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

Planification des réseaux régionaux

Direction – Planification des actifs

Hydro-Québec TransÉnergie

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These *Technical Requirements for Customer Facilities Connected to the Hydro-Québec Transmission System* were translated into English by Hydro-Québec. In the event of a conflict between the French text and the English text, the French text shall prevail.

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PART I – GENERAL

1. PURPOSE AND APPLICATION

This document is divided into three parts. Part I covers the document's purpose and application, and defines a number of terms used. Part II deals with the connection of *customer facilities*. It also lists technical information and studies required of *customers* at various stages of the connection process carried out by the *Transmission Provider*, from initial studies to the commissioning of the *customer facilities*. Part III gives the technical requirements with which *customer facilities* must comply. These include both general requirements and specific requirements related to voltage, equipment, protection systems, maintenance and operations.

The document also has three appendices. The first two outline technical information to be submitted and the content of *customer facility* protection studies. The third lists the information about *customer facilities* required to operate the Hydro-Québec *transmission system*.

This document supersedes the version dated March 2006.

1.1. Purpose

This document presents the minimum technical requirements for *customer facilities* connected to the 44 kV to 345 kV Hydro-Québec *transmission system* and guidelines applying to the connection. In this document, the term *customer*[1] refers to an electricity user. For *customer facilities* that also have generating capacity connected to the transmission system, further technical requirements apply.[2]

This document was drafted following standards for end-user *facilities* by the *North American Electric Reliability Corporation*.[3]

1.2. Application

Requirements regarding access, modification of *facilities*, power factor, immunity, and operations and maintenance apply to all *customer facilities* and are not limited to the situations listed below.

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1 See definition of *customer* in Section 2.

2 These requirements are set out in the following document (and later amendments): *Technical Requirements for the Connection of Power Plants to the Hydro-Québec Transmission System*, TransÉnergie, Direction – Planification des actifs, 2006.

3 Based on the standard for end-user *facilities* (Reliability Standards for the Bulk Electric Systems of North America, Facility Connection Requirements, FAC-001-0).

All requirements in this document, including the appendices, and in the reference document entitled *Emission Limits for Customer Facilities Connected to the Hydro-Québec Transmission System*, Hydro-Québec TransÉnergie, Direction – Planification des actifs, December 2008 or any later version (available at: www.hydroquebec.com/transenergie/fr/commerce/pdf/limites_emission_en.pdf), apply to *customer facilities* connected to the Hydro-Québec *transmission system* in any of the situations below.[4]

1. When *Distributor customer facilities* are connected, or *facilities* partially or totally shut down are recommissioned, or existing *facilities* that were not previously supplied directly by the Hydro-Québec *transmission system* are connected.
2. When the load of one of the *Distributor*'s *customers*, whose *facilities* are already connected, increases beyond the *declared power*,[5] or when equipment that produces disturbances or may increase disturbance emissions is added or replaced. The *Transmission Provider* may then reaffirm requirements in this document after having assessed impacts on the *transmission system*.
3. When the characteristics of existing *customer facilities* are modified.[6] The *Transmission Provider* may then reaffirm requirements in this document after having assessed impacts on the *transmission system*.

These requirements also apply in the above situations to a *customer substation* of a *municipal system* or regional *electricity cooperative* even if the *municipal system* or regional *electricity cooperative* is a customer of the *Distributor*, or under either point-to-point or network integration transmission service.

The *Transmission Provider* reserves the right to refuse to supply or deliver electricity to any *customer* not making the modifications or adjustments needed to bring its *facilities* into compliance with *Transmission Provider* requirements.

[4] For *customer facilities* connected to a neighboring Québec system or to the distribution system, the requirements of those managing such systems apply.

[5] See Section 2 for the definition of *declared power*, which corresponds to "available power" as defined by the *Distributor*.

[6] Examples include modifying the design of *customer facilities* (besides simply adding metering for billing purposes), replacing a major piece of equipment (line, transformer, reactive compensator, surge arrester or high-voltage breaker), modifying protection systems, adding 500-hp or larger motors, adding equipment that may increase disturbances emitted onto the system, or modifying the characteristics or operating mode of such equipment.

2. DEFINITIONS

Italicized terms in the text are defined below for the purposes of this document.

Bulk power system
The portion of the interconnected system in north-eastern North American comprising generating and transmission equipment for which faults and disturbances may have a significant adverse impact outside a local area.[7]

Certified relay
Any relay that the *Transmission Provider* has approved for use following validation testing.

Connection point
In this document, the boundary point between the Hydro-Québec *transmission system* (usually a high-voltage line) and the *customer facilities*. The point is generally located at the dead-end insulators in the *customer substation*, near the *connection switch* or at any other place agreed to by the parties in writing.

Connection switch
The first visible disconnection point (disconnecting switch) in the *customer facilities* located as close as possible to the *connection point*.

Customer
In this document, any electricity user supplied at a voltage of 44 kV or higher whose *facilities* are or will be connected to the *transmission system*. This includes *Distributor customers* or applicants, i.e., native load (retail) *customers* or applicants, *municipal systems* and the *electricity cooperative*. It also includes *customers* with point-to-point or network integration transmission service, i.e., *municipal systems* or the *electricity cooperative* should they be connected. It excludes *customers* connected to the Hydro-Québec distribution system, to a neighboring Québec system, to *municipal systems* or to the *electricity cooperative*.[8]

Customer facility(ies)
All of a *customer*'s support structures, other structures, switchgear and electrically powered equipment that are located on the *customer* side of the *connection point*. They comprise the electrical installation that is or will be connected to the Hydro-Québec *transmission system*.

[7] Based on this definition, the method Hydro-Québec uses to identify its *bulk power system* consists in finding system elements that are subject to a significant adverse impact when a three-phase fault is applied and not cleared by the local protection system.
[8] See footnote 4.

Customer substation
A transformer substation that does not belong to Hydro-Québec and that supplies a *customer*'s electrically powered equipment.

Declared power
The maximum power to be delivered to the *connection point* for the *customer* load as declared by the *Distributor* to the *Transmission Provider* in accordance with the *Hydro-Québec Open Access Transmission Tariff*. The *Transmission Provider* uses this value to determine the capacity of the infrastructure to be built to connect the *customer facilities* and then to plan *transmission system* capacity based on its own criteria. The declared apparent power in MVA corresponds to the available power agreed to between the *customer* and the *Distributor* and specified in the *Distributor*'s Conditions for Electrical Service.

Distributor
Hydro-Québec when carrying on electric power distribution activities (Hydro-Québec Distribution).

Emission limits
The maximum authorized emission levels for harmonics, imbalances, flicker or rapid voltage changes that may be generated or amplified by all disturbance-producing equipment in *customer facilities* connected to the Hydro-Québec *transmission system*. *Emission limits* involve the contribution from a *customer facility* to the level of disturbances that may be transmitted over the power system by all disturbance-producing equipment in the *facility* under study. If required, other types of disturbances, e.g., interharmonics, subharmonics, harmonics above 3 kHz or repetitive bursts of harmonic currents, may be subject to specific emission limits during customer facility planning, connection or modification studies. *Emission limits* are described in detail in the reference document entitled *Emission Limits for Customer Facilities Connected to the Hydro-Québec Transmission System*, Hydro-Québec TransÉnergie, Direction – Planification des actifs, December 2008 or any later version (www.hydroquebec.com/transenergie/fr/commerce/pdf/limites_emission_en.pdf).

Facilities study
An engineering study conducted by Hydro-Québec to specify technical aspects, cost, and schedule for the supply solution selected in the *planning study*, and which includes any environmental studies required to obtain permits.

Hydro-Québec Open Access Transmission Tariff
The document approved by the Régie de l'énergie that sets down the rates and conditions applying to electricity transmission service on the Hydro-Québec system.

Municipal system* and *electricity cooperative
Under the *Act respecting the Régie de l'énergie*, any municipal power distribution system governed by the *Act respecting municipal and private electric power systems* (R.S.Q. c. S-41), including the Coopérative régionale d'électricité de Saint-Jean-Baptiste-de-Rouville, which have been *Distributor customers* since May 13, 1997.

NERC (North American Electric Reliability Corporation)
The organization mandated to promote the reliability of the electricity supply in North America. It comprises ten regional reliability councils that account for virtually all electricity supplied in the U.S., Canada, and a portion of Baja California Norte, Mexico.[9]

Nomenclature
In this document, all terms for identifying equipment in *customer facilities* using the *Transmission Provider*'s standard code.

Nominal voltage (of a system – voltage level)
The phase-to-phase RMS voltage used in designating a power system. In this document, the *nominal voltages* are as follows: 44 kV, 49 kV[10], 69 kV, 120 kV, 161 kV, 230 kV, 315 kV and 345 kV.

NPCC (Northeast Power Coordinating Council)
A voluntary coalition of electric power stakeholders working in north-eastern North America. The organization is a *NERC* regional reliability council whose membership includes several electric utilities and independent system operators active in five regions, called "control areas": New York State, New England, Québec, Ontario and the Maritime Provinces.[11]

Planning study
A study which, for the reference connection and connection options, specifies the supply solution for *customer facilities*, estimated *facilities study* and project costs, lead times and specific technical requirements.

Remote tripping
The remotely controlled change in state of a circuit breaker by an automatic control or protection system.

Telecommunications junction point
The boundary point between the Hydro-Québec or a third-party telecommunication network and *customer substation* equipment. The point is generally located at the junction box

[9] Web site: www.nerc.com
[10] More precisely, 49.2 kV
[11] Web site: www.npcc.org

connecting telecommunication equipment (at the end of the link) to the tone unit (when present) or to the protective relay of the *customer facilities*. Refer to the block diagram in Section 8.5.

Tie breaker(s)
The circuit breaker(s) located closest to the *connection switch*.

Transmission Provider
Hydro-Québec when carrying on electric power transmission activities (Hydro-Québec TransÉnergie).

Transmission system
The set of facilities for carrying electricity, including step-up transformers on generating sites, transmission lines at 44 kV and higher, transmission and transformer substations, and any other facility for connecting generating sites to the distribution system. In this document, the term refers to the Hydro-Québec *transmission system*.

Tripping/reclosing
The change in state of a circuit breaker by an automatic control or protection system.

PART II – CONNECTION AND TECHNICAL STUDIES REQUIRED

3. CONNECTION

This section sets down guidelines for and requirements governing the connection of *customer facilities*. Its purpose is to explain the factors the *Transmission Provider* uses to determine the connection solution and to select the voltage level. It describes the content of the reference connection and distinguishes it from connection options that may be requested. It also gives details regarding the *connection point*.

3.1. Determining the connection solution for *customer facilities*

The *Transmission Provider* chooses the connection solution for *customer facilities* and determines *transmission system* upgrades and modifications needed for the new load. The required capacity of equipment upgrades is selected to carry the *declared power* specified by the *Distributor*.

Based on technical and economic criteria, the solution is chosen to optimize use of the *transmission system*, while being environmentally acceptable. Section 2 gives *Nominal voltage* levels on the *transmission system*.

3.2. Reference connection

The *Transmission Provider* plans, builds, operates and maintains the additional infrastructure providing the reference connection. This may include lines, substations, shunt compensation, automatic control and protection systems, and telecommunication links. Three categories of infrastructure are needed.

(1) New infrastructure to link the *connection point* to the existing grid. Generally, a single overhead circuit is used when its capacity suffices to serve the load to connect; otherwise, the *Transmission Provider* will select an adequate number of circuits. The *Transmission Provider* retains ownership of this infrastructure and may use it to connect other loads or generating *facilities* while still honoring its obligations. The *Transmission Provider* may for operating reasons, however, choose a multi-circuit reference connection if technical and economic considerations so warrant. In such instances, the *customer substation* may have to be modified to connect any other circuit.

(2) Modifications to the *transmission system* by adding equipment or advancing upgrades. This may involve increasing system capacity to serve the new load or modifying protection systems as needed to connect the *customer facilities*.

(3) Telecommunication links and equipment required for power system operation and protection functions up to the *telecommunications junction point* (see Section 8.5, Figure 2).

3.3. Connection point

The *connection point*, defined in Section 2, is generally located in the *customer substation* being served, at the dead-end insulators where the supply circuit conductors are attached. The incoming line structure, *connection switch* or any other load-side conductor belong to the *customer facilities*. The *connection point* may in some cases, at the *customer*'s request or for operating reasons, be located on the supply-side insulators of the first line structure located just inside the *customer*'s property line.

As stipulated in Section 7.2.1, a *connection switch* is required at (or near) the *connection point*. Figure 1 is a block diagram showing where various devices are located with respect to the *connection point*. If the *connection point* is located at the *customer*'s property line, the line structure there must be equipped with jumpers so the *Transmission Provider* can open the circuit(s) for the reasons given in Section 7.2.1. This alternative still requires that there be a disconnect switch at the *customer substation* very near the incoming high-voltage line.

The *tie breaker* must be located as close as possible to the *connection switch*. Like the *connection switch*, current transformers must be located on the supply side of the circuit breaker. This also applies to voltage transformers if the *customer substation* is supplied over two or more circuits normally operated in parallel.[12] Surge arresters, which must not be on the supply side of the *connection switch*, are the only other units that may be located between the *connection switch* and circuit breaker(s). For requirements regarding revenue metering equipment, refer to Section 5.8.

[12] If there is just one circuit or the circuits are not normally operated in parallel, voltage transformers may not be required or may be located on the load side of the high-voltage breakers.

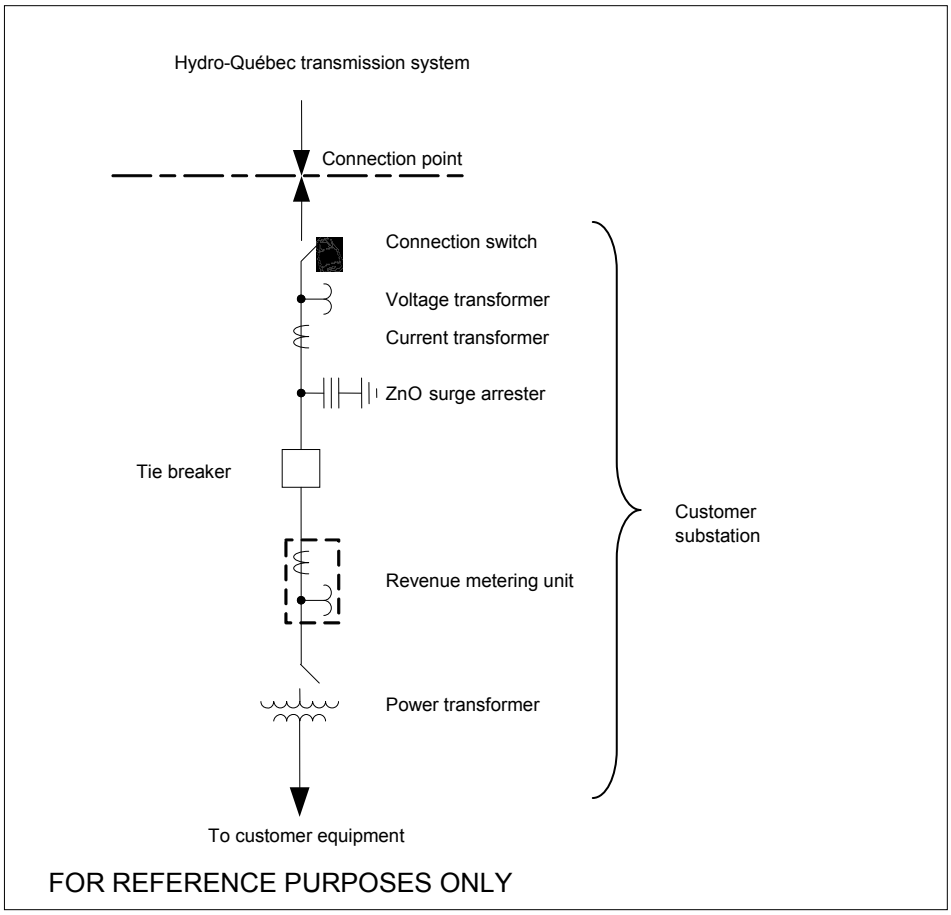

Figure 1: Position of equipment on the high-voltage side of the *customer substation* relative to the *connection point*

3.4. Connection options

If the *transmission system* so permits, one or more connection options enhancing the reference connection are possible at the *customer*'s explicit request. One such option is a connection with a second supply circuit as backup to minimize the risk of interruptions due to power failures or maintenance work, or to increase the steady-state short-circuit level.[13] Although a second circuit does not guarantee continuous supply and does not necessarily protect *customer facilities* from an interruption should an equipment outage or failure occur on the *transmission system*, it does reduce the probability that interruptions occur, particularly for maintenance. A *customer* for whom interruptions are critical is well advised to consider seriously the option of having a second supply circuit.

[13] The customer must consider that a circuit outage will lower the short-circuit power.

4. TECHNICAL INFORMATION AND STUDIES REQUIRED

This section explains the technical information and studies that a *customer* must provide during the various stages of the *Transmission Provider*'s project to connect the *customer facilities*. The *customer* must submit the technical information and studies requested so that the *Transmission Provider* can connect the *customer facilities* properly. Furthermore, technical studies carried out by the *customer* at the *Transmission Provider*'s request must be accepted by the latter in writing before the *customer facilities* are commissioned. Any late technical studies, or corrections thereto requested by the *Transmission Provider*, may delay connection of the *customer facilities*.

There are three main stages[14] of *Transmission Provider* work between initial studies and the commissioning of *customer facilities*: *planning study, facilities study* and connection project implementation.

At the end of the *planning study* or during the *facilities study*, the *Transmission Provider* will supply all power system electrical data needed for *customer* studies, e.g., short-circuit levels, system operating conditions and harmonic impedance loci at the *connection point*. It will also supply all details required, particularly regarding the *nomenclature* of *customer substation* high-voltage equipment, the list of signals required for system control, and, if needed, the neutral reactor requirements of transformers and the list of *certified relays*.

Table 1 at the end of Section 4 summarizes the technical information and studies a *customer* must submit.

4.1. *Customer* input for the *planning study*

The *planning study* determines the best solution for the reference connection and for any connection options requested by the *customer*. It includes a proposed *connection point* and indicates any specific requirement that may apply to *customer facilities*. It also determines whether the *customer facilities* are part of the *bulk power system*.

To carry out its *planning study*, the *Transmission Provider* must first receive from the *customer* the technical information listed in **Appendix A, Part 1**. The *customer* also describes any specific requirements it might have, and indicates whether it plans to generate electricity within its *facilities*.

[14] Ignoring exploratory studies (not covered in this document), which provides a cursory examination of ways to supply various *customer facilities*.

4.2. *Customer* input for the *facilities study*

The *facilities study* is undertaken once the *customer* decides to proceed with the connection. It fleshes out the project's technical content, and sets more precisely the project duration (with schedule) and project costs. It also includes environmental studies needed to obtain the required government permits. The *Transmission Provider* will produce additional requirements stemming from the *facilities studies*.

To carry out its *facilities study*, the *Transmission Provider* must first receive from the *customer* the information requested in **Appendix A, Part 2**. At that time, the *declared power* and *connection point* will have been determined. If major modifications to *transmission system* protection systems are anticipated, the *Transmission Provider* can ask the *customer* to submit at this stage for approval a preliminary study of protection systems that covers the information specified in **Appendix B**.

Certain requirements regarding studies that the *customer* must submit are worked out following an agreed schedule that accounts for the steps in *customer* studies for its own *facilities*. These are described below.

(1) A study demonstrating that disturbances comply with *emission limits* (see Section 6.3) for harmonics, load imbalance, rapid voltage changes, flicker or other *emission limits* specified for a given *customer facility*. The *customer* that meets the simplified assessment criteria set out in the document *Emission Limits for Customer Facilities Connected to the Hydro-Québec Transmission System*[15], must confirm this in writing to the *Transmission Provider*, specifying the total power of disturbance-producing equipment. The *customer* that doesn't meet these criteria and whose *facilities* are subject to the *emission limits* must submit for approval by the *Transmission Provider* an emission study conducted by an engineer following the assessment methods and application steps described in the document (see footnote 15) in order to demonstrate that its *facilities* are designed to meet allowable *emission limits*. The study must mention any operating restrictions required for the *customer* to comply with *emission limits*. The *customer facilities* must comply with limits and operating restrictions in order to be connected to the grid.

[15] These requirements are set out in the following document (and later amendments): *Emission Limits for Customer Facilities Connected to the Hydro-Québec Transmission System*, Hydro-Québec TransÉnergie, Direction – Planification des actifs, December 2008, available at: www.hydroquebec.com/transenergie/fr/commerce/pdf/limites_emission_en.pdf

(2) The *customer* must submit to the *Transmission Provider* the above-mentioned protection study (meeting Appendix B criteria) before proceeding with its own substation project.

4.3. *Customer* input for project implementation

Project implementation runs from the start of the actual work to connect the *customer facilities* to their commissioning.

The required commissioning date for the *customer facilities* must be confirmed for the *Transmission Provider* to implement the connection project. Two months prior to the commissioning date, the *customer* must submit to the *Transmission Provider* the final protection report for its *facilities* mentioned in Section 4.2. The report must include the final settings of protections in the *customer facilities*. The *customer* must also have approval for the *connection switch* it selected. Lastly, before connecting the *customer facilities*, the *Transmission Provider*, *Distributor* and *customer* must sign an operating agreement based on common operating instructions drafted by the *Transmission Provider* and governing such matters as operating modes and communications between the *Transmission Provider* and the *customer*.

Note in closing that the *customer* must also submit the equipment testing reports[16] agreed to with the *Transmission Provider* in order to demonstrate that its *facilities* meet the requirements herein and comply with *emission limits*. It must also submit for approval the commissioning procedure for its *customer substation*.

If *customer* studies meet requirements (protection systems and *emission limits*), the *Transmission Provider* signifies its acceptance in writing so the *customer substation* can be connected and commissioned.

4.4. *Customer* input after *facility* commissioning

The *customer* must confirm after its *facilities* have been commissioned that protection study settings have been applied. Hydro-Québec may further require the *customer* to measure emissions using procedures accepted by the *Transmission Provider*. Such measurements in no way replace, however, the emission study required prior to connection or prior to adding disturbance-producing equipment (see Section 4.2 and the document entitled *Emission Limits*

[16] Such tests may measure the electrical characteristics of equipment given in Appendix B, breaker trip sequences and timing, adjustment curves and protection systems.

for Customer Facilities Connected to the Hydro-Québec Transmission System). Hydro-Québec may also ask a *customer* who is part of the *bulk power system* to make dynamic measurements for event recording.

Table 1: Summary of information and studies to be submitted

STAGES OF *TRANSMISSION PROVIDER* WORK		TECHNICAL INFORMATION AND STUDIES TO BE SUBMITTED BY THE *CUSTOMER*	INFORMATION TO BE SUPPLIED BY THE *TRANSMISSION PROVIDER*
Planning study	• At start	• Technical information in Appendix A, Part 1	• Opinion on information received
	• At end		• Connection solution and proposed *connection point* • Whether substation is part of *bulk power system* (5.4) • Any and all specific requirements (5.2, 5.3, 5.7, 5.8, 6.3, 6.4, 8.1 and 8.3.3)
Facilities study	• At start	• Acceptance of connection solution and *connection point* • *Declared power* (forecast) • Technical information in Appendix A, Part 2	
	• During study	• Declaration of compliance with simplified assessment criteria for *emission limits* • Emission study for *customer facilities* (see note) • Get approval of *connection switch* (7.2.1)	• Additional requirements, if any • Technical information requested by *customer* – system short-circuit levels, operating conditions, harmonic impedance loci, transformer neutral impedance (7.1, see note) • List of required signals (9.3) • List of *certified relays* (8.4.2) • *Nomenclature* of equipment connected to HV line (9.2) • Opinion on emission study (see note)
Project implementation	• At least two months before commission-ing (or at a date agreed to by the *Transmission Provider*)	• Final protection study • *Customer* protection settings • Signed operating agreement (9.2) • Remote indication tests (9.3) • Switchgear and protection system test report	• Draft common operating instructions for operating agreement to be signed • Specify test report requirements • Opinion on protection study • Approval of commissioning procedure • Approval to proceed with connection
	• 1 month after commission-ing	• Settings as applied • On special request, emission measurements or dynamic measurements for event recording (4.2 and 5.4)	

N.B. *This table provides only summary information. It is necessary to refer to the text of this document and to that of the document "Emission Limits for Customer Facilities Connected to the Hydro-Québec Transmission System".*

PART III – TECHNICAL REQUIREMENTS FOR *CUSTOMER FACILITIES*

5. GENERAL REQUIREMENTS

5.1. Basic principles

The requirements in this document are intended to ensure that the *transmission system* functions properly and that the *Transmission Provider* honors contract commitments. They are based on the following three principles:

- All *customers* connected to the Hydro-Québec *transmission system* must be assured high-quality, reliable service, including *transmission system* stability.
- Hydro-Québec power system equipment must be protected.
- The safety of Hydro-Québec employees must be assured.

It is the *customer*'s responsibility to consider any other technical specifications or requirements needed for it own *facilities*.

5.2. General requirements for *customer facilities*

The design, construction and operation of *customer facilities* must comply with the laws, codes, standards and regulations applicable in Québec in addition to meeting the requirements in this document. For the safety of Hydro-Québec employees and any third party called upon to work on *customer facilities*, buildings and access to *facilities* must comply with safety rules, standards and regulations.

5.3. Requirements for major loads

When the *declared power* is 900 MW or higher, the *Transmission Provider* will set down specific requirements for the design and operation of *customer facilities*. Such requirements are warranted to limit excessive voltage and frequency deviations under single-contingency conditions at *customer facilities* or on the system connecting them.

5.4. Requirements for the *bulk power system*

Since Hydro-Québec is a member of *NPCC*, part of its *transmission system* is defined as being a *bulk power system*. Some *customer facilities* may also be part of the *bulk power system* as defined in Section 2. The *Transmission Provider* will determine whether this is the case during its *planning study*.[17] *Customer facilities* belonging to the *bulk power system* must comply with specific requirements for that system laid down in *NERC* and *NPCC* criteria and guidelines. Those requirements cover the design, operation and maintenance of protection, automatic control and telecommunication systems (for some of these, see Section 8.3.3).[18] Under the requirements, the *Transmission Provider* may further require that a *customer facility* belonging to the *bulk power system* be equipped with event recorders, fault recorders or any other instrument needed to analyze disturbances or events (faults) on the *transmission system* or on *facilities* connected to it. Information thus recorded helps both to determine the performance of the power system and facilities connected to it, and to analyze the nature and causes of faults and disturbances.

5.5. *Transmission Provider* access to *customer facilities*

The *customer* must give the *Transmission Provider* (or any company leasing telecommunication links to the *Transmission Provider*) full access privileges during regular hours or as otherwise agreed, so it can install, maintain, repair and operate its equipment located on the *customer*'s premises, or to check or inspect *customer facilities* to see that protection systems and equipment needed to meet *Transmission Provider* requirements are working properly. The *Transmission Provider* must have access at all times to the *connection switch* in particular so it can disconnect the *customer facilities* for system operation purposes.

If it is a matter of personal safety or *transmission system* security, or when *transmission system* or telecommunication link failures occur, the *customer* must give the *Transmission Provider* (or the company leasing telecommunication links to the *Transmission Provider*) access to its *facilities* with no further ado.

[17] *Customer facilities* not connected to lines supplied directly from a *bulk power system* substation are unlikely to be part of that system. Most *bulk power system* substations now listed operate at 735 kV.

[18] *NPCC* documents are found at www.npcc.org/CriteriaGuidesProcedures.asp.

5.6. Property rights and line clearances

The *customer* must assign to the *Transmission Provider*, free of charge, real rights on its property for the *Transmission Provider*'s line supplying the *customer facilities*. It must also conform to the clearances for the line in accordance with *Transmission Provider* standards.

5.7. Requirements for modifications to *customer facilities*

The *customer* must notify Hydro-Québec in writing when its *facilities* are modified under any of the situations described in Section 1.2, and provide the information in Appendix A and B that must be changed.

The *customer* load must not exceed the *declared power* without the *Transmission Provider*'s written consent.

5.8. Requirements for *customer substations* facing a change in system voltage

The *Transmission Provider* may require that *customer facilities* be designed to account for an anticipated change in the voltage of the power system supplying the *facilities*. For instance, it may request (1) that transformers operate adequately at both voltage levels, or (2) that the substation and high-voltage equipment be insulated for the higher voltage. Any applicable requirements are specified at the *planning study* stage.

If the *Transmission Provider* is to change the voltage of the system serving existing *customer facilities*, *Distributor customers* will take the measures possible to facilitate the change. The *customer substation* will have to be modified to support the new voltage.

5.9. Requirements for revenue metering[19]

Metering on *customer facilities* for billing purposes must be implemented in compliance with *Distributor*-specific metering standards. Revenue metering equipment must always be located between the high-voltage circuit breaker and transformers. If that is not feasible, the most appropriate location must be determined with the *Transmission Provider*.

It is essential that, between the metering unit and other load-side equipment, the *customer substation* have a visible disconnection point that can be locked out for safe maintenance of metering equipment.

6. VOLTAGE-RELATED REQUIREMENTS

6.1. Power factor of the *customer* load

The *customer* load at the *connection point* must have a power factor of 95% or higher for large-power *customers* and 90% or higher for medium- and small-power *customers*.[20] When the power factor is usually below these percentages, the *customer* must, at Hydro-Québec's written request, install corrective equipment while avoiding that the corrected power factor becomes capacitive. The *Transmission Provider* may, however, agree to a capacitive power factor in specific situations as long as problems on the grid are not an issue.

Compensation equipment used to correct the power factor of the *customer* load must be designed, installed and operated so as to avoid disturbances on the *Transmission Provider*'s system. It must be possible to disconnect such equipment, in whole or in part, at the request of Hydro-Québec or depending on changes in *customer* power consumption.

[19] If a *municipal system* or *electricity cooperative* requires point-to-point or network integration service, metering requirements will be specified by the *Transmission Provider*.

[20] See definition of *declared power*.

6.2. Immunity of *customer facilities*

Customer facilities must be designed and built to operate adequately without causing *transmission system* operating constraints. Note particularly that under regular operating conditions, the steady-state voltage may vary from the *nominal voltage* by ±6% on 44 kV to 49.2 kV *transmission systems* and by ±10% on 69 kV to 315 kV systems.

Under degraded operating conditions or emergency situations, the system may be operated for some time outside the ranges above. It is the *customer*'s responsibility to protect itself from the consequences of any power supply interruption and to protect its *facilities* and equipment from voltage variations or loss, phase loss, frequency variations and accidental grounds.

The document entitled *Characteristics and target values of the voltage supplied by Hydro-Québec transmission system*,[21] or any later version, overviews for information purposes the various types of disturbances to which the grid is subject. The *customer* is responsible for ensuring that its equipment has adequate protection and immunity to minimize potential impacts of power quality disturbances such as voltage dips, momentary interruptions, transients, imbalances, harmonics, frequency variations and rapid voltage changes. The purpose of the document referred to above is to make *customers* aware of various phenomena that may affect power quality and to encourage them to design, protect and operate their *facilities* in a way the ensures that their equipment is compatible with the power supply under such conditions.

6.3. *Emission limits*

Emission limits are intended to constrain power quality disturbances produced by *customer facilities* to avoid causing disturbances on the *transmission system* and impairing the power supply to other *customers*. Limits apply to such common disturbances as harmonics, load imbalance, rapid voltage changes and flicker. If required, other types of disturbances, e.g., interharmonics, subharmonics, harmonics above 3 kHz or repetitive bursts of harmonic currents, may be subject to specific *emission limits* during *customer facility* planning, connection or modification studies.

[21] *Characteristics and target values of the voltage supplied by Hydro-Québec transmission system*, TransÉnergie, Direction – Planification et développement des actifs, 2001 (www.hydroquebec.com/transenergie/en/publications/pdf/cib_tesec.pdf).

Customer facilities covered by Section 1.2 must be designed and operated to meet the allowable *emission limits* for disturbances, which are given in the document entitled *Emission Limits for Customer Facilities Connected to the Hydro-Québec Transmission System*.[22] When its *facilities* are designed, or *facility* characteristics or operation are modified, the *customer* must demonstrate by appropriate studies that they are designed to meet the *emission limits* in force (see Section 4.2 and footnote).

6.4. Additional requirements for power quality

Since the characteristics of equipment, uses of electricity and possible technology trends are so diverse, the *Transmission Provider* may specify additional power quality requirements that *customer facilities* must meet in order to maintain adequate service quality and stay within *emission limits* for disturbances. Without restricting this general principle, such requirements will be specified based on the type of disturbing load, how *customer facilities* are connected and the characteristics of the part of the grid to which they are connected. Particular care must be taken, for instance, when *customer facilities* drawing relatively high power are connected at a point where system short-circuit level is relatively low. As mentioned earlier, if required, other types of disturbances, e.g., interharmonics, subharmonics, harmonics above 3 kHz or repetitive bursts of harmonic currents, may be subject to specific *emission limits* during *customer facility* planning, connection or modification studies.

[22] These requirements are set out in the following document (and later amendments): *Emission Limits for Customer Facilities Connected to the Hydro-Québec Transmission System*, Hydro-Québec TransÉnergie, Direction – Planification des actifs, December 2008, available at: www.hydroquebec.com/transenergie/fr/commerce/pdf/limites_emission_en.pdf.

7. EQUIPMENT-RELATED REQUIREMENTS

Following standards and industry practices, the *customer* must conduct engineering studies, particularly short-circuit and insulation coordination studies for its *facilities* to be connected to the *transmission system* in order to determine fully the characteristics of its equipment. The requirements below are strictly from a *transmission system* standpoint.

7.1. Grounding connection

The grounding connection is the way the neutral point of an equipment unit or *customer facility* is electrically connected to ground.

7.1.1. *Transmission system* grounding connection

Most of the 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 the system
X_0 = zero-sequence reactance of the system
R_0 = zero-sequence resistance of the system

Parts of the 69 kV or lower *transmission system* exist, however, where the neutral is not effectively grounded under normal conditions. The zero-sequence impedance is then clearly higher than for the criteria above.

The characteristics of the *transmission system* grounding connection can affect ground fault levels, the interrupting capacity of circuit breakers, overvoltages and equipment insulation levels, surge arrestor characteristics, the type of connection of transformer windings, protection system characteristics and settings, etc. *Customer facilities* must thus be of adequate design and compatible with the characteristics of the *transmission system* grounding connection under both normal and fault conditions.

The requirements in Section 7.1.2 and 7.1.3 are intended to limit any temporary overvoltage arising when *transmission system* circuit breakers open first to clear a ground fault on the part of the system to which the *customer facilities* are connected.

7.1.2. Connection of *customer facilities* to an effectively grounded *transmission system*

If the neutral point on the *transmission system* is effectively grounded under normal conditions and the *customer facilities* include motors that can temporarily maintain a voltage on the system and cause undue constraints (after grid circuit breakers open and the normal power supply is lost), then the grounding connection on the *customer substation* must be effectively grounded as seen from the high-voltage side. The *Transmission Provider* will analyze such constraints during the *planning study*.

To meet this requirement, the neutral of *customer substation* power transformer primary windings must be grounded or a grounding transformer must be inserted on the high-voltage side. Furthermore, the impedance of such transformers and winding connections must be such that the *customer facilities* themselves meet the criteria for effective grounding:

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

where:

X_1 = positive-sequence reactance of the *customer facilities* seen from the high-voltage side
X_0 = zero-sequence reactance of the *customer facilities* seen from the high-voltage side
R_0 = zero-sequence resistance of the *customer facilities* seen from the high-voltage side

If the motors are connected to the *transmission system* through existing *customer facilities*, the grounding connection criteria above still apply. The following means may then be used to meet those requirements:

- Adding grounding transformer(s) on the high-voltage side of the *customer substation*
- Modifying the connection type of existing transformer windings in the *customer substation* (i.e., YNd- or YNynd-connected windings)
- Taking into account the effect on the grounding connection of other transformers connected to the same transmission line
- Adding a *customer facility remote tripping* system if grid characteristics so permit without overly degrading service to other *customers*

Depending on the characteristics of the *transmission system* near the *connection point*, it may also be necessary to add an reactor on the high-voltage side between the neutral of each transformer and ground to limit the contribution of *customer facilities* to zero-sequence current for *transmission system* faults. If such a neutral reactor is required, the *Transmission Provider* will determine its value at the time of the *facilities study* based on the criteria above.

7.1.3. Connection of *customer facilities* to a non-effectively grounded *transmission system*

Customer facilities connected to a portion of the *transmission system* where the neutral is not effectively grounded under normal conditions must be designed to avoid contributing more than 400 A to the single-phase fault current on that part of system. Depending on system conditions, a higher contribution to the fault current may be agreed upon between the *customer* and the *Transmission Provider*.

A grounding transformer of appropriate impedance will also generally be 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.

7.2. General electrical characteristics of equipment

The electrical characteristics of equipment forming the *customer facilities* must be compatible with those of the *transmission system* to which those *facilities* are connected, especially regarding insulation coordination.

Table 2 gives present standard values for insulation and short-circuit levels on the *transmission system*. In designing its *facilities*, the *customer* must check with the *Transmission Provider* to confirm the electrical characteristics that apply to the portion of the *transmission system* to which its *facilities* are to be connected.

A *customer* installing equipment with a interrupting capacity or short-circuit rating below the *Transmission Provider*'s standard short-circuit levels must pay to replace such equipment if the capacity or rating becomes too low as the *transmission system* evolves.

Table 2: Standard insulation and short-circuit levels for Hydro-Québec *transmission system* equipment

***Nominal voltage* of system** [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 [4-6]	460	31.5 and 50 [5]

Notes:
1. Levels have not been standardized for 44-, 49.2- and 345-kV systems and must be confirmed on a case-by-case basis.
2. Other requirements also apply to circuit-opening devices like circuit breakers and disconnects, whose terminal-to-terminal insulation must be higher than the ground insulation level.
3. The X/R ratio used for these voltage levels is 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 level depends on the specific characteristics of the particular system.
6. The switching impulse withstand voltage is 850 kV peak-to-peak.

7.2.1. *Connection switches* (disconnecting switches) [23]

To ensure the safety of Hydro-Québec employees during work on the *transmission system*, *customer facilities* must be equipped with a *connection switch* (disconnect switch) on each supply circuit to isolate the *customer facilities* from the *transmission system*. It must be possible to lock out the disconnect switch in the open position. If the blades open upwards, they must form an angle greater than 90° in the open position. The disconnect switch must provide a visible disconnection point and be accessible to the *Transmission Provider*. For motorized disconnect switches, it must be possible to disable and lock out the drive control mechanism. The *customer* must provide the specifications for the disconnect switch so that the *Transmission Provider* can verify that they comply with safety requirements in effect at the time the *facility* is connected. The selected *connection switch* must allow for applying the safety measures described in the Hydro-Québec "Work Safety Code".

In no instance may the *connection switch* be coupled to a supply-side grounding switch that grounds automatically when the *connection switch* opens.

[23] See also Section 5.8.

7.2.2. Circuit breakers [24]

Circuit breakers must have adequate insulation withstand and interrupting capacity (transient recovery voltage [TRV], recovery voltage [RV], short-term withstand current, short-circuit interrupting capacity, etc.) to interrupt any kind of fault on the *customer facilities* or on any part of the *transmission system* to which those *facilities* are connected. Particular care must be taken regarding TRV and RV to ensure that the circuit breakers have the required interrupting capacity.

It must be possible for *customer facility tie breakers* to perform an O-C-O (open-close-open) cycle for eight hours with no power from the grid in the event of a prolonged power system failure.

If the *tie breakers* have built-in detectors for faulty internal states (e.g., SF6 density too low) that can force the circuit breakers to close or disable their normal functioning (e.g., locking their state), the *customer* is responsible for acting as quickly as possible to remove the circuit breakers in question from operation to avoid possible damage to its *facilities* and undue disturbances on the *transmission system*. The *customer* must submit for approval to the *Transmission Provider* an action plan detailing the measures it intends to take.

7.2.3. Surge arresters on the high-voltage side of the *customer substation*

Surge arresters must be appropriately rated for the overvoltage constraints on the *transmission system* and on the *facilities* to which they are connected. If the *customer substation* has high-voltage surge arresters, they must be of the zinc oxide type with no spark gap and must not be located on the supply side of the *connection switch* so that they can be isolated from the *transmission system*.

7.2.4. Power transformers

Given the voltage-related requirements (Section 6.2) and more specifically possible steady-state voltage variations, 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 to load level and *transmission system* voltage conditions and to avoid hindering present and future grid operation. Power quality characteristics of the supply (Section 6.2) describe the electrical environment on the *transmission system* under normal operating conditions.

[24] See also Section 8.2.

Winding connections of *customer facility* power transformers must meet the requirements in Section 7.1.2 or 7.1.3, as applicable.

7.2.5. Tie line

In order for the *transmission system* to remain reliable and secure, and offer high-quality service, any *customer*-built tie line to connect *facilities* to the grid must have electrical and mechanical characteristics equivalent to those of a line that the *Transmission Provider* would build for a comparable project. The *customer* must therefore design and build its line in accordance with the technical specifications, environmental criteria and specific requirements given to it by the *Transmission Provider*.

7.2.6. Interlock device for two or more supplies

If the *customer facilities* can be supplied from more than one (high- medium- or low-voltage) source or any other generating resource, the *Transmission Provider* may require that interlock devices be installed to prevent parallelism in the cases mentioned in Section 9.2.

8. PROTECTION SYSTEM REQUIREMENTS

8.1. General requirements

Any *customer* that is or will be connected to the *transmission system* is responsible for protecting its equipment. A *customer* is responsible for ensuring that it has a sufficient number of protection systems and that they perform functions adequately to protect its *facilities* from any fault or abnormal operating condition occurring either within its *facilities* or on the *transmission system*.

Customer facilities and the *transmission system* may interact to produce various phenomena on the *transmission system*, notably overvoltages. These may occur during switching operations or faults, for instance, or may arise from harmonic resonance, ferroresonance or (voltage or current) imbalances. The *customer* is responsible for designing its *facilities* so they are adequately protected from any overvoltage or other phenomena that the *transmission system* may produce or carry to its *facilities*, and from any specific constraint this entails. Furthermore, the *Transmission Provider* may specify requirements to the *customer* for adequately protecting the *transmission system* and third-party facilities from these phenomena.

The principles and requirements in this section are to protect the *transmission system* from harmful effects arising from any type of fault and to limit impacts to an acceptable level, whether the faults originate in the *customer facilities* or on the *transmission system* with the *customer substation* possibly contributing (for current and voltage). In both cases, the *customers* must procure and install protection systems on its *facilities* in addition to the equipment itself meeting certain requirements. Such systems and equipment may vary in number and quality depending on whether they are for protection from a fault in the *customer facilities* or from a fault on the *transmission system*. This section gives distinct references for each of these two cases.

The requirements set out here are general rules needed to connect *customer facilities*. Other specific requirements based on the general requirements or on the *customer*'s particular situation may be added at the time of the *planning study* or *facilities study*.

8.2. Circuit breaker vs. fuse protection

As a general rule, *customer facilities* must be equipped with at least one high-voltage circuit breaker to adequately clear the various types of faults.

This rule can only be relaxed for *customer facilities* connected over a single circuit to a portion of the *transmission system* at a voltage of 69 kV or less. The combined action of fault detection and clearing may then be achieved using fuses at the *customer substation* provided the fuses are coordinated with *transmission system* protection. That requirement is met when the ratio of short-circuit current to fuse rating is at least 100. It must also be possible to maintain and replace fuses without creating undue constraints on *transmission system* operation.

Prior approval from the *Transmission Provider* must be obtained to protect *customer facilities* with fuses.

8.3. Performance requirements for *customer facility* protection systems

This section specifies what protections must be implemented in *customer facilities* for *transmission system* requirements and the performance requirements they must meet.

8.3.1. Protection from *customer facility* faults

The *customer substation* must be equipped with a protection system that can quickly and reliably detect and clear any type of fault on the *customer facilities*. Such systems must be compatible and coordinated with those used by the *Transmission Provider* at the source substation. It is up to the *customer* to select protective relays that ensure secure and selective coverage for its facilities.

As part of the *facilities study*, the *Transmission Provider* establishes the required performance of protection systems for components in the high-voltage portion of the *customer substation*. This includes power transformer protections. These requirements cover the maximum fault-clearing time and the degree of functional redundancy of systems protecting those components.

8.3.2. 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 a number of circuits normally operated in parallel, the requirements below apply.

The *customer substation* must be equipped with protections to detect faults on the *transmission system* and clear the fault contribution using circuit breakers. The protections may vary depending on the characteristics of the *transmission system* to which the *customer facilities* are connected. They must quickly, reliably, selectively and safely remove the fault contribution carried through the *customer facilities*.

At 69 kV or higher, protections against faults on the *transmission system* must be redundant, i.e., comprised of two primary protections implemented using two distinct relays each with a trip relay.

Primary protections are comprised of relays with the specific functions and settings below.

- 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 faults, the fault resistance used must be $Rf = 10\ \Omega$, i.e., a zero-sequence component of $3Rf = 30\ \Omega$.
- *Tripping* must not be intentionally delayed. Action is thus taken as quickly as possible and must meet *transmission system* speed requirements.
- Protection must be selective. Primary protection must be coordinated with the protection zone of other components.

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

Breaker failure protection

If the *customer substation* is supplied over more than one circuit normally operated in parallel, the *Transmission Provider* requires breaker failure protection that trips the circuit breakers in adjacent zones when a circuit breaker refuses to trip.

When rapid *tripping* is needed to meet *transmission system* requirements, breaker failure protection is required at the *customer substation* to ensure *remote tripping* of circuit breakers at the source substations serving the *customer substation*.

***Reclosing* of circuit breakers by line protections**

If the *customer substation* is supplied over more than one circuit normally operated in parallel and has line protections, automatic *reclosing* of circuit breakers in the high-voltage portion of that substation is prohibited regardless of whether the faults originate in the *customer facilities* or on the *transmission system*. This requirement may, however, be waived after the protection is reviewed by the *Transmission Provider* during the *facilities study*.

8.3.3. Protection under other situations

Islanding of motor loads on other substations

In some cases, protections may be required to prevent islanding of motor loads on the load of neighboring substations (another *customer substation* or a *transmission system* substation). The choice of protections and ranges for settings will be specified during the *facilities study* based on motor load characteristics.

Remote tripping

Remote tripping of the *customer substation* from the source substation(s) may be required in the cases below.

- **Short *reclosing* time**

  If, for *transmission system* purposes, the *reclosing* time of the line(s) to the source substation(s) must be set to less than 2 seconds and the *customer* has a motor load that is sensitive to rapid *reclosing*.

- **Self-excitation**

  If self-excitation may occur, as when islanding of a motor load is possible in *customer facilities* with a capacitive load, such as a capacitor bank, filter, unloaded line or cable.

Requirements for *customer facilities* forming part of the *bulk power system*

If the *Transmission Provider* determines that the *customer facilities* are part of the *bulk power system*, equipment must be protected by two independent protection systems in compliance with the standards and requirements in *NPCC* Document A-5, *Bulk Power System Protection Criteria*, or any later version thereof. Furthermore, periodic maintenance of the protection systems must be carried out in compliance with the standards and requirements in *NPCC* Document A-4, *Maintenance Criteria for Bulk Power System Protection*, or any later version thereof.

Details on design, installation and maintenance requirements for independent protection systems will be given at the time of the *facilities study*.

8.4. Design requirements for *customer facility* protection equipment

This section describes the minimum design requirements that protection equipment at *customer facilities* must meet for *transmission system* needs.

8.4.1. Protection system settings

The control and protection schematic, protection coordination study and protection system settings proposed by the *customer* must be submitted to the *Transmission Provider* for approval. The *customer* may not modify settings without the *Transmission Provider*'s written consent but must calibrate protective devices initially and verify them regularly. The *Transmission Provider* may, at any reasonable time and without prior notice, check that these devices are compliant.

8.4.2. Equipment required for *transmission system* faults

If the *customer substation* is supplied by a number of circuits normally operated in parallel, the requirements below apply. Their purpose is to protect the *transmission system* from a *customer facility* fault contribution during faults on the *transmission system*.

Protective devices and disconnects

Only *certified relays* may be used as protection and *tripping* relays in systems to protect against *transmission system* faults. The *Transmission Provider* may, however, accept relays with certification pending for a specific project if it considers this is warranted.

Protection system power supply

The *customer substation* protection systems for *transmission system* faults must remain functional during an auxiliary power supply failure. Such protection systems must thus be powered from a storage battery, which must have two chargers that can either run in parallel with the battery or back up each other. Battery backup time must be at least eight hours.

Voltage and current transformers

The Transmission *Provider* requires that current and voltage transformers be installed on all three phases supplying the protection systems required for *transmission system* faults. The transformers must have separate secondary windings in order to supply separately the two primary protection systems. They must also be designed to a degree of precision acceptable to the *Transmission Provider*. They must be located on the high-voltage side of the *customer substation*.

8.5. Requirements for telecommunication systems

Telecommunication systems convey both teleprotection signals needed for grid protection and operation signals needed for grid control. If a telecommunication link is required, it is the *Transmission Provider* that determines the solution, taking into account the needs to meet, reliability required and service continuity targeted for the *transmission system*. It is also the *Transmission Provider*, or any agent leasing telecommunication links to it, that supplies, installs and maintains the required telecommunication links and equipment up to the *telecommunications junction point* (see Figure 2).

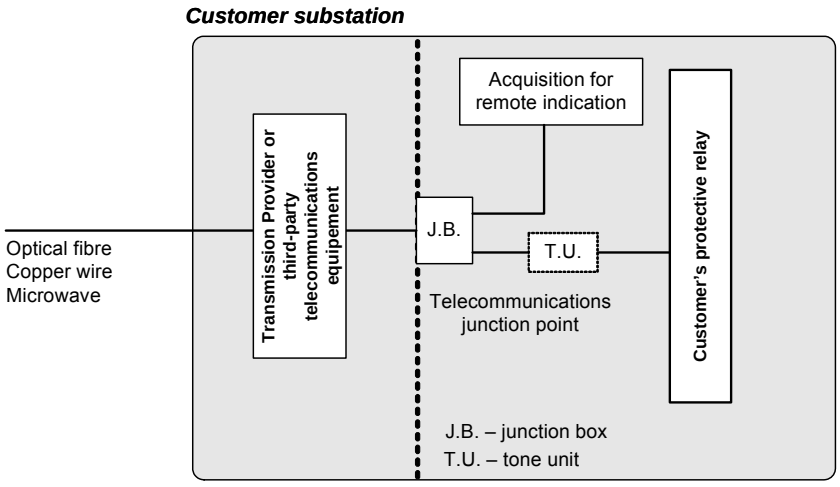

Figure 2: Position of *customer substation* devices relative to the *telecommunications junction point*

The *customer* must provide adequate safe space near the relays required for protection so that the *Transmission Provider* or its agent can install the telecommunications equipment and appropriate (AC) power sources.

9. OPERATION AND MAINTENANCE REQUIREMENTS

9.1. Maintenance requirements for *customer facilities*

Following all existing standards, industry practices and equipment manufacturer requirements, the *customer* must ensure maintenance of equipment from the *connection point* up to and including the high-voltage circuit breakers so it does not degrade the reliability of or place undue constraints on the operation of the *transmission system*, and so it allows safety measures to be applied for Hydro-Québec (or third-party) workers. The equipment to which this requirement applies includes, but is not limited to, any high-voltage line, disconnect switches, insulators, metering equipment, surge arresters, fuses, high-voltage circuit breakers and protection systems impacting the *transmission system*.

The *customer* must have a means of informing the *Transmission Provider* of maintenance performed on the equipment above.

9.2. Operation requirements

The *customer* must comply with the operating agreement signed before being connected, which includes the common operating instructions drafted by the *Transmission Provider*. That agreement governs such matters as communication methods and supply conditions for the *customer facilities*. The *customer* must not, for instance, modify the operating mode of the *customer substation* without *Transmission Provider* approval. The *customer* must also have staff with a thorough knowledge of Hydro-Québec's operating code and the terms and methods used by Hydro-Québec in applying safety measures.[25]

High-voltage equipment in the *customer facilities* must use the *Transmission Provider*'s *nomenclature*, which will be given at the time of the *facilities study*.

The *customer* must bear in mind that the *Transmission Provider* may interrupt the electricity supply for the purpose of maintenance, repairs or modification, and may do so at any time for reasons of public necessity, public safety or grid management.

[25] The *Transmission Provider* will give the *customer* any pertinent information regarding these matters.

If the *customer facilities* are served by more than one circuit, electricity must be used following load splitting assigned by the *Transmission Provider*. Load splitting will be determined to reconcile, to the extent possible, needs expressed by the *customer* with those of the *transmission system*.

If the *customer facilities* can be supplied from more than one (high- medium- or low-voltage) source or any other generating resource, the *Transmission Provider* requires that the *customer* obtain its prior approval before performing any parallelism operation. Any such operation that is a hazard for Hydro-Québec workers, third-party workers or equipment is prohibited and the requirement under Section 7.2.6 shall apply.

9.3. Data required for *transmission system* operation

In order to operate the *transmission system* efficiently, the *Transmission Provider* may require that real-time data in a form compatible with its equipment be sent directly from *customer facilities*. The data required will vary, depending on the *customer facility* load and on the portion of the grid to which it is connected, and is determined based on Hydro-Québec standard operating requirements in effect at the time the *customer facilities* are connected. Data requirements are listed in Appendix C for information purposes.

The telecommunication circuits needed for operation signals are implemented following the method described in Section 8.5.

The *customer* must equip its *facilities* with all sensors needed to transmit the required data to the *Transmission Provider*. At the request of the *Transmission Provider*, the *customer* must take part in tests two months before the *customer facilities* are commissioned, or at a date agreed upon with the *Transmission Provider*, to check that remote indication is working properly.

APPENDICES

Appendix A: Technical Information Required for *Transmission Provider* Studies

Part 1 – Information required for the planning study

1 Scheduled commissioning date

Date of initial energizing of transmission line (if before commissioning date)

Date of *customer facility* commissioning

2 Drawing of *customer facility* location

3 Power requirements anticipated by *customer*

- Short-term power requirements anticipated by *customer*, and medium- and long-term forecasts
- Anticipated power factor
- Load factor and typical annual consumption pattern for type of load
- Type of load (for representation in grid simulations):
  - aluminum smelter
  - pulp & paper mill
  - steel plant
  - other

4 Proposed single-line diagram of *customer facilities*

Schematic diagram showing preliminary proposal for position of power transformers, switchgear and its operating mode (NO/NC), instrument transformers, surge arresters and circuit breakers.

Main characteristics of equipment on single-line diagram, including reactive compensation system.[26]

Number and power of largest synchronous and asynchronous motors with medium-voltage supply (including all 500 hp or higher motors).

Preliminary control and protection schematic, if available.

Statement as to whether *facilities* will include generation synchronized to grid.

[26] The *customer* may be asked for other information if dynamic studies of grid response are required.

5 *Customer*-specific needs

Spare line

Other

6 Main characteristics of equipment apt to produce disturbances on Hydro-Québec *transmission system*

Type of disturbance-producing process or equipment (arc furnaces, converters, etc.).

General characteristics of load (type of converter, pulse numbers, etc.)

Power of disturbance-producing equipment

Part 2 – Information required for the facilities study

7 Further details for items 1 to 6

8 Protection study with content as given in Appendix B

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

- *Connection switch*: type and specifications (requiring *Transmission Provider* approval)
- Power transformers:
  - number
  - rated power and voltage
  - positive- and zero-sequence impedances
  - winding resistance
  - coupling (i.e., winding connection)
  - number of taps and range of automatic regulation
  - exciting current (80%–110% of rated voltage)
- Grounding transformer
  - zero-sequence impedance
- High-voltage circuit breakers:
  - insulation levels
  - interrupting capacity
  - other characteristics rated in voltage and current

- Reactive compensation system
  - number of shunt capacitor banks or filters
  - rated power
  - rated voltage
- High-voltage surge arresters:
  - type
  - steady-state voltage (Uc)
  - nominal discharge current
  - protection characteristics

10 Tie line (rare case of customer-built line based on *Transmission Provider* standards)

- Confirm the following information:
  - 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)
  - ampacity

11 Dynamic characteristics of large motors (items to be confirmed by *Transmission Provider*, if needed)

- Number and power of motors connected to medium-voltage supply (> 100 hp)
- Synchronous motors:
  - type (smooth pole/salient pole)
  - damper winding (connection method)
  - rated power and voltage
  - rated power factor
  - unsaturated direct-axis synchronous reactance (Xd)
  - unsaturated quadrature-axis synchronous reactance (Xqi)
  - 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 (X1)
- negative-sequence reactance (X2)
- time constants T'do (and corresponding temperature in °C), T'qo, T"do and T"qo
- armature resistance, by phase (Ra) and corresponding temperature in °C
- stator forward resistance (R1) at 60 Hz and corresponding temperature in °C
- saturation curve of generators to calculate parameters and factors needed in saturation modeling (Sgu, Sgl, Eu and El)
- inertia constant H (of rotor and load driven)

- Excitation system :
  - Detailed model and associated parameters, referring to standard IEEE model (IEEE 421.5-1992 *Recommended Practice for Excitation System Models for Power System Stability Studies*) or to manufacturer-specific model
- Asynchronous motors:
  - rated power and voltage
  - power factor at 100%, 75% and 50% of rated power
  - stator leakage reactance (Xs)
  - stator resistance (Rs)
  - rotor leakage reactance (Xr)
  - rotor resistance (Rr)
  - magnetizing reactance (Xm)
  - locked rotor reactance (Xlr)
  - open-circuit reactance (Xo)
  - time constant T'do
  - inertia constant H (of rotor and load driven)
  - torque-slip curve
  - slip at rated power

Appendix B: Information Required in *Customer Facility* Protection System Studies

The *customer* must submit to the *Transmission Provider* a study of the protection systems in its *facilities*. The study, conducted by an engineer, must include the information listed in this Appendix. It will enable the *Transmission Provider* to determine whether the protection systems installed in the *customer substation* meet the requirements for protecting the *transmission system*. The protection study must include a control and protection schematic, protection coordination study and protection system settings.

Section 1: Introduction

- Brief description of site, project and nearby Hydro-Québec *transmission system*
- Distinctive project features (added protection, specific instructions, etc.)
- Future developments (additional power)

Section 2: Characteristics of *customer facilities*

- Single-line diagram of *customer facilities*
- Electrical characteristics of equipment and protection systems:
  - synchronous motors and excitation systems; asynchronous motors
  - transformers
  - circuit breakers
  - grounding transformer impedance or neutral reactor
  - protective relays
  - instrument transformers for protection
  - tie line

Section 3: Fault study

- Calculations for three-phase, two-phase, two-phase-to-ground, and single-phase-to-ground faults with and without fault impedance. For high-impedance faults, fault resistance must be Rf = 10 Ω and Z0 = 3Rf = 30 Ω.
  - at primary-side busbar of *customer substation*
  - at secondary-side busbar of *customer substation*
  - at bus(es) of associated Hydro-Québec substation(s)
  - on supply side of *tie breaker* (if far from *customer substation*)
- Fault calculations must include contribution of motors in *customer facilities*.

Section 4: Relay settings and coordination curves

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

Appendix C: Data Required by the *Transmission Provider* for *Transmission System* Operation

Table 3: Data from *customer facilities* for the Telecontrol Centre (TC) and System Control Centre (SCC)

	Data required[1]	
	Telecontrol centre (TC)	**System Control Centre (SCC)**
***Tie breaker*(s)**	**State**[2]	**State**[2] If connected to line under SCC responsibility
***Connection point* MW, Mvar, kV and A**	**Measurements**[2,3]	**Measurements**[2,3] If connected to line under SCC responsibility
Load shedding[4]	**Status signals, measurements and controls** To be specified, if applicable	**Status signals, measurements and controls** To be specified, if applicable
Acquisition unit	**State**[2]	**State**[2] If connected to line under SCC responsibility
Telephone link	[5]	[5]
Status signals and alarms	**State**[6]	**State**[6]

Notes:

1. Information for the SCC may go through a TC.
2. This data may not be required if the impact on the grid is considered negligible.
3. *Customers* with generation in addition to load must send generation data and load data in a way that allows them to be processed separately.
4. This refers to all load management measures implemented manually or automatically.
5. Link for contacting the operator of the *customer substation* 24/24 x 7/7 (directly without dialling, e-mail or voice mailbox).
6. 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*.