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

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Hydro Québec
TransÉnergie

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* facilities[1] 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

Italicized terms in the text are defined below.

Available power

Defined in Section 21.1 of the *Conditions of Electricity Service*, as approved from time to time by the Régie de l'énergie.

Bulk Power System

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.

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.

[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.

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Customer

Defined in Section 21.1 of the *Conditions of Electricity Service*, as approved from time to time by the Régie de l'énergie.

Customer substation

Defined in Section 21.1 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 21.1 of the *Conditions of Electricity Service*, as approved from time to time by the Régie de l'énergie.

Technical requirement

Defined in Section 21.1 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 21.1 of the *Conditions of Electricity Service*, as approved from time to time by the Régie de l'énergie.

Medium voltage: nominal phase-to-phase *voltage* of more than 750 V, but less than 44,000 V

High voltage: nominal phase-to-phase *voltage* of 44,000 V or more

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

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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.

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Table 1
Technical information required

Customer	**Hydro-Québec**
1- Connection request (including any modification to a connected facility)	
• Provide technical data regarding the facility, in accordance with section 1 of Appendix A	• Provide a written opinion on the information received • Determine the work to be done ◦ 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 *Transmission System* representing the work to be done ◦ 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: ◦ Future conversion of the supply voltage ◦ Declared power of 900 MW or more ◦ *Customer* facility power transformer(s) (type of connection and required voltage regulation range, if applicable) ◦ Protection systems
2- Facilities Study	
• Provide written acceptance of the work to be done and the connection point • Provide technical data regarding the facility, in accordance with section 2 of Appendix A • Specify: ◦ 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 Provider* an action plan detailing means and measures for removing circuit-breaker(s) with built-in detectors, if applicable	• 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: ◦ *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* (nomenclature) ◦ Performance requirements of protection systems for components on the *high-voltage* side of the *customer substation*, including

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• Submit technical specifications of connection switch for approval to the *Transmission Provider*	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 diagrams, 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
3- Project	
• Confirm commissioning date • Provide final study of facility protection systems, in accordance with Appendix B • Contribute to facility remote signaling test reports, if required • Provide test reports regarding facility equipment and protection systems • Submit the facility commissioning procedure for approval to the *Transmission Provider*	• 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*
4- Post-commissioning	
• 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 diagrams	

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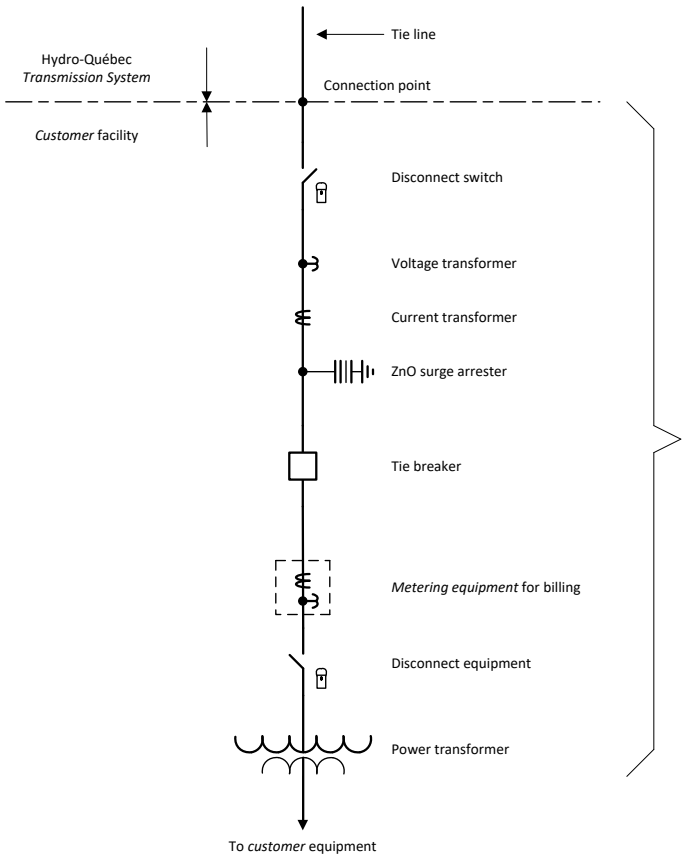
5 Technical requirements applicable to customer substation equipment

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 general principle diagram in Figure 1.

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



GENERAL PRINCIPLE DIAGRAM ONLY

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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 several 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 disconnect switch) must be located between the *metering equipment* and the *customer* equipment. If it is a disconnect switch, it must be possible to lock it out 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 criteria:

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

Where:

X_1 = positive-sequence reactance of system

X_0 = zero-sequence reactance of system

R_0 = zero-sequence resistance of system

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

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

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 criteria, 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 equipment insulation coordination.

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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 peak)	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.

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 control and drive mechanism. A device for cutting power to the motor (e.g., using a knife-switch) and a place 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.

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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 closed and 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 SF_6 density) that can force it to close or prevent it from operating normally (e.g., latching in open or closed position), 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 variations[4] 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.

[4] Voltage ranges are provided in *Caractéristiques de la tension fournie par le réseau de transport d'Hydro-Québec*, a reference provided only for explanatory and informative purposes.

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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 power 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 protection systems to protect equipment within its facility against 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), when required.

Coordination of *customer* facility protection systems must comply with section 15.2.7 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* protections; 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 against 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 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

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

6.3.2 Protection against Transmission System faults

If the *customer substation* is supplied over a single circuit or several 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 the *Transmission System* to which the *customer* facility is connected. They must quickly, reliably, selectively and safely clear the contribution to the fault carried on the *Transmission System* through the *customer* facility.

At 69 kV or higher, *customer* facility protection systems must comprise two primary protections. Each one of these primary protections uses a separate protective relay, as well as a trip relay. Such protections must have the following characteristics:

- The primary protection must cover all types of faults (three-phase, two-phase, two-phase-to-ground, and phase-to-ground with and without a fault impedance). For high-impedance faults[5], the fault resistance used must be R_f = 10 Ω, i.e., a zero-sequence component of $3R_f$ = 30 Ω.
- 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:

[5] 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.

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- 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.

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Remote tripping

Remote tripping[6] of the *customer substation* is 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 against 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 certified[7] 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 autonomy 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 diagram shown, in Figure 2 unless agreed otherwise with the *Transmission Provider*.

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

[7] Certified relays are relays that the *Transmission Provider* has approved for use following validation testing.

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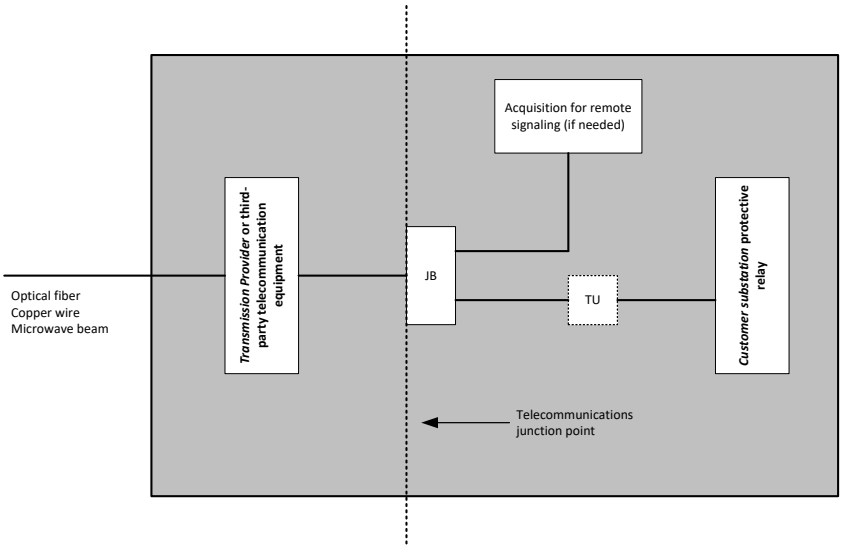
Figure 2
***Customer substation* telecommunication system**



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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) inclusively, on an annual basis and coordinate its maintenance schedule with that of *Transmission Provider*.

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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 parallelism[8] 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 the *customer* facility is connected, as indicated in Appendix C.

9 Special technical requirements

The *Transmission Provider* determines whether special *technical requirements* resulting from sections 9.1, 9.2, 9.3 and 9.5 must apply to the *customer* facility. If so, it informs the *customer* and submits the applicable special requirements at the Régie de l'énergie for approval such that these requirements can become mandatory regarding any *customer* facility subject to the same special requirements.

9.1 Declared power of 900 MW or more

If the declared power[9] of the *customer* facility is 900 MW or more, the design or operation of the *customer* facility is subject to special requirements in order to limit excessive voltage and frequency deviations under single-contingency conditions at the *customer* facility 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*. 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.

[8] Parallel connection of multiple power sources within the same *customer* facility.

[9] Declared power (in kW) corresponds to 95% of *available power* (in kVA).

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9.4 Future system voltage changes on the 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 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 transmission line

To maintain *Transmission System* reliability and security, a *customer* building a transmission 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.

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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

- 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 shown on single-line diagram, including reactive compensation equipment and relevant information (if any)
- Number and power of synchronous and asynchronous motors powered by *medium-voltage* supplies (500 hp or more)
- Preliminary control and protection diagram, if available
- If applicable, a statement indicating that the *customer* facility will include generation synchronized to the *Transmission System*.

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5 *Customer*-specific needs

Spare line

Other needs

6 Main characteristics of disturbance-producing equipment[10] in the *customer* facility

Type (e.g., motors ≥ 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-sequence impedance (R_1, X_1, B_1)
  - zero-sequence impedance (R_0, X_0, B_0)
  - 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

[10] 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.

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- interrupting capacity
- 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 transmission line (if any):

- configuration (construction)
  - overhead line (wood/steel)
  - underground line (direct burial/conduit system)
- type of conductor
  - overhead line (conductor gauge in kcmil or mm^2; aluminum, copper or aluminium conductor steel reinforced)
  - underground line (conductor gauge in kcmil or mm^2, aluminum or copper)
- positive-sequence impedance (R_1, X_1, B_1)
- zero-sequence impedance (R_0, X_0, B_0)
- thermal capacity

11 Dynamic characteristics of motors ≥ 100 hp (upon request by *Transmission Provider*)

- number and power of motors connected to *medium-voltage* power sources (100 hp or more)
- Synchronous motors:
  - type of motor (round rotor or salient pole)
  - damper windings (connection method)

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- 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)[11] 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)

[11] 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.

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- rotor resistance (R_r)
- magnetizing reactance (X_m)
- locked rotor reactance (X_{lr})
- open-circuit reactance (X_o)
- time constant T'_{do}
- inertia constant H (of rotor and driven load)
- torque-slip curve
- steady-state slip

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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 transmission 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 phase-to-ground with and without a fault impedance). For high-impedance faults, the fault resistance used must be R_f = 10 Ω, i.e., a zero-sequence component of $3R_f$ = 30 Ω):
  - on the *high-voltage* busbar of the *customer substation*

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- 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 diagrams

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Appendix C Data required for *Transmission System* operation

	Required data
Any tie breaker	**State** Unless instructed otherwise by the *Transmission Provider*
MW, Mvar, kV and A at each connection point	**Measurement**[1] Unless instructed otherwise by the *Transmission Provider*
Load shedding[2]	**State signaling, 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).
State signaling and alarms	To indicate the state of tone units or the operation of protections (such as back-up protection) that may affect the *Transmission System*.

Notes:

1 Dynamic data on loads and power generation must be supplied separately.

2 Defined in Section 1.20 of the *Hydro-Québec Open Access Transmission Tariff*, as approved from time to time by the Régie de l'énergie.

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