producer shall submit to the Wires Owner detailed information as required for the Wires Owner to design, construct, operate and maintain the Wire Owner's portion of the interconnection.

Such information may include:

I General Information:

a. a detailed map showing the proposed plan location
b. a site plan showing the arrangement of the major equipment
c. diagram showing the voltage and current rating of each major component

II Interconnection Protection

a. complete and accurate protection diagrams
b. a description of the proposed protection schemes
c. maintenance plans for the interconnection protective devices and interconnection interrupting devices.

III Prime Mover

a. type, make and model
b. rating
c. inertia constant

IV Power Factor Regulator

a. limits of range of reactive power (VAr) lagging and leading
b. accuracy tolerance of setting

V Generator

a. type
b. make and model
c. nominal KVA rating
d. nominal voltage rating
e. governor droop

VI Voltage Regulator

a. voltage regulator setting range
b. voltage regulator setting tolerance

VII Compensator

a. type of input(s)
b. compensating resistance(s)
c. compensating reactance(s)

VIII Transformers

a. MVA base rating
b. fan rating, cooling type
c. high voltage - nominal voltage, connection
d. low voltage - nominal voltage, connection
e. tapchanger - onload or offload, tap chart
f. ratio and accuracy class of instrument transformers. If multiratio, state the available ratios and the proposed ratio.

IX Operating characteristics - provide information on:

a. whether the facility will operate islanded or interconnected to the electric system
b. is it intended for the facility to sell electric energy to the power pool
c. will the facility consume electric energy services from the electric system
d. expected availability and load factors

X Contact names and addresses

a. commercial terms
b. engineering design
c. operating terms

2.0 Modeling Information

In addition, where the generator is of a size to impact adjacent Wires Owner's customers or dynamic stability or the aggregate generation on the line is of such a size; the Producer shall submit to the Wires Owner detailed information as required to model the transient, dynamic and steady-state behaviour of the generator consistent with WSCC modeling criteria. The Wires Owner is responsible for determining where such an impact is likely to occur. Power Producers are responsible for ensuring that the data they submit provides an adequate mathematical representation of his facility's electric behaviour. Data may not be available prior to purchase, in which case it should be submitted as soon as it becomes available. Data is adequate if it allows the Wires Owner to determine accurately

- the impact of the producer's facility on adjacent Wires Owners' customers; and
- the dynamic stability, in aggregate, of the Wires Owner's system as an interconnected system within the WSCC.

Data may be supplied by the manufacturer, or may be acquired directly by testing. Such additional information may include:

I Generator

a. for Synchronous Generators only

1. Speed (RPM)
2. Inertia constant (H)
3. Damping Factor (D)
4. Direct axis synchronous reactance (x_d)
5. Direct axis transient reactance (x'_d)
6. Direct axis subtransient reactance (x''_d)
7. Direct axis transient time constant (T'_{do})
8. Direct axis subtransient time constant (T''_{do})
9. Quadrature axis synchronous reactance (x_q)
10. Quadrature axis transient reactance (x'_q)
11. Quadrature axis subtransient reactance (x''_q)
12. Quadrature axis transient time constant (T'_{qo})
13. Quadrature axis subtransient time constant (T''_{qo})
14. Stator Resistance (R)
15. Stator leakage reactance (X_ℓ)
16. Saturation factor at 1.0 per-unit flux ($S_{1.0}$)*
17. Saturation factor at 1.2 per-unit flux ($S_{1.2}$)*
18. Negative sequence resistance (R_2)
19. Negative sequence reactance (X_2)
20. Zero sequence resistance (R_0)
21. Zero sequence reactance (X_0)
22. Excitation system type (AC or DC; rotary, "brushless" or "static"; et cetera) **
23. Excitation system Filter time constant (T_r) **
24. Excitation system Lead time constant (T_c) **
25. Excitation system Lag time constant, (T_b) **
26. Excitation system Controller Gain (K_a) **
27. Excitation system Controller lag Time constant (Ta) **
28. Excitation system Maximum Controller output (V_{rmax}) **
29. Excitation system Minimum Controller output (V_{rmin}) **
30. Excitation system regulation factor (K_c) **
31. Excitation system Rate feedback gain (K_f) **
32. Excitation system Rate feedback time constant (T_f) **

* Or, submit saturation curves

** Or, submit a Laplace-domain control block diagram showing all control blocks with all time constants greater than 0.02s, completely specifying the transfer function from the compensator output voltage (or generator terminal voltage, if there is no compensator) and field current, to the generator field voltage.

b. also, for Induction Generators only

1. Speed (RPM)
2. Inertia constant (H)
3. Steady-state reactance (x_d)
4. Transient reactance (x'_d)
5. Subtransient reactance (x")
6. Subtransient time constant (T")
7. Transient time constant (T")
8. Stator Resistance (R)
9. Stator leakage reactance (X_ℓ)
10. Saturation factor at 1.0 per-unit flux ($S_{1.0}$)*
11. Saturation factor at 1.2 per-unit flux ($S_{1.2}$)*
12. Negative sequence resistance (R_2)
13. Negative sequence reactance (X_2)
14. Zero sequence resistance (R_0)
15. Zero sequence reactance (X_0)

* Or, attach saturation curves

c. also, for Inverter Generators only

a Laplace-domain control block diagrams showing all control blocks with all time constants greater than 0.02s; completely specifying the transfer function from the distribution-system inputs (bus voltage and system frequency), to the Producer's outputs to the Distribution Facility (Electric Power, Terminal Voltage, Terminal Current, Angle and Frequency.

II Governor

a. Governor lead time constant (T_2) *
b. Governor lag time constant(s) (T_1) *
c. Permanent Droop (R) or Governor gain (K) *
d. Fuel Starting delay (T_w or T_4) *
e. Minimum Turbine power *
f. Maximum valve or gate opening velocity *
g. Maximum valve or gate closing velocity *
h. Maximum valve or gate position *
i. Minimum valve or gate position *
j. Turbine damping *
k. Governor non-linearity characteristic curve (Gate position to output power)
l. Also, for hydro governors only

    1. Temporary Droop (r) *
    2. Temporary Droop time constant (T_r) *
    3. Filter time constant *
    4. Gate servo time constant *
    5. Turbine Gain *
    6. No-load flow *
    7. Valve positioner time constant *

m. Also, for steam governors only

    1. Reheat delay time constants *
    2. Reheat stage gains *

* Or, submit a Laplace-domain control block diagram showing all control blocks with all time constants greater than 0.02s, completely specifying the transfer function from system frequency or generator speed, to the turbine mechanical power output.

III Power-System Stabilizer

a. Type of input(s)
b. Gain for each input *
c. Lead Time constant(s) for each input *
d. Lag time constant(s) for each input *

* Or, submit a Laplace-domain control block diagram showing all control blocks with all time constants greater than 0.02s, completely specifying the transfer function from the inputs, to the stabilizing voltage input to the voltage regulator

IV Compensator

a. Type of input(s)
b. Compensating Resistance(s)
c. Compensating Reactance(s)

V Transformers

a. Positive Sequence Impedance
b. Negative Sequence Impedance
c. Zero Sequence Impedance

APPENDIX III: INFORMATION REQUIRED FROM WIRE OWNER

1. Minimum and maximum 60 Hz source impedances (positive-sequence, negative-sequence and zero-sequence) at the point of interconnection with and without the generator in operation, and the time frame for which the impedances are expected to be valid.

2. Maximum and minimum normal and emergency system operating voltage ranges

3. Harmonic impedance envelope information, and the time frame for which they are expected to be valid.

4. Planning, operating and reliability criteria, standards and policies.

5. Planning study documenting the availability of system capacity, equipment necessary to connect, breakdown of cost estimates for interconnection and time schedule to build the facilities.

6. Clearing and reclosing times for single phase and multiple phase faults occurring on the Wire Owner's Distribution Facility.

7. Characteristics and settings of protection on the Distribution Facility

APPENDIX IV: BIBLIOGRAPHY OF RELEVANT INDUSTRY STANDARDS

The following list is provided for reference purposes:

Part 1 of the Canadian Electrical Code

CSA Standard CAN3-C235-83 Preferred Voltage Levels for AC Systems 0 to 50 000 V

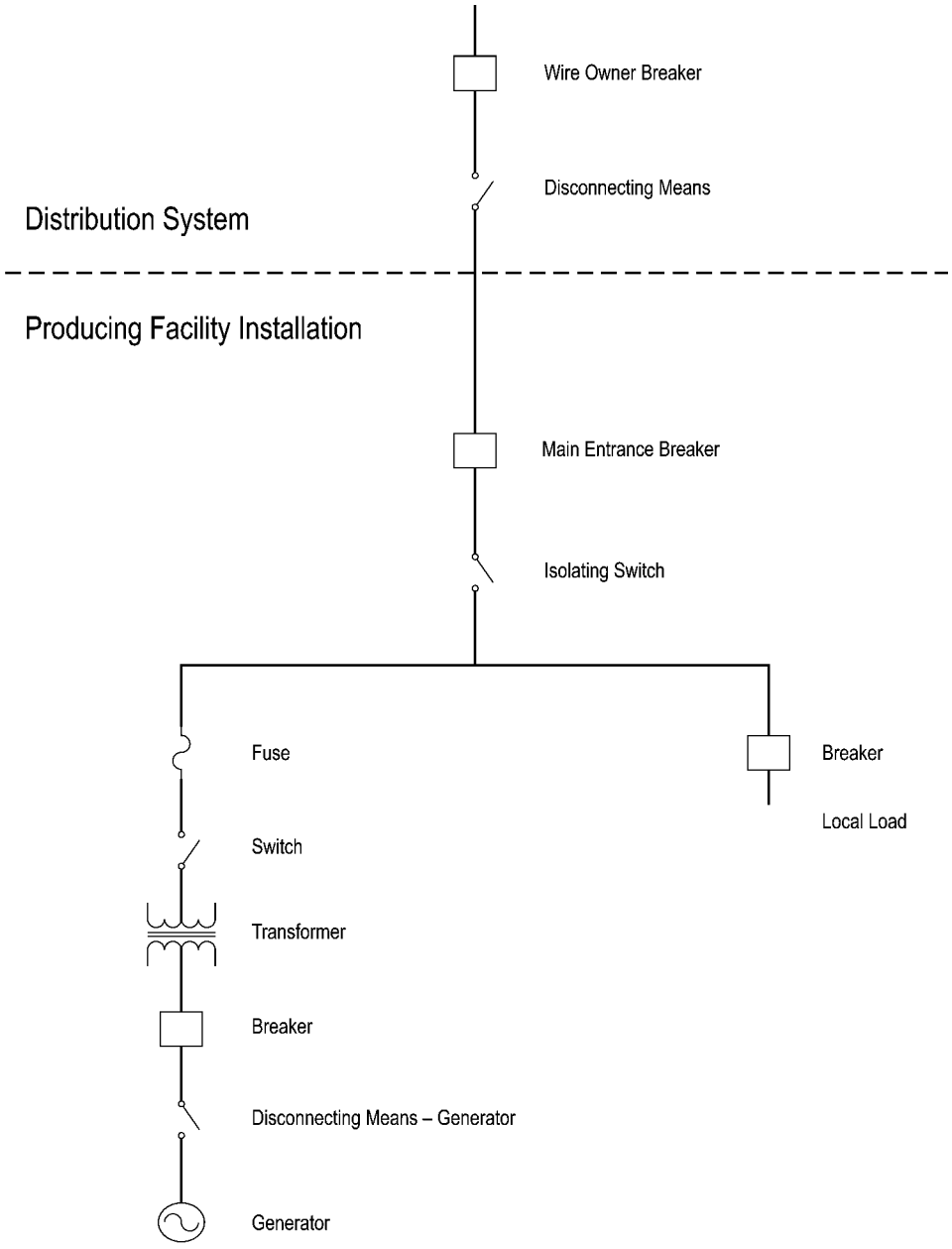
CEA report128 D 767: Connecting small Generators to Utility Distribution Systems

Measurement System Standard / Transmission Administrator Metering Standard GC301 Practices for Management and Transfer of Metered Data

IEEE Std. 519-1992 IEEE Recommended Practices and Requirements for Harmonic Control in Electric Power Systems

ANSI/NEMA Standards Publication MG 1-1993 14.35

APPENDIX V: TYPICAL INTERCONNECTION OF ELECTRIC POWER PRODUCTION SOURCES



Typical Interconnection of Electric Power Production Sources
(reference 1998 CE Code Handbook Figure 84-002)

APPENDIX VI: GENERIC OPERATING AGREEMENT

Interconnection and Operating Agreement

between

_____(the producer)

and

_____(the Wires Owner)

This agreement provides for the safe and orderly operation of the electrical facilities interconnecting the Producer's facility at **(land location or description of project)** and the electrical Distribution Facility owned by the Wires Owner.

This Agreement does not supersede any requirements outlined in Government Regulations such as (but not limited to) the Alberta Electric and Communication Utility Code, the Canadian Electrical Code, and Occupational Health and Safety Act, nor does it supersede any terms of the Commercial Contract between the producer and the Wires Owner.

1. **Intent of Parties:** It is the intent of **(the producer)** to generate for sale to the Power Pool of Alberta up to the maximum available power, and to dispatch the amount of power produced at their discretion.

   It is the intent of **(the Wires Owner)** to operate the Distribution Facility to maintain a high level of service to their customers and to maintain a high level of power quality.

   It is the intent of both parties to operate the facilities in a way that ensures the safety of the public and their employees.

2. **Operating authority:** The operating authority is the person identified by name or job title responsible to establish operating procedures and standards within their organization. The operating authority shall ensure that timely updates are made to this document to reflect any changes to disconnect devices and single line diagrams referenced in this document. The operating authority for the producer and of the Wires Owner shall ensure that the operators of the Generating Facility and the Distribution Facility are competent in the operation of the electrical systems and are aware of the provisions of any operating agreements and regulations relating to the safe operation of electrical power systems.

   The operating authority for **(the producer)** is **(name or title of operating authority, along with address and phone numbers)**.

   The operating authority for **(the Wires Owner)** is **(name or title of operating authority, along with address and phone numbers)**.

3. **Operator in Charge:** The operator in charge is the person identified by name or job title responsible for the real time operation of all electrical facilities related to the interconnection and owned by their organization.

   The operator in charge for **(the producer)** is **(name or title of operator in charge, along with address and phone numbers)**.

   The operator in charge for **(the Wires Owner)** is **(name or title of operating authority, along with address and phone numbers)**.

4. **Description:** **(The producer's)** facilities consist of a **(size), (type), (connection)** generator connected to the Distribution Facility through the main bus at the facility. **(The Producer)** owns and is responsible for the maintenance and operation of all facilities on the generator side of **(interface point)**.

   (The Wires Owner's) facilities consist of 25 kV or less line **(line number)** and a **(transformer size), (transformer connection designation)** transformer**. (The Wires Owner)** owns and is responsible for the operation of all facilities on the line side **of (interface point)**.

   The Point of Interconnection is designated as **(description of Point of Interconnection)**. A single line diagram is attached.

   The **(breaker, switch etc.) (switch number)** will be used as the main disconnect point for the facility, and is owned and operated by **(producer or Wires Owner)**. This switch **(does/does not)** have loadbreak capability and therefore **(can/cannot)** be operated while the Generating Facility is producing or consuming power.

   The facility is designed to operate interconnected to the grid, with synchronizing facilities provided on producer-owned breaker **(breaker number)**. In the absence of outstanding clearances between the operators in charge, notice is not required to be given to the Wires Owner prior to synchronization taking place. It is recognized by **(the producer)** that there are no synchronization schemes in place on **(the Wires Owner's)** facilities, and that the upstream Distribution Facility contains automatic equipment that will provide for voltage regulation or automatic recloses under some conditions. **(description of any special blocking or protection schemes)**

   The generator is capable of controlling either voltage or power factor, and is normally set to control **(voltage or power factor)** to **(setting, tolerance)** at the generator terminals. **(Islanded capabilities to be identified here also, if any)**.

5. **Suspension of Interconnection:** It is intended that the interconnection should not compromise **(the Wires Owner's)** protection or operational requirements. The operation of the **(producer's)** System and the quality of electric energy supplied by **(the producer)** shall meet the standards as specified. If the operation of the **(producer's)**

system or quality of electric energy supplied does not meet the standards as specified, then **(the Wires Owner)** will notify **(the producer)** to take reasonable and expedient corrective action. **(The Wires Owner)** shall have the right to disconnect the **(producer's)** System, until compliance is reasonably demonstrated. Notwithstanding, **(the Wires Owner)** may in its sole discretion disconnect the **(producer's)** generating plant from the Distribution Facility without notice if the operating of the Generating Plant may be or may become dangerous to life and property.

6. **Safe Work Planning:** Safe work planning procedures such as pre-job plans and tailboard conference procedures, will be followed where both parties are involved in work. Nothing in this document should be interpreted as to change the intent of the Wires Owner's safe practices manual or safe operating procedures. Any contradictions are to be identified and resolved prior to work commencing.

   Safe work routines described in Division D of the Electrical and Communication Utility Systems Regulations (AECUC) will be followed in providing isolation for work on any part of the interconnected system.

7. **Maintenance Outages:** Maintenance outages will occasionally be required on the **(Wires Owner's)** system and on the **(producer's)** system. Both parties will provide as much notice and planning as possible to minimize downtime. It is noted that in some emergency cases such notice may not be possible. Outages will be coordinated by the Operator in Charge for each of the parties. Except as provided for in a separate commercial agreement, compensation will not be made for unavailability of facilities due to outages.

8. **Access:** Access is required by **(the Wires Owner)** to the **(producer's)** plant site for maintenance, operating and meter reading. **(The Wires Owner)** reserves the right, but not the obligation, to inspect the **(producer's)** facilities, and **(the producer)** reserves the right, but not the obligation, to inspect the **(the Wires Owner's)** facilities. Access or inspections will be arranged between the **(Wires Owner)** Operator in Charge and the **(producer)** Operator In Charge.

9. **Revision and Approval:** This document is intended to be valid for a period of five (5) years, after which it will be reviewed for currency and reissued.

10. **APPROVED by:**

Wires Owner Operating Authority	Producer Operating Authority
Date	Date

WHERE DO I FIND IT? LOCATING INFORMATION REFERENCED IN THIS GUIDE

Canadian Electric Code

Alberta Electrical and Communications Utility System Regulation 44/1976

Electric Utilities Act

Alberta Queen's Printer

Edmonton:
11510 Kingsway Avenue
Edmonton, Alberta T5G 2Y5
Phone: (780) 427-4952
Fax: (780) 452-0668
Website: www.gov.ab.ca/qp
Email: qp@gov.ab.ca

Calgary:
Main Floor, McDougall Centre
Calgary, Alberta T2P 4E8
Phone: (403) 297-6251
Fax: (403) 297-8450
Website: www.gov.ab.ca/qp
Email: qp@gov.ab.ca

Terms and Conditions: Generation Pool Access Service Practices for Management and Transfer of Metering Data

ESBI Alberta Ltd.

900, 736-8TH Avenue S.W.
Calgary, Alberta T2P 1H4
Phone: (403) 232-0944
Fax: (403) 266-2959
Website: www.eal.ab.ca
Email: info@eal.ab.ca

IEEE Std. 519-1992

IEEE Customer Service

445 Hoes Land, PO Box 1331
Piscataway, NJ 08855-1331, USA
Phone: 1-800-678-IEEE (4333)
Fax: (732) 981-9667
Website: www.ieee.org
Email: customer.service@ieee.org

CEA report 123D 767: Connecting Small Generators to Utility Distribution Systems

Canadian Electricity Association

Suite 1120, 1155 Metcalfe Street
Montreal, Quebec H3B 2V6
Phone: (514) 866-5364
Fax: (514) 866-1880
Website: www.canelect.ca

CSA Standard CAN3-C235-83 Preferred Voltage Levels for AC Systems 0 to 50000 V

Canadian Standards Association

Western Region
1707-94 Street
Edmonton, Alberta T6N 1E6
Tel: (780) 450-2111, 1-800-463-6727
Fax: (780) 435-0998
Website: www.csa.ca
Email: sales@csa.ca

ANSI/NEMA Standards Publication MG 1-1993 14.35

National Electrical Manufacturers Association

CSSinfo
310 Miller Avenue
Ann Arbor, MI 48103 USA
Phone: (734) 930-9277, 1-800-699-9277
Fax: (734) 930-9088
Website: www.cssinfo.com
Email: service@cssinfo.com

OTHER IMPORTANT CONTACTS

This information is provided as a general contact for each organization. As every organization has a different structure, please request the department that can best assist you in connecting a generator to that organization's distribution facilities.

Power Pool of Alberta

1800, McFarlane Tower
700 4 Avenue SW
Calgary, Alberta T2P 3J4
Phone: (403) 543-0380
Fax: 543-0388
Website: www.powerpool.ab.ca

TransAlta Utilities Corporation

110 12 Avenue SW
Calgary, Alberta T2P 2M1
Phone: (403) 267-7110
Website: www.transalta.com

Edmonton Power

10065 Jasper Avenue
Edmonton, Alberta T5J 3B1
Phone: (780) 412-3550
Fax: (780) 412-3034
Website: www.edpower.com

Alberta Power Limited

10035 105 Street, PO Box 2426
Edmonton, Alberta T5J 2V6
Calgary Phone: (403) 245-7397
Calgary Fax: (403) 245-7265
Edmonton Phone: (780) 420-7634
Edmonton Fax: (780) 420-3483
Website: www.albertapower.com

Enmax Corporation

2808 Spiller Road SE
Calgary, Alberta T2G 4H3
Phone: (403) 262-2923
Fax: (403) 262-5928
Website: www.enmax.com

City of Medicine Hat - Electric Utility

2172 Brier Park Place NW
Medicine Hat, Alberta T1C 1S6
Phone: (403) 529-8258
Fax: (403) 502-8061

City of Red Deer - Electric Light and Power Department

5581 - 45 St. (Cronquist Business area)
Mailing Address:
The City of Red Deer
Electric Light and Power Department
P.O. Box 5008
Red Deer, Alberta T4N 3T4
Phone: (403) 342-8274
Fax: (403) 341-6806

Lethbridge Power

City Administration Building
3rd Floor (next to City Council Chambers)
817 - 4th Avenue South, Lethbridge
Mailing Address: Lethbridge Power
Lethbridge City Hall
910 - 4th Avenue South
Lethbridge, Alberta T1J 0P6
Phone: (403) 320-3934
Fax: (403) 380-2541
Website: www.lethpower.com

Alberta Federation of Rural Electrification Associations

165 Seneca Road
Sherwood Park, Alberta T8A 4G9
Phone: (780) 417-3396
Fax: (780) 417-3398

Central Alberta R.E.A. Ltd.

#4, 5112 - 47 Avenue
Innisfail, Alberta T4G 1P8
Phone: (403) 227-4011
Fax: (403) 227-5750

Rural Electric Services Ltd.

#1, 7895 - 49 Avenue
Red Deer, Alberta T4P 2B4
For: Barrhead R.E.A. Ltd.,
Darwell R.E.A. Ltd.,
Entwistle Magnolia R.E.A. Ltd.,
Onoway R.E.A. Ltd.
Phone: (403) 309-4211, 1-888-248-0444
Fax: (403) 309-4205

Rocky R.E.A. Ltd.

PO Box 6538
Rocky Mountain House, Alberta T0M 1T0
Phone: (403) 845-4600
Fax: (403) 845-2751

South Alta R.E.A. Ltd.

PO Box 2657
Claresholm, Alberta T0L 0T0
Phone: (403) 625-4348
Fax: (403) 625-3569

Municipality of Crowsnest Pass

PO Box 600
Blairmore, Alberta T0K 0E0
Phone: (403) 562-8833
Fax: (403) 536-5474

Town of Fort Macleod - Electrical Department

258 MainStreet
Box 1959
Fort Macleod, Alberta T0L 0Z0
Phone: (403) 553-4601
Fax: (403) 553-2426

Town of Cardston

238 - 1 Avenue West
Cardston, Alberta T0K 0K0
Phone: (403) 653-3772
Fax: (403) 653-3122

Town of Ponoka

5102 48 Avenue
Ponoka, Alberta T4J 1P7
Phone: 783-0147
Fax: 783-0151