

**Exigences techniques de raccordement
d'installations de client au réseau de transport
d'Hydro-Québec
(version anglaise)**

À la suite de la décision D-2016-127

Technical Requirements for the Connection of Customer Facilities to the Hydro-Québec Transmission System

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1 Purpose

This document sets out technical requirements for the connection of customer facilities¹ to the Hydro-Québec Transmission System.

Compliance with technical requirements is required to ensure:

- Reliability of the Hydro-Québec Transmission System
- Stability of the Transmission System and of the facilities connected to it
- Maintaining service quality for customers connected to the Hydro-Québec Transmission System
- Protection of Transmission Provider equipment
- Human safety

2 Application

This document applies to any customer facility to be connected to the Hydro-Québec Transmission System and any facility connected to it undergoing modifications, including the recommissioning of a facility that has been completely or partially shut down.

The connection of a generating station to the Transmission System through a customer facility is subject to the relevant provisions of *Technical Requirements for the Connection of Generating Stations to the Hydro-Québec Transmission System*².

3 Definitions

Available power

Defined in Section 3.1 of the *Conditions of Electricity Service*, as approved from time to time by the Régie de l'énergie.

Conditions of Electricity Service

The conditions governing electricity service set out by the Distributor, as approved from time to time by the Régie de l'énergie.

Customer

Defined in Section 3.1 of the *Conditions of Electricity Service*, as approved from time to time by the Régie de l'énergie; includes the applicant, also defined in this section.

¹ The term *facilities* refers to *electrical installations* as defined in the *Conditions of Electricity Service*, as approved from time to time by the Régie de l'énergie.

² As approved from time to time by the Régie de l'énergie.

Customer substation

Defined in Section 3.1 of the *Conditions of Electricity Service*, as approved from time to time by the Régie de l'énergie.

Distributor

Hydro-Québec when carrying on electric power distribution activities.

Hydro-Québec Open Access Transmission Tariff

Document setting out the rates and conditions whereby the Transmission Provider transmits electricity in Québec, as approved from time to time by the Régie de l'énergie.

Metering equipment

Defined in Section 3.1 of the *Conditions of Electricity Service*, as approved from time to time by the Régie de l'énergie.

Technical requirement

Defined in Section 3.1 of the *Conditions of Electricity Service*, as approved from time to time by the Régie de l'énergie.

Transmission Provider

Hydro-Québec when carrying on electric power transmission activities.

Transmission System

Defined in Section 1.49 of the *Hydro-Québec Open Access Transmission Tariff*, as approved from time to time by the Régie de l'énergie.

Voltage

Defined in Section 3.1 of the *Conditions of Electricity Service*, as approved from time to time by the Régie de l'énergie.

Medium voltage

High voltage

4 Procedure and technical information required

Table 1 summarizes the procedure and technical information required from the customer and Hydro-Québec further to a request for the connection of any customer facility to the Transmission System or in the advent of any modification to an already connected customer facility.

Technical information required to evaluate compliance with emission limits is specified in Appendix A of *Emission limits for disturbances on the Hydro-Québec Transmission System*³.

³ As approved from time to time by the Régie de l'énergie.

Table 1
Technical information required

Customer	Hydro-Québec
1- Connection request (including any modification to a connected facility)	
<ul style="list-style-type: none"> • Provide technical data regarding the facility, in accordance with section 1 of Appendix A 	<ul style="list-style-type: none"> • Provide a written opinion on the information received • Determine the reference offer⁴ <ul style="list-style-type: none"> ◦ Offer options according to any stated needs of the customer • Determine the general characteristics of the Transmission System (e.g., voltage level, voltage range, short-circuit power, connection zone) • Determine the diagram of the reference offer <ul style="list-style-type: none"> ◦ Determine the diagrams in accordance with any stated needs of the customer • Determine the connection point, including the nominal supply voltage level • Specify technical requirements regarding: <ul style="list-style-type: none"> ◦ Future conversion of the supply voltage ◦ Declared power of 900 MW or more ◦ Bulk Power System ◦ Customer facility power transformer(s) (type of connection and required voltage regulation range, if applicable) ◦ Protection systems
2- Facilities Study	
<ul style="list-style-type: none"> • Written acceptance of reference offer and connection point • Provide technical data regarding the facility, in accordance with section 2 of Appendix A • Specify: <ul style="list-style-type: none"> ◦ Anticipated power requirements in the short term and over a 10-year period ◦ Anticipated power requirement when facility is energized ◦ Declared power (in kW) and available power (in kVA) • Provide preliminary study of facility protection systems, in accordance with Appendix B • Submit for approval to the Transmission 	<ul style="list-style-type: none"> • Provide technical data regarding the Transmission System (e.g., voltage level, short-circuit power, X/R ratios) required by the customer to adequately design the customer facility and carry out the required studies (protection study, emission study) • Specify: <ul style="list-style-type: none"> ◦ Transmission System short-circuit levels ◦ Transmission System operating conditions ◦ Neutral impedance of customer facility transformer(s), if applicable ◦ Identification of customer substation equipment in accordance with terminology used by Transmission Provider

⁴ Defined in Section 3.1 of the *Conditions of Electricity Service*, as approved from time to time by the Régie de l'énergie.

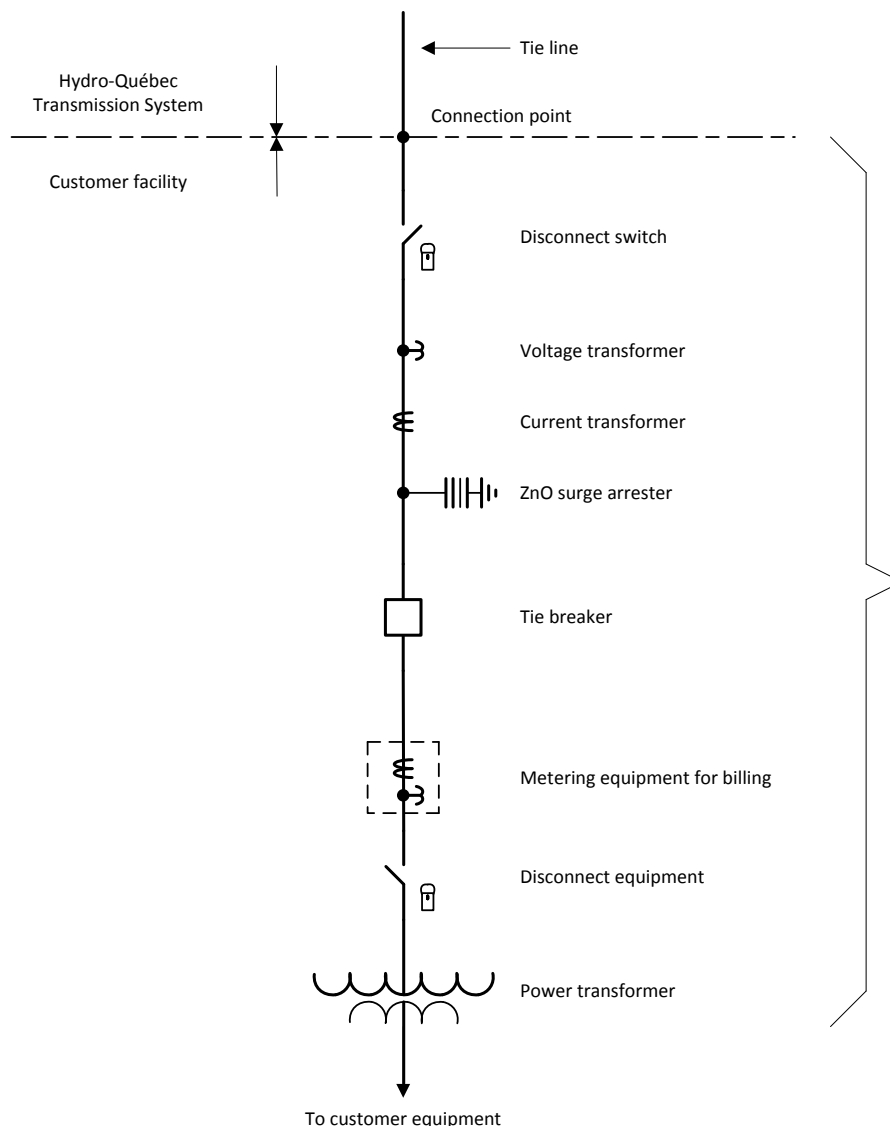
<p>Provide an action plan detailing means and measures for removing circuit-breaker(s) with built-in detectors, if applicable</p> <ul style="list-style-type: none"> • Submit technical specifications of connection switch for approval to the Transmission Provider 	<p>(nomenclature)</p> <ul style="list-style-type: none"> ◦ Required performance of protection systems for components on the high-voltage side of the customer substation, including any power transformer • Provide list of certified relays • Provide list of any data required for Transmission System operation, as described in Appendix C • Provide requirements specific to customer facility • Provide comments on the protection study regarding the control and protection schematics, proposed relay settings, and means and measures for removing any circuit-breaker with built-in detectors, if applicable • Confirm compliance of connection switch with requirement 5.4
<p>3- Project</p>	
<ul style="list-style-type: none"> • Confirm commissioning date • Provide final study of facility protection systems, in accordance with Appendix B • Contribute to facility remote indication test reports, if required • Provide test reports regarding facility equipment and protection systems • Submit the facility commissioning procedure for approval to the Transmission Provider 	<ul style="list-style-type: none"> • Draft common operating instructions • Specify any test report required regarding customer facility • Provide a written opinion, if applicable, on the final facility protection study • Approve facility commissioning procedure • Provide acceptance of facility connection • Connect customer facility to the Transmission System
<p>4- Post-commissioning</p>	
<ul style="list-style-type: none"> • Provide protection systems settings, as applied • Provide, upon request by the Transmission Provider, dynamic measurements of event recording • Provide as-built versions of previously submitted drawings and schematics 	

5 Technical requirements applicable to customer substation equipment

5.1 Customer substation

The customer facility comprises the high-voltage customer substation and the medium-voltage customer equipment. The customer substation comprises high-voltage equipment, including the power transformer, and must follow the block diagram in Figure 1.

Figure 1
Equipment on the high-voltage side of the customer substation



FOR REFERENCE PURPOSES ONLY

The connection point is located between the Hydro-Québec Transmission System (usually a high-voltage line) and the customer facility. The point is generally located at the dead-end insulators in the customer substation, near the disconnect switch or at any other place agreed to, in writing, by Hydro-Québec and the customer.

The disconnect switch is the first visible disconnection point in the customer facility; it must be located as close as possible to the connection point. It must be possible to lock out the disconnect switch in the open position.

The tie breaker (i.e. the circuit breaker on the high-voltage side of the customer substation) must be located as close as possible to the disconnect switch.

The current transformer must be located between the connection switch and the tie breaker.

A voltage transformer may be required; it may be located on either side of the tie breaker if the customer substation is supplied over a single circuit or a number of circuits not normally operated in parallel. The voltage transformer must be located on the line side of the tie breaker if the customer substation is supplied over several circuits normally operated in parallel.

If the customer wishes to install a surge arrester, it must be installed on each of the three phases, on the customer substation side of the disconnect switch.

The metering equipment for billing must be located between the tie breaker and the power transformer of the customer substation, unless another location is agreed to in writing by the customer and Hydro-Québec. A visible disconnection point (e.g., a disconnecting switch) must be located between the metering equipment and the customer equipment; it must be possible to lock out the disconnect switch in the open position.

5.2 Transmission System grounding connection

The customer facility must be designed to be compatible at all times with the characteristics of the Transmission System grounding connection.

5.2.1 Effectively grounded Transmission System

Most facilities on the Transmission System are effectively grounded, i.e., meet the following conditions:

$$0 \leq X_0/X_1 \leq 3 \quad \text{and} \quad 0 \leq R_0/X_1 \leq 1$$

Where:

X_1 = positive-sequence reactance of system

X_0 = zero-sequence reactance of system

R_0 = zero-sequence resistance of system

The customer substation must be effectively grounded on the high-voltage side and has to meet the following conditions:

$$0 \leq (X_0)_i / (X_1)_i \leq 3 \quad \text{and} \quad 0 \leq (R_0)_i / (X_1)_i \leq 1$$

Where:

$(X_1)_i$ = positive-sequence reactance of customer facility seen from high-voltage side of customer substation

$(X_0)_i$ = zero-sequence reactance of customer facility seen from high-voltage side of customer substation

$(R_0)_i$ = zero-sequence resistance of customer facility seen from high-voltage side of customer substation

To meet these conditions, the customer must:

- add grounding transformer(s) on the high-voltage side of the customer substation;
or
- ground the neutral on the high-voltage winding side of the power transformer(s) of the customer substation, i.e. choose the YNd or YNynd winding connection type or modify the winding connection type accordingly.

In the case of an existing facility, the Transmission Provider determines whether an alternate requirement may apply.

5.2.2 Non-effectively grounded Transmission System

In parts of the 69 kV or lower Transmission System, the neutral is not effectively grounded. The zero-sequence impedance is then higher than for an effectively-grounded Transmission System.

The customer facility must be designed to avoid contributing more than 400 A to the single-phase fault current on the part of the Transmission System which is not effectively grounded, unless otherwise agreed to by the Transmission Provider.

A grounding transformer of appropriate impedance is generally required on the high-voltage side of the customer substation to keep the zero-sequence impedance from becoming capacitive due, for instance, to the capacitive effect of lines or cables on the Transmission System side, and causing significant overvoltages.

5.3 General electrical characteristics of equipment

The general electrical characteristics of equipment forming the customer facility must be compatible with those of the Transmission System to which this facility is connected, in particular regarding insulation coordination.

Table 2 presents standard insulation and short-circuit levels for Transmission System equipment according to nominal Transmission System voltage.

Table 2
Standard insulation and short-circuit levels for Transmission System equipment

Nominal system voltage ¹ (kV L-L rms)	Rated voltage of equipment (kV L-L rms)	Ground insulation level ²		Standard short-circuit levels ³ (kA sym. rms)
		Lightning (kV p-p)	60 Hz (kV rms)	
69	72,5	350	140	31,5
120	145	550	230	40
161	170	650-750 ⁴	275-325 ⁴	31.5 and 50 ⁵
230	245	850-950 ⁴	360-395 ⁴	31.5 and 50 ⁵
315	330	1 050-1 175 ⁴	460	31.5 and 50 ⁵

¹ Insulation and short-circuit levels have not been standardized for 44 kV, 49.2 kV, 345 kV and 735 kV voltage levels and must be confirmed by the Transmission Provider on a case-by-case basis.

² Insulation level between open contacts of disconnect switches must be higher than the ground insulation level. This requirement also applies to 330-kV circuit breakers.

³ The X/R ratio used for these voltage levels is equivalent to 30.

⁴ The lower value applies to transformers and shunt reactors protected by surge arresters at their terminals; the higher value applies broadly to all other equipment.

⁵ The short-circuit level depends on the specific characteristics of the Transmission System to which the customer substation is connected.

⁶ The switching impulse withstand voltage is 850 kV peak-to-peak.

5.4 Disconnect switch

To ensure the safety of all personnel during work on the Transmission System, each supply circuit of the customer substation must be equipped with a disconnect switch. In some cases, the Transmission Provider may allow some device other than a disconnect switch (e.g., plug-in circuit breaker) to act as a disconnection point.

The disconnect switch must provide a visible disconnection point in the customer facility and be accessible to the Transmission Provider.

It is used to isolate the customer facility from the Transmission System. It must be possible to lock out the disconnect switch in the open position (blades opening upwards forming an angle greater than 90°).

For motorized disconnect switches, it must be possible to disable, uncouple and lock out the drive control mechanism. A device for cutting power to the motor (e.g., using a knife-switch) and a device for installing a padlock on the control box door must be provided. The control tube must also include a locking device equipped with a pin.

Furthermore, if the emergency mechanism is a wheel, it must be possible to lock out the external selection switch and the knife-switches must be visible through a window when the control box is locked out.

If the emergency mechanism is crank-operated, the knife-switches and local control selector switch must be visible through a window when the control box is locked out.

Openings for padlocks or locking clamps must have a diameter of 12 mm.

In no instance may a disconnect switch be coupled to a grounding switch on the Transmission System side; such a configuration would automatically ground the connection point when the disconnect switch opens.

5.5 Tie breaker

The tie breaker, which is usually required, must interrupt any fault current within the customer facility or on any part of the Transmission System to which this facility is connected.

It must be possible for tie breakers to perform an O-C-O (open-close-open) cycle for eight consecutive hours with no power from the grid.

If a tie breaker has a built-in system for detecting faulty internal states (e.g., low SF₆ density) that can force it to close or prevent it from operating normally (e.g., latching up), the customer must, when a faulty state is detected, remove the breaker in question from operation as quickly as possible to avoid damage to its facility or undue disturbances on the Transmission System.

5.6 Surge arrester

If the customer wishes to install a surge arrester, it must be of the zinc oxide type with no spark gap when it is located on the high-voltage side of the customer substation. The surge arrester must be sized according to Transmission System constraints.

5.7 Power transformer

The customer must provide appropriate regulation equipment in the customer substation, taking into account potential steady-state voltage variations⁵ in the Transmission System.

The customer is advised to equip power transformers with on-load tap changers and automatic voltage regulation systems in order to be able to adjust the transformer ratio according to Transmission System voltage and load conditions.

⁵ Voltage ranges are provided in *Caractéristiques de la tension fournie par le réseau de transport d'Hydro-Québec*

The impedance and connections of power transformer windings must always be compatible with the characteristics of the Transmission System grounding connection.

Depending on the characteristics of the Transmission System near the connection point, it may also be necessary to add a reactor on the high-voltage side of the customer substation, between the neutral of each transformer and ground, to limit the contribution of the customer facility to zero-sequence current during Transmission System faults.

6 Technical requirements applicable to customer facility protection systems

The customer must provide systems to protect equipment within its facility from any fault or abnormal operating condition occurring either within its facility or on the Transmission System. These protection systems include equipment such as protective relays, panels, junction boxes, cabling, current and voltage transformers and remote protection systems (remote tripping or remote blocking), as required.

Coordination of customer facility protection systems must comply with section 18.11 of *Conditions of Electricity Service*.

6.1 Circuit breaker protection

The customer facility must be equipped with at least one circuit breaker on the high-voltage side of the customer substation to adequately clear faults.

6.2 Fuse protection

If the customer facility is connected over a single circuit to a portion of the Transmission System operating at 69 kV or less, a fuse-based protection system may be used in the customer substation to protect the customer facility subject to prior approval by the Transmission Provider. Fuse protection of the customer facility must be coordinated with Transmission System protection; the ratio of short-circuit current to fuse rating, at the connection point, must be at least 100.

6.3 Performance of customer facility protection systems

6.3.1 Protection from customer facility faults

The customer substation must be equipped with protection systems that can quickly and reliably detect and clear any type of fault within the customer facility. Such systems must be compatible and coordinated with those used by the Transmission Provider at the substation serving the customer substation. The customer must select protective relays that ensure secure and selective coverage for its equipment.

Protection systems for customer substation equipment must comply with the performance requirements set out by the Transmission Provider, in particular the maximum fault-clearing

time, and the number of protective functions required to ensure adequate coverage of the equipment in question.

6.3.2 Protection from Transmission System faults

If the customer substation is supplied over a single circuit or a number of circuits not normally operated in parallel, it is generally unnecessary to install protection systems to detect faults on the Transmission System.

If the customer substation is supplied by circuits normally operated in parallel, the following requirements apply.

The customer substation must be equipped with protection systems that detect Transmission System faults. The contribution of the customer facility to such faults must be cleared using a circuit breaker. The design of such protection systems varies according to the characteristics of Transmission System to which the customer facility is connected. They must quickly, reliably, selectively and safely clear the fault contribution carried on the Transmission System through the customer facility.

At 69 kV or higher, customer facility protection systems must comprise two primary protections implemented using two separate relays, each with a trip relay. Such protections and relays must have the following characteristics:

- The primary protection must cover all types of faults (three-phase, two-phase, two-phase-to-ground, and single-phase-to-ground with and without a fault impedance). For high-impedance faults⁶, the fault resistance must be $R_f = 10 \Omega$, i.e., a zero-sequence component of $3R_f = 30 \Omega$.
- The primary protection must operate as soon as the fault is detected, without delay, and comply with the Transmission System speed requirements.
- The primary protection must be selective and coordinated with protections in adjacent zones.

It is recommended that these protection systems differ in design or in manufacturer. Such protection systems may require telecommunication links.

Breaker failure protection

Breaker failure protection is required at the customer substation in the following circumstances:

⁶ Type of insulation fault where the fault resistance is sufficiently high to maintain a significant voltage at the fault location between the conductor and the ground, or between the conductors.

- If the customer substation is supplied over several circuits normally operated in parallel, breaker failure protection is required to enable tripping of circuit breakers in adjacent zones when a circuit breaker refuses to trip.
- When rapid circuit breaker tripping is needed to meet Transmission System requirements, breaker failure protection is required to ensure remote tripping of circuit breakers at the substations serving the customer substation.

Reclosing of circuit breakers by line protections

If the customer substation is supplied by circuits normally operated in parallel and equipped with line protections, automatic reclosing of high-voltage circuit breakers in that substation is prohibited.

6.3.3 *Special protection measures*

Islanding of motor loads on other neighboring substations

In some cases, protections may be required to prevent islanding of motor loads on neighboring substations (another customer substation or a Transmission System substation) according to the characteristics of the motor load on the customer facility and Transmission System to which it is connected.

Remote tripping

Remote tripping⁷ of the customer substation may be required in either of the cases below.

- The reclosing time of the line is less than 2 seconds and the customer facility has a motor load that is sensitive to rapid reclosing.
- There is a risk of self-excitation when islanding of a motor load is possible in the customer facility with a capacitive load (e.g., capacitor bank, filter, unloaded line or cable).

6.4 Design of customer facility protection systems

Protection from Transmission System faults

When protection systems are required in the customer substation to detect abnormal conditions on the Transmission System, they must comply with the requirements below.

- Protective and trip relays must be certified⁸ by the Transmission Provider.
- Protection systems must be powered using storage batteries, since they must remain functional during an auxiliary power supply failure. Each storage battery must have two chargers that can either run in parallel with the battery or back up each other. Battery life must be at least eight consecutive hours.
- Current and voltage transformers must be installed on each of the three phases to power protection system relays. The transformers must have separate secondary windings in order to power separately the relays of the two primary protection systems.

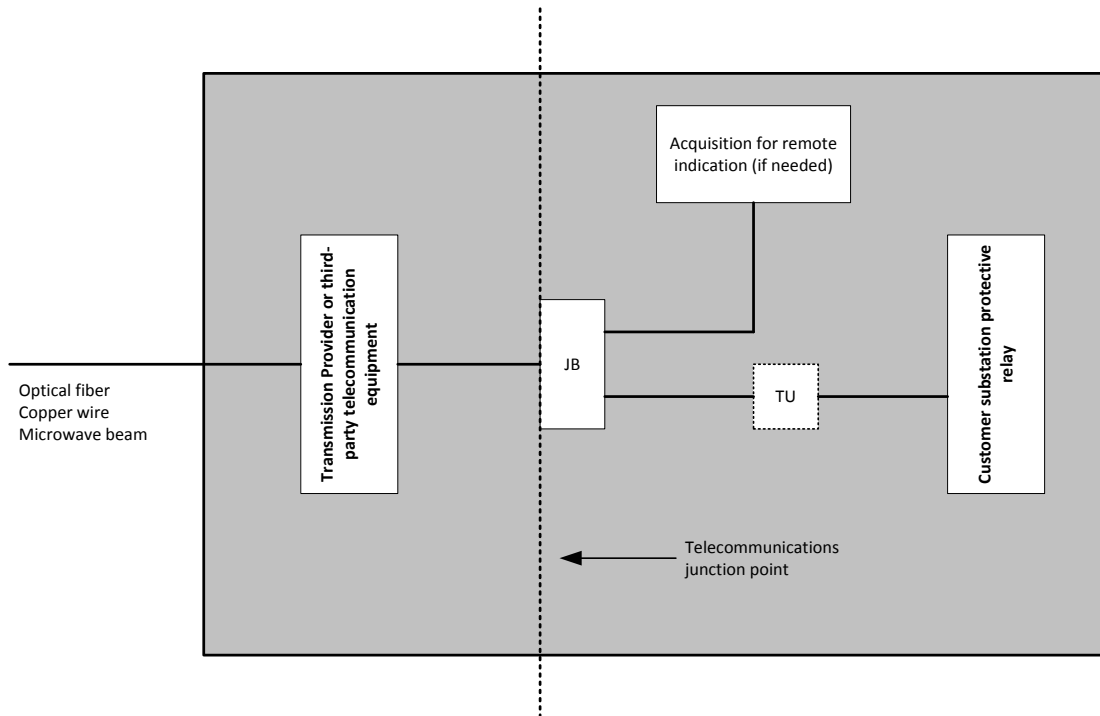
6.5 Telecommunication systems

The customer substation telecommunication system must follow the block diagram shown in Figure 2 unless agreed otherwise with the Transmission Provider.

⁷ The remotely controlled opening of a circuit breaker by an automatic control or protection system.

⁸ Certified relays are relays that the Transmission Provider has approved for use following validation testing.

Figure 2
Customer substation telecommunication system



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The junction point between the telecommunication network of the Transmission Provider (or a third-party) and customer substation equipment constitutes the telecommunication junction point. In most cases, this point coincides with the junction box (JB) used to connect the telecommunication equipment of the Transmission Provider (or a third-party) to the tone unit (TU), if applicable, or the protective relay of the customer substation.

The customer must supply electricity, as well as adequate secure space for installing all this equipment; the customer must also install all required ductwork, junction boxes, as well as tone or remote protection units that are part of the protection systems.

7 Requirements regarding customer substation equipment maintenance

The customer must plan the maintenance of its equipment, in particular all equipment located between the connection point and the tie breaker (high-voltage side) inclusive, on an annual basis and coordinate its maintenance schedule with that of Transmission Provider.

8 Requirements regarding customer substation equipment operation

If the customer facility can be supplied with electrical power from several sources, it may be necessary to equip the customer substation with interlock devices to prevent parallelism⁹ and the customer must receive prior approval from Transmission Provider before performing any parallelism operation, in accordance with the common operating instructions.

The customer facility must provide real-time information to enable proper operation of the Transmission System depending on the customer facility load and the part of the Transmission System to which it is connected, as indicated in Appendix C.

9 Special technical requirements

9.1 Declared power of 900 MW or more

If the declared power¹⁰ of the customer facility is greater than 900 MW, the design or operation of customer facilities are subject to special requirements in order to limit excessive voltage and frequency deviations under single-contingency conditions at customer facilities or on the Transmission System.

9.2 Bulk Power System

The Transmission Provider will determine whether the customer substation is part of the *Bulk Power System*¹¹. If so, the Transmission Provider shall supply to the client any requirement specific to the *Bulk Power System* that is applicable to the customer substation. In particular, such special requirements concern protection, automatic control and telecommunication systems.

9.3 Event Recorders

If the customer facility belongs to the *bulk power system*, the customer substation must be equipped with event recorders, disturbance recorders or any other instrument needed to analyze disturbances on the Transmission System or on facilities connected to it.

9.4 Future system voltage changes on Transmission System

If the Transmission Provider intends to change the voltage of the portion of the Transmission System to which the customer facility is connected, the customer must take this change into account during the design of its facility. The customer may thus plan the installation of a double-winding power transformer designed to operate at both the current

⁹ Parallel connection of multiple power sources within the same customer facility.

¹⁰ Declared power (in kW) corresponds to 95% of available power (in kVA).

¹¹ The *Bulk Power System* as defined in the *Glossary of terms and acronyms used in reliability standards* and its modifications as adopted from time to time by the Régie de l'énergie.

voltage and the future voltage, as well as the installation of customer substation equipment designed to provide the required insulation level at the future voltage.

9.5 Construction of tie line

To maintain Transmission System reliability and security, a customer building a tie line to connect its facility to the Transmission System must ensure the electrical and mechanical characteristics of the line are equivalent to those of line the Transmission Provider would build for a comparable project. If so, the Transmission Provider shall supply to the customer all special design requirements according to the type of line and its location.

Appendix A Technical data to be provided with a connection request

Part 1: Connection request

1 Scheduled commissioning date

- Date of customer facility commissioning
- Date of initial energizing of customer facility (if before commissioning date)

2 Location diagram for customer facility

3 Data regarding load anticipated by customer

- Anticipated power requirements in the short term and over a 10-year period
- Anticipated power factor
- Load factor and typical annual consumption pattern for type of load
- Type of load
 - aluminum smelter
 - pulp and paper mill
 - steel plant
 - other

4 Proposed single-line diagram of customer facility

- Schematic diagram showing the layout of the customer substation equipment: power transformer, switches and their operating mode, instrument transformer (current transformer and voltage transformer if applicable), surge arrester (if any) and circuit breaker
- Main characteristics of customer substation equipment on single-line diagram, including any reactive compensation equipment and relevant information
- Number and power of synchronous and asynchronous motors powered by medium-voltage supplies (500 hp or more)
- Preliminary control and protection schematic, if available
- If applicable, a statement indicating that the customer facility will include generation synchronized to the Transmission System.

5 **Customer-specific needs**

Spare line

Other needs

6 **Main characteristics of disturbance-producing equipment¹² in the customer facility**

Type (e.g., motors \geq 100 hp, arc or induction furnaces, converters)

Type of process and power of disturbance-producing equipment

General characteristics of load (e.g., type of converters, pulse numbers)

Part 2: Facilities Study

7 **Confirmation of data supplied in response to points 1 to 6**

8 **Customer facility protection study, in accordance with Appendix B**

9 **Characteristics of customer substation equipment (data in p.u. based on MVA for each equipment)**

- Connection switch: type and specifications
- Power transformer:
 - number
 - rated power and voltage
 - positive- and zero-sequence impedance
 - winding resistance
 - coupling (i.e., winding connections)
 - number of taps and range of automatic regulation
 - exciting current (80%–110% of rated voltage)
- Grounding transformer (if any):
 - zero-sequence impedance
- Tie breaker (high-voltage side):
 - insulation levels
 - interrupting capacity

¹² Within the meaning of the *Emission limits for disturbances on the Hydro-Québec Transmission System*, as approved from time to time by the Régie de l'énergie.

- other voltage and current ratings
 - Reactive compensation equipment (if any):
 - number of shunt capacitor banks or filters
 - rated power
 - rated voltage
 - High-voltage surge arresters (if any):
 - type
 - steady-state voltage (U_c)
 - nominal discharge current
 - protection characteristics
- 10 **Customer-built tie line (if any):**
- configuration (construction)
 - overhead line (wood/steel)
 - underground line (direct burial/conduit system)
 - type of conductor
 - overhead line (ACSR) name and gauge in kcmil
 - underground line (conductor gauge in kcmil or mm^2 , and whether aluminum or copper)
 - positive- and zero-sequence impedance (R, X, B)
 - thermal capacity
- 11 **Dynamic characteristics of motors ≥ 100 hp (upon request by Transmission Provider)**
- number and power of motors powered by medium-voltage power sources (100 hp or more)
 - Synchronous motors:
 - type of motor (round rotor/salient pole)
 - damper windings (connection method)
 - rated power and voltage
 - rated power factor

- unsaturated direct-axis synchronous reactance (X_d)
- unsaturated quadrature-axis synchronous reactance (X_{qi})
- direct-axis transient reactance – unsaturated (X'_{di}) and saturated (X'_{dv})
- quadrature-axis transient reactance – unsaturated (X'_{qi}) and saturated (X'_{qv})
- direct-axis subtransient reactance – unsaturated (X''_{di}) and saturated (X''_{dv})
- quadrature-axis subtransient reactance – unsaturated (X''_{qi}) and saturated (X''_{qv})
- positive-sequence leakage reactance (X_1)
- negative-sequence reactance (X_2)
- time constants T'_{do} (and corresponding temperature in °C), T'_{qo} , T''_{do} and T''_{qo}
- armature resistance, by phase (R_a) and corresponding temperature in °C
- stator forward resistance (R_1) at 60 Hz and corresponding temperature in °C
- saturation curve of generators to calculate parameters and factors needed in saturation modeling (S_{gu} , S_{gl} , E_u and E_l)
- inertia constant H (of rotor and driven load)
- Excitation system:
 - detailed model and associated parameters, referring to standard IEEE model (IEEE Std 421.5-2005, IEEE Recommended Practice for Excitation System Models for Power System Stability Studies)¹³ or to manufacturer-specific model
- Asynchronous motors:
 - rated power and voltage
 - power factor at 100%, 75% and 50% of rated power
 - stator leakage reactance (X_s)
 - stator resistance (R_s)
 - rotor leakage reactance (X_r)
 - rotor resistance (R_r)
 - magnetizing reactance (X_m)
 - locked rotor reactance (X_{lr})

¹³ Reference provided only for explanatory and informative purposes. The Transmission Provider shall display on its website a hyperlink pointing to the website of the Institute of Electrical and Electronics Engineers, Inc., where it is possible to obtain any copyrighted standard.

- open-circuit reactance (X_o)
- time constant T'_{do}
- inertia constant H (of rotor and driven load)
- torque-slip curve
- steady-state slip

Appendix B Customer facility protection study

The customer facility protection study must be carried out by an engineer and contain the information indicated below.

Part 1: Introduction

- Brief description of the site, the project and the point where the facility is to be connected to the Hydro-Québec Transmission System according to information provided by the Transmission Provider
- Distinctive project features (e.g., added protection, specific instructions)
- Future developments (additional power)

Part 2: Characteristics of customer facility (customer substation equipment and customer equipment)

- Single-line diagram of customer facility
- Electrical characteristics of customer substation equipment:
 - power transformers
 - circuit breakers
 - grounding transformer or neutral reactor impedance
 - current transformers and voltage transformers
 - customer-built tie line (if any)
- Electrical characteristics of customer equipment:
 - synchronous motors and excitation systems
 - asynchronous motors
- Protection system characteristics:
 - protective relays

Part 3: Fault study

- Fault calculations (three-phase, two-phase, two-phase-to-ground, and single-phase-to-ground with and without a fault impedance; for high-impedance faults, the fault resistance must be $R_f = 10 \Omega$, i.e., a zero-sequence component of $3R_f = 30 \Omega$):
 - on the high-voltage busbar of the customer substation
 - on the medium-voltage busbar of the customer substation

- on the busbar of any substation serving the customer substation
- on the line side of the tie breaker (if the fault is far from the customer substation)
- Fault calculations must include contributions of motors in the customer facility.

Part 4: Protective relay settings and coordination curves

- Table showing protective relay settings and operation time for faults studied
- Protection coordination time or curves
- Control (or logic) and protection schematics

Appendix C Data required for Transmission System operation

	<u>Required data</u>	
Any tie breaker	State Unless instructed otherwise by the Transmission Provider	
Connection point MW, Mvar, kV and A	Measurement¹ Unless instructed otherwise by the Transmission Provider	
Load shedding²	Status signals, measurements and controls To be specified, if applicable	
Acquisition unit	State Unless instructed otherwise by the Transmission Provider	
Telephone link	Link for contacting the operator of the customer substation 24/24 x 7/7 (directly without extension number, e-mail or voice mailbox).	
Status signals and alarms	State Certain signals or alarms may be required to indicate the state of tone units or the operation of protections (such as back-up protection) that may affect the Transmission System.	
<p>Notes:</p> <p>¹ Dynamic data on loads and power generation must be supplied separately.</p> <p>² Defined in Section 1.20 of the <i>Hydro-Québec Open Access Transmission Tariff</i>, as approved from time to time by the Régie de l'énergie.</p>		