Hydro Québec
TransÉnergie

Transmission System Modeling Data Requirements and Reporting Procedures

In Accordance with NERC Reliability Standard MOD-032-1 “Data for Power System Modeling and Analysis”

Originator:	*Hydro-Québec TransÉnergie* *Direction Planification*
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Revision:	*4 (November 2020)*

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Revision History

Revision no.	Section	Revision Description	Date
0		• Original version	December 16, 2015
1	All sections	• General revision of document	April 15, 2016
2	1, 2.1, 2.2, 2.3.2, 3.1, 4.1, 5.1, 6.1.1, 6.2.1, 7.3, References, Appendices 1, 4 and 6	• Revised text • Added Revision History • Added Scope and Data Confidentiality sections • Modified list of functional entities • Revised requirements for modeling data for generation facilities, transmission equipment and demand • Added requirements for the modeling data needed to calculate DC currents during geomagnetic storms • Revised templates in Appendices 1, 4 and 6	March 30, 2017
3	All sections	• Corrected minor errors • Removed Subsections i and ii of Section 5.1.1 to prevent redundancy • Modification related to the concept of load aggregation (Section 5) • Removed reference to standard PRC-006-NPCC, which is not in effect in Québec (Section 5) • Corrected the e-mail address for sending data (Section 7) • Modified data submission dates to reflect current procedures (Section 7) • Added a provision for entities to request an extension to the data submission deadline (Section 7) • Added the GENTPJ dynamic generator model to the list of approved models (Appendix 2)	May 31, 2018
4		• Corrected minor errors • Removed section 2.3.3 • Modification regarding accepted dynamic models. User-defined models vs generic models.(section 3.1.2) • Removed information about bus numbering convention, these numbers being attributed by the PC (section 4.1.1) • Added precisions on impedances to be provided. Positive and negative sequence and mutual impedances in compliance with appendix 1 of the standard. (section 4.1.2) • Modified data submission schedule[1] (section 7.2)	November 2020

[1] In order to allow entities sufficient time to adapt their practice, for the first data submission exercise following the publication of the present document (2021 data submission), an entity may choose to submit their data according to the former schedule.

		• Removed provision for entities to request an extension to the data submission deadline. This provision was not in compliance with the standard. (section 7.3) • Removed redundant appendices • Modified list of accepted models (Appendix 1)	

1. Application

1.1 Objective

Hydro-Québec TransÉnergie (HQT), in its role as Planning Coordinator and Transmission Planner, is charged with the task of maintaining transmission system models (steady-state, dynamics, and short-circuit) and developing power flow and dynamics cases necessary to support planning studies and reliability analysis of Québec's interconnected transmission system. The accuracy of system models is heavily dependent on the reliability of modeling data collected from the various functional entities that interface with the transmission system.

The purpose of this document is to establish steady-state, dynamics, and short-circuit modeling data requirements and reporting procedures, in accordance with NERC's MOD-032 reliability standard, "Data for Power System Modeling and Analysis." The document shall serve as a reference guide to all functional entities that provide data necessary for system modeling, providing the basic requirements regarding the type of data required as well as applicable data submission procedures. It will also describe how entities shall reference and use existing HQT technical documents and procedures to meet modeling data requirements.

The most updated version of the present document shall be made available to all concerned functional entities by means of an online posting on HQT's website, via the following link:

http://www.hydroquebec.com/transenergie/en/modeling.html.

1.2 Scope

The data required by this document is determined by the reliability analyses performed by the Planning Coordinator (PC) or the Transmission Planner (TP). The following table presents the range of study types carried out and their associated NERC standards:

Table 1 – Study types carried out by the PC and TP that require modeling data

Standard	Standard name	Purpose or type of reliability study
FAC-002-2	Facility Interconnection Studies	Impacts of interconnecting new generation, transmission, or electricity end-user facilities.
FAC-013-2	Assessment of Transfer Capability for the Near-Term Transmission Planning Horizon	Assessment of the transfer capability to identify potential future weaknesses and limiting facilities that could impact the system's ability to reliably transfer energy.
FAC-014-2	Establish and Communicate System Operating Limits	Determine System Operating Limits (SOLs), including Interconnection Reliability Operating Limits (IROLs), for its planning area.
PRC-002-2	Disturbance Monitoring and Reporting	Identification of elements that are part of a stability (angular or voltage) related operating limit or in major

Standard	Standard name	Purpose or type of reliability study
		voltage sensitive areas. These elements will be equipped with dynamic disturbance recorders.
PRC-006-3	Automatic Underfrequency Load Shedding	Development and assessment of the Underfrequency Load Shedding Program (UFLS). Analysis of the UFLS program during underfrequency events.
PRC-006-NPCC-2	Automatic underfrequency load shedding	Development and assessment of the Underfrequency Load Shedding Program (UFLS).
PRC-010-2	Undervoltage Load Shedding	Development (as required) and periodic assessment of an undervoltage load shedding (UVLS) program. Analysis of the UVLS program during events causing undervoltage conditions.
PRC-023-3	Transmission Relay Loadability	Identification of circuits for which protective relay settings must be adjusted to prevent transmission system loadability limiting.
PRC-026-1	Relay Performance During Stable Power Swings	Identification of the generating units, transformers and transmission lines where an angular stability constraint exists.
TPL-001-4	Transmission System Planning Performance Requirements	Annual planning assessment: Documented evaluation of future Transmission System performance and Corrective Action Plans to remedy identified deficiencies.
TPL-007-4	Transmission System Planned Performance for Geomagnetic Disturbance Events	Periodic assessment of geomagnetic disturbance (GMD) vulnerability.

The system models prepared by the PC are also used by the Transmission Operator (TOP) and Balancing Authority (BA) in the system simulations explicitly required by some standards or implicitly required for the development of operating strategies and plans. The following table presents these reliability study types and their associated NERC standards:

Table 2 – Study types carried out by the TOP require modeling data

Standard	Standard name	Purpose or type of reliability study
EOP-005-3	System Restoration from Blackstart Resources	Steady state and dynamic simulations to validate the restoration plan.
FAC-014-2	Establish and Communicate System Operating Limits	Identification of System Operating Limits (SOLs) and Interconnection Reliability Operating Limits (IROLs).
MOD-029-2a	Rated System Path Methodology	Calculation of the Total Transfer Capacity (TTC) for paths published in OASIS.

1.3 Data Confidentiality

Data exchanged for the purposes of the requirements set out in this document and the requirements of MOD-032 are considered confidential by the recipient entities, including the PC and the TP. Furthermore, all data submitted to the NPCC is subject to the confidentiality provisions in Section 1500 of the North American Electric Reliability Corporation Rules of Procedure and is generally aggregated in a non-identifiable manner with the data of other functional entities. While the primary objective of this document is to allow the exchange of data required for modeling and reliability analyses, any data sent to the PC or TP that is subject to a confidentiality request will be treated as confidential by the receiving entity.

2. Power System Modeling

Power flow and dynamics cases are developed by the Planning Coordinator (PC) in order to realistically simulate the steady-state and dynamic performance of the Québec interconnected transmission system. All electrical elements that comprise the transmission system, such as generating units, power lines, transformers, reactive power compensation equipment, and system loads, are modeled based on measured electrical parameters (modeling data) provided by various functional entities within or connected to the transmission system.

2.1 Development of Power System Models

Power flow and dynamics cases are developed using the Siemens Power Technologies Inc. (PTI) Power System Simulator for Engineers (PSS/E) simulation software (Siemens-PTI). A power flow case is a collection of models that reproduce the steady-state system consisting of its generation and transmission equipment, a given system topology, and the short-circuit, load, distribution and power interchange data that constitute a snapshot of a specific combination of operating conditions. A dynamics case is a collection of models of dynamic system response used in conjunction with a power flow case to perform a stability analysis of system performance.

The PC develops a series of power flow and dynamics cases (also referred to as base cases) on an annual basis, reflecting various system conditions and planning scenarios. These cases are used by the PC and Transmission Planners (TPs) for system studies and reliability analysis. They are also used by the NPCC through its SS-37 Working Group on Base Case Development. Consequently, the accuracy of studies and reliability of base cases are heavily dependent on the quality of modeling data collected from functional entities.

2.2 Functional Entities within the Québec Interconnection

The functional entities, as per MOD-032-1 (part A, section 4.1 “Applicability”), that play key roles in obtaining, submitting, validating, and maintaining modeling data within the Québec Interconnection are defined in the following table.

Table 3 – MOD-032-1 Functional Entities

Functional Entity[2]	Application	Role in Power System Modeling
Generator Owners (GOs)	Any owner of generation facilities (hydroelectric, biomass, fossil fuel, wind, etc.) connected to the transmission system	Provides modeling data for generating units and generation outage information.

[2] This table is for information purposes only. The full list of the entities subject to reliability standards in Québec is available on the Régie de l’Énergie Web site: http://www.regie-energie.qc.ca/en/audiences/NormesFiabiliteTransportElectricite/RegistreEntites.html.

Load-Serving Entity (LSE)	Hydro-Québec Distribution (HQD)	Provides the demand modeling data.
Planning Authority/Coordinator (PC)	Hydro-Québec TransÉnergie – *Direction – Planification*	Responsible for Interconnection-wide base case building and modeling data maintenance (data storage).
Resource Planner (RP)	Hydro-Québec Distribution (HQD)	Provides generator dispatching information based on load-side contractual obligations.
Transmission Owners (TOs)	Any owner of transmission equipment operated at 44 kV or more.	Provides modeling data and outage information of transmission system equipment.
Transmission Planners (TP)	Hydro-Québec TransÉnergie – *Direction – Planification*	Users of base cases for system studies.
Transmission Service Providers (TSP)	Any entities registered as Transmission Service Providers (TSP) with Régie de l'Énergie.	Provides transmission service customer contract data (point-to-point transmission service details) as published on OASIS.

2.3 Power System Modeling Workflow

2.3.1 Modeling Workflow Diagram

The PC's annual exercise of developing reliable base cases is an intricate process requiring active inter-organizational collaboration from all function entities.

The following figure illustrates a general overview of how the functional entities listed above shall interact in regards to the submittal and processing of modeling data within the Québec Interconnection.

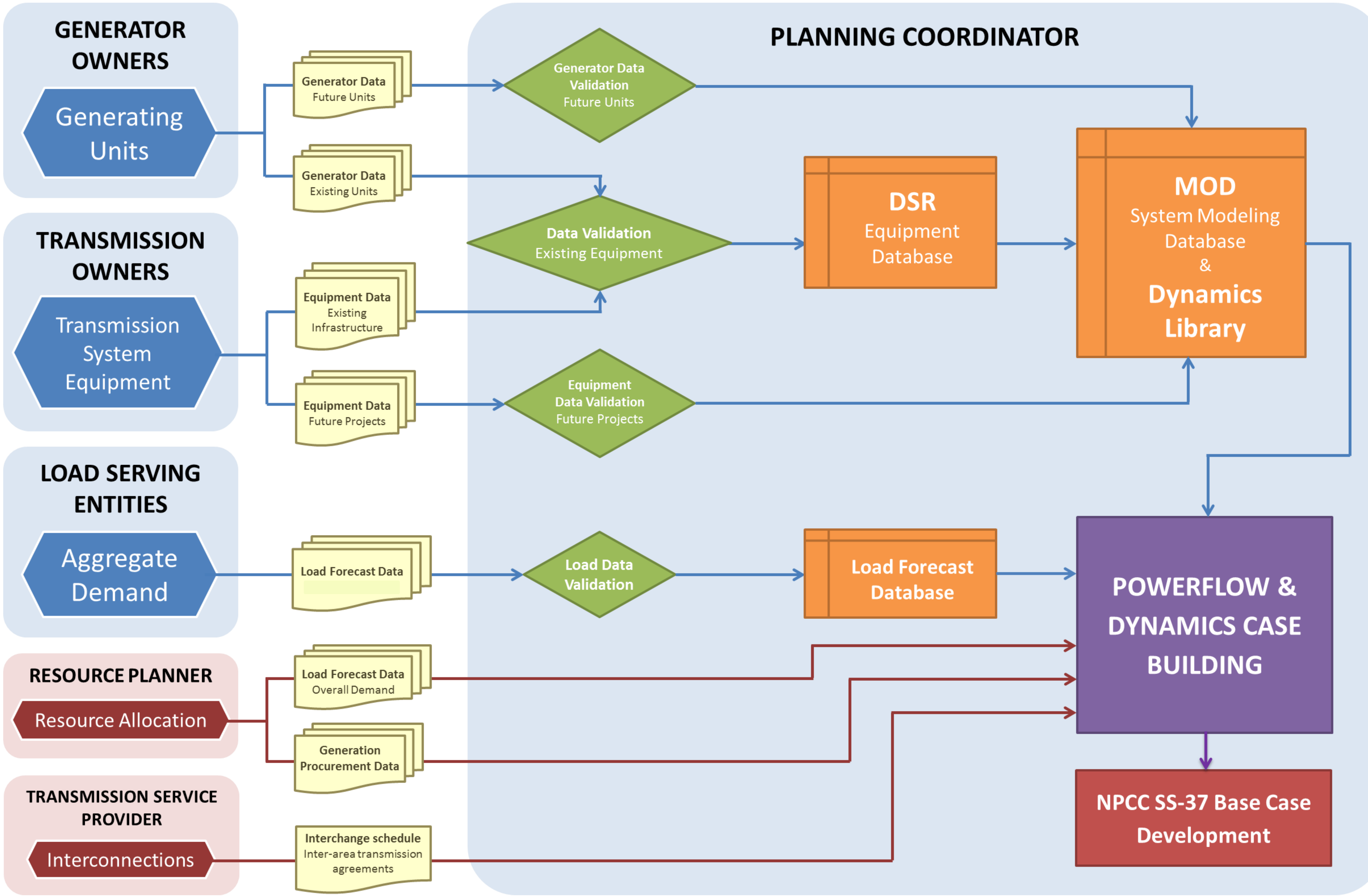

Figure 1 – Planning Coordinator Modeling Data Workflow

2.3.2 Description of Power System Modeling Activities

As illustrated above, power system modeling is comprised of a sequence of modeling data submission, validation and processing activities required to produce interconnection-wide base cases suitable for system studies. Modeling data is collected from various functional entities, validated to ensure functionality and compatibility with simulation tools, and then entered into specific data bases for referencing and base case building.

Essentially, case building is achieved based on the following inputs:

1. **Steady-state and Short-circuit Modeling Data from PSS® Model on Demand (MOD) Database**

   The MOD database consolidates all generation and transmission system steady-state and short-circuit modelling data (including planned future projects) collected from various functional entities in a central data repository. MOD is synched with DSR, the PC's main equipment data base containing updated modeling data of all existing generating and transmission system facilities, producing a MOD base case scenario in PSS/E format (.sav). Future projects, consisting of generation or transmission system additions, upgrades or modifications, are submitted to the PC by TPs and stored in MOD. They are then applied to the MOD base case scenario, allowing the PC and TPs to customize planning cases for any desired future point in time.

   Corrections or modifications to modeling data for existing facilities are validated before data is updated in the DSR database. In the case of future projects, preliminary modeling data submitted by GOs, TOs and TPs are entered directly into MOD, after model validation by the PC. New generating units or transmission system equipment are only added to DSR after project commissioning and after the PC has received all updated modeling data. This updated data is obtained from GOs and TOs at the later stages of the project commissioning phase.

2. **Dynamics Models and Modeling Parameters**

   Validated dynamics models and modeling parameters of existing facilities and future projects collected from GOs, TOs and TPs are stored in the PC's dynamics library. The PC's dynamics library consists of all dynamics model files required to run dynamics simulations in PSS/E (*.lib, *.obj, *.dll, etc.), source code files for certain user-defined models, dynamics parameters in the form of DYR files, and any IDEV or PYTHON programs necessary to set up dynamics simulation parameters.

3. **Demand Data**

   Once aggregate demand data for each load is received from the LSE, the PC validates and processes the data, mapping load data to the appropriate load serving buses in the MOD base case. The validated data is then stored in the PC's Load Forecast Database which is used to produce load profiles for a given forecast year in the form of PYTHON automation files.

These files are applied to the MOD base case scenario to produce customized planning cases for any desired future point in time.

4. Resource Data

The RP, in collaboration with GOs, provide the PC with data regarding all available resources needed to fulfill LSE demand requirements. This allows the PC to produce realistic generation dispatch scenarios, adequately balancing load and generation.

5. Interchange Data from TSPs

When preparing a base case scenario, the PC must consider scheduled MW transfer levels at each inter-area interconnection facility. Interchange data used in base case building is based on transmission service customer contract data (point-to-point transmission service details) as published on OASIS, as well as the NPCC Interchange Schedule prepared annually by NPCC's SS-37 work group.

6. Equipment Outage Information

Planned maintenance or commissioning of generating units and transmission system equipment resulting in outages must be considered in base case development. Short-term generator outages are reported to the PC by GOs and transmission system equipment outages are reported by the TOs.

3. Generating Facility Modeling

3.1 Modeling Data Requirements

All Generator Owners (GOs) connected to the Québec interconnected transmission system must provide valid modeling data of existing and future generating units to the PC on an annual basis. Planned generation facilities are defined as new generating station projects that are subject to a connection agreement.

The PC also requires GOs of existing facilities to recertify generator modeling data on an annual basis, either by resubmitting all required modeling data or by certifying that data has not changed from the previous year's data submission. In the case of changes to modeling data, GOs must clearly identify all changes and submit all modified modeling data in accordance with the requirements herein.

For planned generating facilities, modeling data is generally submitted at three times: 1) during the study phase, 2) after generating station commissioning, and 3) during the annual generating facility modeling data submission period.

1 – Study phase

The PC and TPs initially collect approximated generator modeling data from new and prospective GOs in order to conduct interconnection or system impact studies prior to commissioning of generating facilities. This preliminary data is submitted to the PC and the TPs using Appendices A and B of the HQT document entitled "Transmission Provider Technical Requirements for the Connection of Power Plants to the Hydro-Québec Transmission System" (hereinafter "HQT connection requirements"), available on HQT's website at:

http://www.hydroquebec.com/transenergie/fr/commerce/pdf/2_Exigences_raccordement_centrales_D-2018-145_2018-11-15.pdf

Normally, this data is submitted when a GO requests an impact study for the connection of a new generating station. The connection procedure for new generating units is available (in French) on HQT's website at:

http://www.hydroquebec.com/transenergie/fr/commerce/pdf/demarche-a-suivre-2012.pdf.

2 – Commissioning

GOs shall update the preliminary data provided to the PC and TPs during the project study and draft-design phases by providing actual or measured modeling parameters. GOs must validate modeling data as well as demonstrate that their facilities meet the requirements set out in the HQT connection requirements.

The validation of modeling data is a prerequisite for final TO acceptance of the generating facility project and must be completed within 6 months of initial commercial commissioning.

The validation procedures and testing for wind farms are outlined in HQT's "General Validation Test Program for Wind Power Plants Connected to the Hydro-Québec Transmission System" document, available on HQT's website at:

http://www.hydroquebec.com/transenergie/fr/commerce/pdf/essais-eoliennes2011-fr.pdf.

3 – Annual submission

Planned generating facilities must be included in the GO's annual modeling data submission once the generating station project has been confirmed. This confirmation is received through a connection agreement between the GO and HQT.

The following sections present the steady-state, dynamics and short-circuit data required to effectively model all generating units within the Québec interconnected transmission system, defining the type of data required and the units this data is to be reported in.

3.1.1 Steady-State Data for Modeling and Simulation of the Interconnected Transmission System.

i. The table below summarizes the main steady-state data requirements, as outlined in MOD-032-1, A1-3.

Table 4 – Steady-state data requirements for generating facilities

Generating Equipment	Steady-State Modeling Data
Synchronous or asynchronous generators	• Type of generation (e.g., thermal, wind or hydropower) • Real power capabilities (maximum and minimum values in MW) • Reactive power capabilities (maximum and minimum values in MVAR) • Nominal MVA base • Ratings • Generator unit regulated bus and set point voltage • Machine grounding impedances • In-service status
Generating station step-up transformers[1]	• Number of transformers • Nominal voltages of windings (kV) • Rated power (MVA) • Power ratings (MVA) with corresponding cooling method • Ratings • Positive sequence impedances and winding resistance (Ohms or p.u.)

[1] Data to be provided by the owner of the transformer, which may be the GO or the TO.

Generating Equipment	Steady-State Modeling Data
	• Coupling (i.e., winding connection) • Number of tap positions (kV or p.u.) • Tap ratios (voltage or phase angle) • Regulation range (minimum and maximum tap positions) • Regulated bus (for voltage regulated transformers) • In-service status
Wind farm collector system	• Zero sequence impedance parameters, R and X (ohms or p.u.) • Transmission line admittance (Siemens or p.u.) • Transmission line ratings (MVA or A) • Facility Ratings • Reactive compensation equipment data (capacitors and reactors), i.e., number, in-service status, nominal reactive power, ratings and voltage.

ii. For future planned generating units, GOs shall provide the expected commissioning date.

iii. GOs shall also provide generating station service auxiliary load information for existing units, detailing real (MW) and reactive power (MVAR) load values associated with a given generating unit.

iv. In regards to “in-service status” of a generating facility, annual 10-year forecasts of scheduled outages of duration greater than 6 months, as well as ongoing unscheduled outages expected to last more than 6 months shall be provided by GOs on a yearly basis. Outage information shall consist of:

- Start and end dates of planned outage
- Generating unit(s) and/or specific equipment within generation facility scheduled to be out of service.
- Impact of outage on generation (i.e. reduction in power plant generation in MW)

3.1.2 Short-Circuit and Dynamics Data Requirements for Power Station Modeling

i. In order to accurately simulate dynamic performance of generating units, GOs must provide the PC with validated dynamics models and associated parameters of all power generating equipment and components of the power plant, including:

- Generators, including Wind Turbines, Photovoltaic Systems, Fuel Cells and any other resource that delivers MW to the electric power system.
- Excitation systems
- Turbine and speed governors

- Voltage regulators (if equipped)
- Power system stabilizers (if equipped)

ii. All dynamics models submitted to the PC must be compatible with the current version[2] of Siemens-PTI's PSS/E (Power System Simulator for Engineers) software, which is used by the PC and TPs for dynamics system studies.

Unless agreed to with the PC, dynamic models must be included in the Siemens-PTI PSS/E model library. Appendix 1 lists accepted models and the current version of PSS/E used by the PC.

iii. User-defined models

Upon agreement with the PC, an entity may provide a user-defined model that meets conditions of the present section. However, generic models included to PSS/E model library shall be preferred. User-defined models should only be used where the generic model cannot adequately represent the behaviour of the equipment. In this case, le user-defined model should still be accompanied by the generic model(s) that best reproduce the behavior of the user-defined model.

a) If no dynamic model included in the PSS/E model library is suitable, the Generator may supply user-defined models. A user-defined model is any model that is not a standard Siemens-PTI PSS/E library model but has been accepted by the PC after being successfully tested for compatibility.

b) User-defined models submitted to the PC shall fulfill the following requirements:

- User-defined models must be able to work with a time-step exceeding 4 ms (1/4 cycle).
- User-defined models must be accompanied by a user manual providing all relevant technical documentation and characteristics of the model, including block diagrams, values and names for all model parameters and a list of all state variables.

c) GOs are responsible for validating and maintaining all dynamics models, ensuring that models submitted to the PC are compatible and fully functional in the current version of PSS/E, allowing for error-free initialization. In the event of PSS/E version updates (PC migrates to a newer version of the PSS/E software), GOs shall provide all necessary model updates, ensuring all models are compatible with the new version of PSS/E.

d) In the case of user-defined models representing wind farms, the following requirements shall be observed:

[2] PSS/E version 34.8

- The user-defined model must allow wind turbines to be represented as an agregated generator (1 unit representing all the wind turbine of a same type) and must be functional across its entire range of real and reactive power.

- In the case where voltage regulation of a wind power plant is achieved by means of additional compensation equipment in the switchyard (i.e. statcom), the GO shall also provide the complete PSS/E model for the corresponding reactive power compensation equipment, including all associated technical documentation, modeling data and parameters.

e) In addition to providing all required data for user-defined models as stipulated in 3.1.2.iv above, GOs must also identify the Siemens-PTI PSS/E standard library model(s) that most closely represents the dynamic performance of the user-defined model, as well as provide the corresponding modeling parameters. GOs may refer to the list of accepted models presented in **Appendix 1**.

iv. When submitting model parameters, GOs shall indicate the source of the data reported (manufacturer technical specifications, measured values, typical or estimated theoretical values, etc.).

v. In the case of incomplete data or unknown parameters, GOs shall provide the PC with estimated values based on the GO’s assumptions and hypotheses. All estimated values shall be clearly indicated as such.

vi. Regarding under/over-frequency protection of generating units, all GOs shall provide under/over-frequency relay trip setting and time delay, in compliance with requirement R11 of reliability standard PRC-006-NPCC-2, Automatic Underfrequency Load Shedding.

3.2 Data Reporting Requirements

3.2.1 Data Format

i. Steady-state, dynamics and short-circuit data shall be submitted to the PC in the following formats:

- **Table format**: Siemens-PTI PSS/E dynamic library models are identified and all corresponding model parameters are provided in a table format. GOs with numerous generating units may use the sample modeling data reporting table provided in **Appendix 4** of the present document.

- **PSS/E Library Data Sheets**: GOs using Siemens-PTI PSS/E dynamic library models may also elect to submit modeling parameters using the corresponding Siemens-PTI PSS/E library model data sheets. These data sheets may be provided to the GO upon request. An example of a PSS/E library model data sheet is included in **Appendix 3**.

- **PSS/E SAV, DYR format**: PSS/E dynamic library models are identified and all corresponding steady-state and dynamics parameters are provided in SAV and DYR files, respectively.

ii. In the case of user-defined models, GOs shall submit:

- All associated model files required to run simulations in PSS/E (*.lib, *.obj, *.dll, etc.). The PC may request the source code for certain user-defined models, which must be submitted in the FLECS language of the current PSS/E revision, in C, or in FORTRAN.

- All corresponding user-defined model steady-state and dynamics parameters, provided in SAV and DYR files, respectively.

- All relevant technical documentation and characteristics of the user-defined model, including compliance test results, block diagrams, values and names for all model parameters and a list of all state variables.

- Any IDEV or PYTHON programs necessary to set up dynamics simulation parameters.

- The Siemens-PTI PSS/E standard library model that most closely represents the generating unit's dynamics performance, along with all corresponding model parameters.

iii. GOs shall provide generator outage information in an Excel table format.

3.2.2 Data Submission Procedure and Schedule

i. Data submission is to be performed annually according to the procedures and schedule described in section 7.

4. Transmission System Equipment Modeling

4.1 Modeling Data Requirements

All Transmission Owners within the Québec Interconnection shall provide the PC with valid modeling data of all existing and future transmission system equipment, including:

- AC transmission lines
- DC transmission systems
- Voltage and phase shifting transformers
- Breakers
- Shunt reactive compensation equipment (capacitors and reactors)
- Series reactive compensation equipment
- Static Var systems and synchronous condensers
- Special protection systems (SPS)

The PC, in accordance with NERC's MOD-032 standard, requires all TOs of existing facilities to recertify system modeling data on an annual basis, either by resubmitting all required modeling data or by certifying that data has not changed from the previous year's data submission. In the case of changes to modeling data, TOs must clearly identify all changes and submit all modified modeling data in accordance with the requirements herein.

For future planned modifications, additions or upgrades of transmission system equipment, TOs must submit preliminary modeling data to the PC and TPs during the planning phase of the project, during which system impact studies are conducted. At this stage, estimated or typical modeling parameters are acceptable.

TOs shall update the preliminary data provided to the PC during the project planning phase by providing actual or measured modeling parameters based on equipment compliance testing results conducted during the commissioning phase. The validation of modeling data is a prerequisite for final TO acceptance of the transmission system facility project and must be completed within 6 months of initial commercial commissioning.

The following sections present the steady-state, dynamics and short-circuit data required to effectively model transmission system equipment within the Québec Interconnection, defining the type of data required and the units this data is to be reported in.

4.1.1 Steady-State Data for Modeling Transmission Systems

i. Each TO shall provide steady-state modeling data of existing and future transmission equipment according to the requirements set forth in the present document.

ii. The table below summarizes the main steady-state data requirements, as outlined in MOD-032-1, A1- 1, 4-8.

Table 5 – Steady-state data requirements for transmission equipment

Transmission System Component	Steady-State Modeling Data
Busbar assemblies	• Single-line diagram of the substation • Bar number name • Ratings • Rated voltage • Type of bus (substation bus bar, load or generator) • Area, zone and owner • Associated substation or line
AC Transmission Lines	• To and from buses or substations • Line length (km) • Impedance parameters (positive sequence), R and X (ohms or p.u.) • Susceptance, B (Siemens or p.u.) • Ratings in normal and emergency conditions[3] • Thermal ratings at -20°C, 0°C and 30°C (MVA or A) • In-service status
DC Transmission Systems (DC lines and converter stations)	• To and from buses or substations • DC Line length (km) • DC Line impedances and data (Voltage, Rcmp-Ohms, Vcmode, CCC Itmax, Rdc-Ohms, Delti, Dcvmin, CCC Accel) • Rectifier and Inverter data (Primary base voltage, Bridges in Series, Trans Ratio, CCC X, AC Tx From Bus, AC Tx To Bus, Max Firing Angle, Commutating R and X, Max & Min Tap Settings, Tap Step) • In-service status
Transformers (Voltage and Phase Shifting)	• Location of transformer (substation name) • Transformer name (ID number) and assigned position number • Nominal voltages of primary, secondary and tertiary windings (kV) • Ratings in normal and emergency conditions[4] • Power ratings (MVA) with corresponding cooling method, at -20°C, 0°C and 30°C

[3] Ratings determined using FAC-008 methodology
[4] Ratings determined using FAC-008 methodology

Transmission System Component	Steady-State Modeling Data
	• Positive sequence impedances and winding resistance (Ohms or p.u.) • Magnetizing admittance G and susceptance B (p.u.) • Coupling (i.e., winding connection) • Number of tap positions (kV or p.u.) • Tap ratios (voltage or phase angle) • Regulation range (minimum and maximum tap positions) • Regulated bus (for voltage regulated transformers) • In-service status
Circuit breakers	• Location of breaker (substation name) • Breaker name (ID number) and assigned position number • Ratings • Rated voltage (kV) • Manufacturing data (manufacturer, year, design standard) • Breaker interrupting symmetrical and asymmetrical current capacities (kA) • Breaker X/R ratio
Shunt Reactive Compensation Devices (Capacitors and Reactors)	• Location of shunt unit (substation name) • Shunt unit name (ID number) and assigned position number • Number of capacitors and reactors in unit • Reactive power capacity of each capacitor and reactor (MVAR) • Ratings • Rated voltage (kV) • Regulated voltage band limits (kV) • Mode of operation (fixed, discrete, continuous, etc.) • Regulated bus • In-service status
Series Reactive Compensation Devices	• Location of series capacitor (substation name and transmission line compensated) • Series capacitor unit name • Unit type • Rated voltage (kV) • Unit impedance (p.u. or ohms) • Unit admittance (p.u. or Siemens) • Reactive compensation % • Ratings • Reactive power capacity (MVA) • Overload factor • In-service status
Static Var Systems and Synchronous Condensers	• Location of Static VAR or Synchronous Condenser (substation name) • Rated voltage (kV) • Base power capacity

Transmission System Component	Steady-State Modeling Data
	• Ratings • Reactive power limits (MVAR) • Regulated bus • Voltage set point (p.u. or kV) • In-service status

iii. Attribution of busbar numbers is done by the PC.

iv. For all future additions or upgrades where HQT is TO, steady-state modeling data shall reflect technical data specified in the Design Specifications Document (cahier des charges).

v. Regarding "in-service status," a 10-year forecast of scheduled outages of duration greater than 6 months shall be provided by TOs on a yearly basis. Outage information shall consist of:

- Start and end dates of planned outage
- Transmission equipment scheduled to be out of service
- Voltage level
- Location (substation name, zone, etc.)
- Description of project or maintenance causing outage

4.1.2 Transmission System Equipment Dynamics and Short-Circuit Data Reporting Requirements

i. Each TO shall provide short-circuit and dynamics modeling data of existing and future transmission equipment according to the requirements set forth in the present document.

ii. The table below summarizes the main short-circuit and dynamics modeling data requirements, as outlined in MOD-032-1, A1.

Table 7 – Requirements for steady-state, dynamic and short-circuit modeling data for transmission equipment

Transmission System Component	Dynamics and short-circuit modeling data
AC Transmission Lines	• Positive, negative and zero sequence impedance parameters, R and X (ohms or p.u.) • Zero sequence susceptance, B (Siemens or p.u.) • Mutual impedance data
DC Transmission Systems (DC lines and converter stations)	• DC line dynamics model and associated parameters • DC converter dynamics model and associated parameters

Transformers (Voltage and Phase Shifting)	• Winding connection • Positive, negative and zero sequence impedance parameters, R and X (ohms or p.u.) • Positive, negative and zero sequence grounding impedances, R_G and X_G (ohms or p.u.)
Shunt Reactive Compensation Devices (Capacitors and Reactors)	• Zero sequence shunt admittances, G and B (p.u.)
Series Reactive Compensation Devices	• Zero sequence impedances, R and X (p.u. or ohms) • Zero sequence admittance, B (p.u. or Siemens) • Unit admittance (p.u. or Siemens)
Static Var Systems and Synchronous Condensers and others Flexible Alternative Current Transmission System (FACTS)	• Positive sequence machine impedances, R1 and X1 (p.u.) • Negative sequence machine impedances, R_2 and X_2 (p.u.) • Zero sequence machine impedances, R_0 and X_0 (p.u.) • Static Var System equipment dynamics model and associated parameters • Synchronous Condenser dynamics model and associated parameters
Automated system controls	• SPS dynamics model and associated parameters

iii. All dynamics models submitted to the PC must be compatible with the current version[5] of Siemens-PTI's PSS/E software, which is used by the PC and TPs for dynamics system studies.

The use of Siemens-PTI PSS/E standard dynamics models is preferred when they can accurately represent the dynamic performance of the device being modeled.

Models accepted by the PC are listed in **Appendix 1** of the present document.

iv. User-defined models

a) If a compatible standard IEEE or PSS/E dynamics model is unavailable, user-defined or "black-box" models may be used. A user-defined model is any model that is not a standard Siemens-PTI PSS/E library model but has been accepted by the PC after being successfully tested for compatibility.

b) User-defined models submitted to the PC shall fulfill the following requirements:

- User-defined models must be able to work with a time-step exceeding 4 ms (1/4 cycle).

[5] PSS/E version 34.8

- User-defined models must be accompanied by a user manual providing all relevant technical documentation and characteristics of the model, including block diagrams, values and names for all model parameters and a list of all state variables.
- TOs must also provide compliance test results demonstrating that the model accurately represents the dynamic performance of the device being modeled. TOs must ensure that model compliance testing is performed every 10 years.

c) TOs are responsible for validating and maintaining all dynamics models, ensuring that models submitted to the PC are compatible and fully functional in the current version of PSS/E, allowing for error-free initialization. In the event of PSS/E version updates (PC migrates to a newer version of the PSS/E software), TOs shall provide all necessary model updates, ensuring all models are compatible with the new version of PSS/E.

d) In addition to providing all required data for user-defined models as stipulated in 4.1.2.iv-vi, TOs must also identify the Siemens-PTI PSS/E standard library model(s) that most closely represents the dynamic performance of the user-defined model, as well as provide the corresponding modeling parameters. GOs may refer to the list of accepted models presented in **Appendix 2**.

v. In the case of incomplete data or unknown parameters, TOs shall provide the PC with estimated values based on the TO's assumptions and hypotheses. All estimated values shall be clearly indicated as such.

vi. For all future additions or upgrades where HQT is TO, short-circuit modeling data shall reflect technical data specified in the Design Specifications Document (cahier des charges).

4.1.3 Additional modeling data needed to calculate DC currents during geomagnetic storms

i. Every TO must provide, for the transmission facilities involved, the modeling data needed to calculate DC currents during geomagnetic storms, and perform the analyses required by standard TPL-007.

ii. The table below summarizes the main modeling data requirements.

Table 8 – Modeling data needed to calculate DC currents during geomagnetic storms

Transmission System Component	Modeling Data

Transmission substation	• Substation grid resistance (Ohms)
	• Coordinates of the substation:
	  ◦ latitude (positive for north and negative for south)
	  ◦ longitude (positive for east and negative for west)

Transmission lines	• DC resistance (Ohms/phase)

	• Coordinates of the line tap • latitude (positive for north and negative for south) • longitude (positive for east and negative for west) • Number of overhead ground and counterpoise wires
Transformers (Voltage and Phase Shifting) **(if one of the winding voltages is > 200 kV and one of the transformer connections is grounded)**	• DC resistance (Ohms/phase) for each winding • Core design ○ Three phase shell ○ Single core ○ 3-phase 3-legged ○ 3-phase 5-legged etc. • Coefficient of reactive power losses as a function of DC current in the transformer (K factor) • Ground resistance (Ohms) • Presence of DC current blocking mechanism on the neutral
Shunt reactor	• DC resistance of winding (Ohms/phase) • Ground resistance (Ohms)

4.2 Data Reporting Requirements

4.2.1 Data Format

i. Steady-state, dynamics and short-circuit data shall be submitted to the PC in the following formats:

- **Table format**: Siemens-PTI PSS/E dynamic library models are identified and all corresponding model parameters are provided in a table format.
- **PSS/E SAV, DYR format**: PSS/E dynamic library models are identified and all corresponding steady-state and dynamics parameters are provided in RAW and DYR files, respectively.

ii. TOs shall also submit a single-line diagram, illustrating the planned or commissioned transmission system additions and/or modifications.

iii. In the case of user-defined models, TOs shall submit:

- All associated model files required to run simulations in PSS/E (*.lib, *.obj, *.dll, etc.). The PC may request the source code for certain user-defined models, which must be submitted in the FLECS language of the current PSS/E revision, in C, or in FORTRAN.
- All corresponding user-defined model steady-state and dynamics parameters, provided in SAV and DYR files, respectively.

- All relevant technical documentation and characteristics of the user-defined model, including compliance test results, block diagrams, values and names for all model parameters and a list of all state variables.

- Any IDEV or PYTHON programs necessary to set up dynamics simulation parameters.

- The Siemens-PTI PSS/E standard library model that most closely represents the generating unit's dynamics performance, along with all corresponding model parameters.

iv. The TO shall provide transmission system equipment outage information in the form of a report or a simplified Excel table.

4.2.2 Data Submission Procedure and Schedule

i. Data submission is to be performed annually according to the procedures and schedule described in section 7.

5. Modeling of Demand

5.1 Modeling Data Requirements

The main Load Serving Entity (LSE), in this case Hydro-Québec Distribution (HQD), is responsible for preparing and submitting demand data to the Planning Coordinator (PC) for the entire Québec Interconnection.

The following sections present the steady-state, dynamics and short-circuit data required to effectively model demand within the interconnected transmission system, defining the type of data required and the units this data is to be reported in.

5.1.1 Steady-State Data Requirements for Demand Modeling

The table below summarizes the steady-state data requirements for loads at satellite substations (< 44 kV) and loads for customer facilities (municipal systems, large industrial plants, pulp and paper mills, aluminum smelters, refineries, mining facilities, etc.), directly connected to the high voltage transmission system (44 kV to 324 kV).

Table 9 – Steady-state data requirements
Steady-State Data Requirements for Demand Modeling

Satellite substation loads < 44 KV (15-year forecast)	Customer facility loads modeled at higher than 44 KV (10 year forecast)
▪ Substation location code ▪ Substation name ▪ Active power (MW) ▪ Reactive power (MVAR) ▪ Load apparent power (MVA) ▪ Rated power (MVA) and voltage (kV) of low-voltage side reactive compensation equipment	▪ Location code ▪ Substation name ▪ Active power (MW) ▪ Total load apparent power (MVA) ▪ Load in-service status

i. Load data submitted to the PC shall reflect the following annually prepared demand forecasts:

- A 15-year demand forecast by substation, aggregated by secondary voltage level for all satellite substations serving the Hydro-Québec distribution system load with a secondary busbar voltage < 44 kV

- A 10-year demand forecast by substation at the high-voltage side for industrial customers (e.g., municipal distribution systems, large industrial plants, etc.) connected directly to the high voltage transmission system (44 to 324 kV)

- A 10-year Interconnection-wide aggregated demand forecast for the entire interconnection.

ii. Each demand forecast shall provide load data for the following types of load levels:

- Winter peak in normal weather conditions
- Summer peak[6]
- Summer light load[7]

iii. HQD must also provide historical peak load data, standardized over five years for all satellite substations serving the system, with secondary bus voltage of under 44 kV.

iv. In the case of new customer facilities connected directly to the high voltage transmission system, the submission of more detailed modeling data is required prior to the commissioning of new customer facilities, as stipulated in the "Technical Requirements for Customer Facilities Connected to the Hydro-Québec Transmission System" document. The most updated version of the document is readily available on HQT's website at:

http://www.hydroquebec.com/transenergie/fr/commerce/pdf/ex_inst_client.pdf.

v. Existing customer facilities must also provide load modeling data according to these same technical requirements upon request from the PC or in the event of any modifications to customer facilities.

5.1.2 Short-Circuit and Dynamics Data Requirements for Demand Modeling

i. Short-circuit and dynamics data is normally required for customer facilities equipped with large motors that can impact the transmission system's transient and dynamic performance. This information is normally provided by customer facilities prior to commissioning and connection to the transmission system or in the event of modifications to existing customer facilities.

ii. Customer facilities, with the collaboration of HQD, shall provide short-circuit and dynamics data according to the requirements set forth in Appendix 1 of HQT's "Technical Requirements for Customer Facilities Connected to the Hydro-Québec Transmission System" document. The most updated version of the document is readily available on HQT's website at:

http://www.hydroquebec.com/transenergie/fr/commerce/pdf/ex_inst_client.pdf.

[6] The summer peak load forecast is to be submitted on demand only.
[7] The summer light load forecast is to be submitted by source substation on demand only. The planning coordinator will provide the correspondence list for source and satellite substations, if required.

iii. Customer facilities must also indicate the source of the data submitted (manufacturer technical specifications, measured values, typical or estimated theoretical values, etc.).

iv. In the case of incomplete data or unknown parameters, HQD/Customer facilities are responsible for providing theoretical or estimated values.

5.2 Data Reporting Requirements

5.2.1 Data Format

i. Steady-state load data submitted to the PC shall be presented in an Excel table or any other format upon agreement with the PC.

ii. Short-circuit and dynamic load data shall be submitted to the PC using the modeling data template provided in Appendix A of the "Technical Requirements for Customer Facilities Connected to the Hydro-Québec Transmission System" document. All fields of the said document must be completed in order to be considered as a valid data submission. Other accepted data submission formats for short-circuit and dynamic load data are the following:

- Excel Table listing model parameters
- PSS/E SAV and DYR files, with all corresponding PSS/E dynamic model files.

5.2.2 Data Submission Procedure and Schedule

i. Data submission is to be performed annually according to the procedures and schedule described in section 7.

6. Complementary Power System Information

In addition to steady-state and dynamics models, transmission system modeling requires quantitative information about the power system to establish generation dispatch and interconnection wheeling levels. This additional information consists of resource planning data and interchange transfer quantities to neighbouring Areas.

The following sections present the data required to effectively integrate resource planning and interchange data into power flow and dynamics cases, defining the type of data required and the units this data is to be reported in.

6.1 Resource Plan Data

6.1.1 Resource Planning Data Requirements

i. The Resource Planner (RP), in this case Hydro-Québec Distribution (HQD), shall provide the PC with data regarding all long term generation purchasing agreements between GOs and LSEs, determining the generating resources available to fulfill demand requirements.

ii. The Resource Planner (RP) shall provide the interruptible load planning hypothesis and details about any Direct Control Load Management (DCLM) programs.

6.1.2 Data Format

i. Resource data shall be reported in an Excel table format in a mutually agreed format between the RP and the PC.

6.1.3 Data Submission Procedure and Schedule

i. Data submission is to be performed annually according to the procedures and schedule described in section 7.

6.2 Interchange Schedule

An Interchange schedule is a list of scheduled power transfer quantities exchanged between the Québec Interconnection and its neighbouring Area systems (i.e. New England, New York, Ontario, and New Brunswick). These transactions and transmission reservations reflect firm export/import or point-to-point transmission agreements, as per HQT's Open Access Transmission Tariff (OATT). This information is published on the OATI webOASIS application and provided to the PC by the Transmission Service Provider (TSP).

6.2.1 Interchange Data Requirements

i. The TSP shall collect and provide the required interchange data regarding firm long term transmission reservations (1 year or more) between transmission systems within the Québec Interconnection as well as with transmission systems of neighbouring NPCC Areas. This information must be reflective of the most updated transaction information available on OATI webOASIS.

ii. Interchange data shall include:

- Transmission service customer name
- OASIS reference number
- Source and destination substations
- Name of interconnection path
- Power flow (MW)
- Transaction frequency (yearly, monthly, etc.)
- Transmission service type
- Start and end date of transmission service contract

6.2.2 Data Format

i. Interchange data shall be reported in an Excel table format or any other format upon agreement with the PC.

6.2.3 Data Submission Procedure and Schedule

i. Data submission is to be performed annually according to the procedures and schedule described in Section 7.

7. Data Submission Procedure and Schedule

7.1 Data Submission Procedure

i. All communications regarding modeling data reporting must be e-mailed to: TEdonneesdemodelisation@hydro.qc.ca.

ii. Data submission is to be performed electronically or by email, preferably using a secure file transfer server such as Hydro-Québec's secure FTP server, available to HQ entities at https://ftps.hydro.qc.ca/ and external customers at https://ftps.hydroquebec.com/.

iii. Periodicity of declaration

Data shall be submitted annually according the schedule presented in the present section. The entity shall indicate clearly the modifications from the previous declaration or, where applicable, indicate that the data hasn't changed.

7.2 Data Submission Schedule

All concerned entities responsible for providing modeling data shall submit data annually according to the following schedule:

Table 10 – Modeling Data Submission Schedule

Modeling Data	Description of Deliverables	Functional Entity Responsible	Date of declaration
Aggregate Demand Data	Steady-state winter peak load forecast	Distribution Provider	**October 1**
	Steady-state summer peak and light load forecasts	Distribution Provider	**October 1**
	Steady-state demand forecast for industrial customer facilities	Distribution Provider	**October 1**
	Total system load forecast	Resource Planner	**October 1**
Generation Data	Steady-state, dynamics and short-circuit modeling data for existing equipment	Generator Owners	**February 1**
	Steady-state, dynamics and short-circuit modeling data for new future planned projects	Generator Owners	**February 1**
	Generator facilities outage schedule	Generator Owners	**February 1**
Transmission System Equipment Data	Recertification of steady-state, dynamics and short-circuit modeling data for existing equipment	Transmission Owners	**February 1**

Modeling Data	Description of Deliverables	Functional Entity Responsible	Date of declaration
	Steady-state, dynamics and short-circuit modeling data for new future planned projects	Transmission Owners Transmission Planners	**February 1**
	Transmission system equipment outage schedule	Reliability Coordinator	**February 1**
Complimentary Power System Information	Resource plan data	Resource Planner	**October 1**
	Interchange Data Requirements	Transmission Service Provider	**February 1**

7.3 Non-Compliances

For entities registered with the Régie, failure to submit required modeling data by the prescribed submission schedule and in the requested format may be in violation of the requirements established in NERC's MOD-032 standard.

For more information regarding compliance violations, functional entities may refer to pages 6-12 of the MOD-032-1 standard document, available on the Régie's website at:

http://www.regie-energie.qc.ca/audiences/NormesFiabiliteTransportElectricite/Normes/MOD-032-1-fr-2017-01-31.pdf

APPENDIX 1 – List of Accepted Dynamics Models

See excel document "Appendix 1" (http://www.hydroquebec.com/transenergie/en/modeling.html)

The Planning Coordinator currently uses PSS/E version 34.8.

Direction – Planification
Hydro-Québec TransÉnergie
A division of Hydro-Québec

Hydro Québec
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