NPCC
2011 Québec Balancing Authority Area Comprehensive Review of Resource Adequacy

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Final Report – Approved by the NPCC RCC on November 29, 2011

October 27, 2011.

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1. EXECUTIVE SUMMARY

The Québec Balancing Authority Area submits this assessment of resource adequacy to comply with the Reliability Assessment Program established by the Northeast Power Coordinating Council (NPCC). The guidelines for the review are specified in Appendix D of the NPCC Regional Reliability Reference Directory #1, "*Guidelines for Area Review of Resource Adequacy*" (Original document: December 1, 2009).

This 2011 Comprehensive Review of Resource Adequacy covers the study period from winter 2011/2012 through winter 2015/2016, Changes about assumptions regarding facility and system conditions, generation resources availability, load forecast and electricity sector regulations, since the last Comprehensive Review and the impact of these changes on the overall reliability of the Québec electricity system are highlighted therein.

Forecasted load has been reviewed downward since the last comprehensive review due to economic recession and energy efficiency gains. About 1,000 MW of additional resources have been added to the system, since the filing of the last Comprehensive Review. An additional amount exceeding 2,500 MW (after wind power derating) is expected to be commissioned by 2015/2016. These capacities additions are hydro generation, wind power and biomass generation.

Wind power generation is taken into account in this review and a 30 percent peak value was retained for reliability assessment.

Results of this comprehensive review show that Québec area reliability criterion of loss of load expectation (LOLE) is below the reliability criterion LOLE = 0.1 days/year of the NPCC for all years of this assessment under the base case scenario.

1.1 Major Findings

The 2011 Comprehensive Review shows that Québec area will be able to meet the NPCC resource adequacy criterion that requires a loss of load expectation (LOLE) value of less than 0.1 days/year for all years from 2011/2012 to 2015/2016. In fact, in 2015/2016, winter peak period planned resources (45,401 MW) are above forecasted load (39,313 MW) by 6,088 MW. There are two reasons explaining this situation:

- A reduction in peak load forecast since the last review due to economic recession and increased energy savings;
- New resources are planned to be installed (hydro, wind, biomass, ...);

1.2 Major Assumptions and Results

This review covers the 2011/2012 to 2015/2016 period inclusive. Major assumptions are summarized in Table 1.1 below. Table 1.1 Major Assumptions

ASSUMPTION	DESCRIPTION
Study Period	Winter 2011-2012 to Winter 2015-2016
Adequacy Criterion	NPCC Loss of Load Expectation (LOLE) requirement of not more than 0.1 day/year
Reliability Model	GE's MARS program
Load Growth	Base Case : 1.0 % per annum High Case : 1.8 % per annum
Load Model	Hourly loads with forecast uncertainty
Generation Capacity Additions	4,795 MW by the end of 2015, including 2,665 MW of wind power.
Generation Capacity Retirements	One unit of Tracy thermal plant (150 MW) is retired in this review.
Internal and Interconnection Transmission Constraints	Transmission system representation and the interface limits are shown in Appendix, sections A3 and A7.1 of this report.
Tie Benefits	Estimated Tie Capability: 2,900 - 3,400 MW. No tie benefit was used to meet the LOLE criterion for all years of this review.
Emergency Operating Procedures (EOP)	Assumed 1,680 MW of load relief from interruptible load programs (1,430 MW) and voltage reduction (250 MW)
Resource Availability	Forced Outages modeled: Based on Equivalent Demand Forced Outage Rate (EFORd) five - year historical data (2006-2010).
Conservation and Demand Management	Impact of new energy savings programs : Up to 760 MW by 2015/2016.

Table 1.2 Summary of Results

		BASE CASE		HIGH CASE	
Winter Peak	**Expected Resources** (MW)	**LOAD (incl. exports)** (MW)	**LOLE** (days / year)	**LOAD** (MW)	**LOLE** (days / year)
2011 / 2012	42,828	37,789	0.010	38,491	0.028
2012 / 2013	42,666	38,248	0.064	39,196	0.091
2013 / 2014	43,029	38,660	0.079	39,856	0.161
2014 / 2015	44,612	39,149	0.034	40,674	0.080
2015 / 2016	45,401	39,313	0.021	41,312	0.076

All resources are assumed to be in service as planned. Table1.2 shows that the Québec area meets the LOLE criterion under the base case demand forecast for all years of this review. Under the high case demand scenario, the area LOLE is below the required NPCC LOLE (0.1 days/year) for all winter periods except 2014. The Québec area will need additional resources for this year to meet NPCC reliability criterion.

Following a higher demand scenario, some thermal resources presently mothballed could be called back within a six months delay and additional call for tenders could be launched, if required.

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3. INTRODUCTION

The Northeast Power Coordinating Council (NPCC) conducts resource adequacy reviews of its member areas to ascertain whether or not each area will have adequate resources to meet the NPCC Resource Reliability Criterion.

Hydro-Québec Distribution (HQD) is the entity responsible for resource planning in Québec. HQD is also responsible for all activities regarding load forecasting and resource procurement required to supply the local load. As such, HQD is the reporting entity for this assessment.

The purpose of this report is to present the results of the Québec Balancing Authority Area's comprehensive review of resource adequacy to the NPCC. Results of this resource adequacy review, conducted by HQD and submitted to the NPCC, are documented in accordance with the reporting guidelines specified in Appendix D of the NPCC Regional Reliability Reference Directory #1, "*Guidelines for Area Review of Resource Adequacy*" (Original document: December 1, 2009).

This report also includes some information regarding Hydro-Québec Production (HQP) and TransÉnergie activities that are required in order to conduct reliability evaluations in this Review.

Information presented in this Comprehensive Review covers the period from November 2011 through October 2016 and is based on the Québec Area load forecast used in the Progress Report of the 2011-2020 Supply Plan filed at the Régie de l'Énergie du Québec on November 1, 2011.

3.1 Reference to Most Recent NPCC Comprehensive Review

Comparisons between this review and the previous Comprehensive Review, submitted in December 2008 and approved by NPCC's Reliability Coordinating Committee (RCC) on March 2009, are included in this report.

3.2 Comparison of this Review and Previous Review

3.2.1. Demand Forecast

The demand forecast presented in this review focuses on winter annual peaks. Two demand scenarios are presented: a base case and a high demand case. Winter peak demand forecasts for this 2011 Comprehensive Review are presented in Table 3.2.1 and Figure 3.2.1, along with the 2008 Comprehensive Review forecasts.

Demand forecasting methodology is basically the same as that used in the previous Comprehensive Review. The Québec peak load forecast is based on normal weather conditions. For this purpose, a 36-year reference period is used to assess average temperatures (1971-2006). The same reference period is used to assess demand uncertainties resulting from weather. More methodological details are provided in Appendix A.

Since the 2008 Comprehensive Review, there has been a substantial shift in some electricity demand drivers. Decreasing manufacturing activity, especially in pulp and paper sector is among the key factors driving down electricity demand in the Quebec area. This structural change was combined with the effect of the 2008-2009 recession have a tremendous effect on electricity demand.

Despite a decreasing consumption of electricity as measured in energy, the peak demand in the Quebec area is still growing continuously. This can be explained by a sustained activity in construction and a still intensive use of electricity for space heating purposes namely in the residential sector.

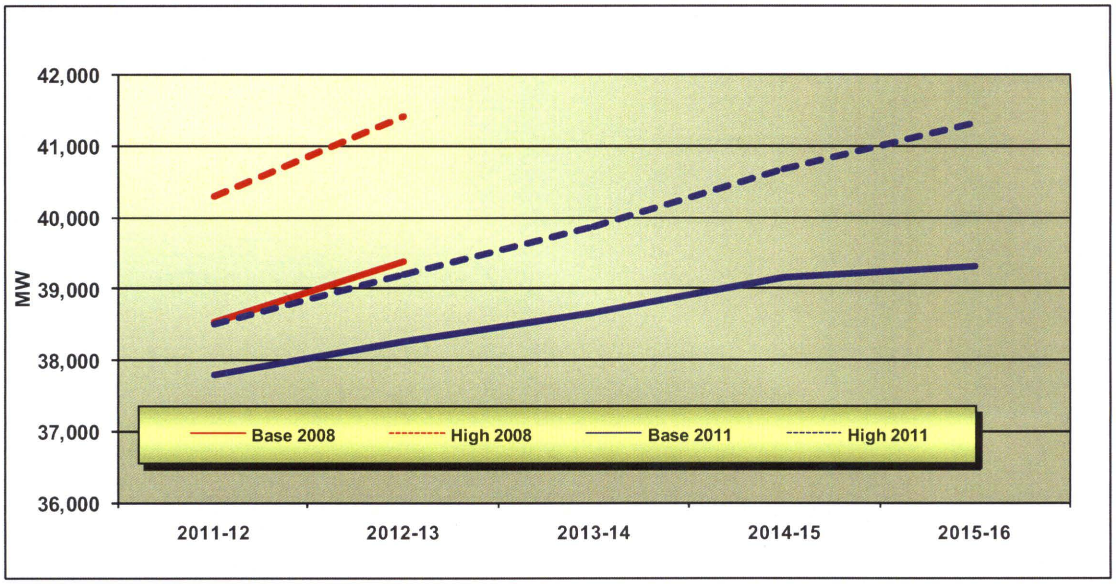
Demand forecasts take into account the impact of energy savings on energy and capacity requirements. The incremental impact of programs to be deployed and those remaining active during the five years covered by this review is estimated to 760 MW.

Forecasts also take into account the load shaving resulting from residential dual energy. The impact of this program on peak load demand is estimated to be 870 MW.

Table 3.2.1 Comparison of Demand Forecasts (MW)

	Base case Scenario			High case Scenario		
Winter Peak	2008 Comprehensive Review	2011 Comprehensive Review	Difference	2008 Comprehensive Review	2011 Comprehensive Review	Difference
2011 / 2012	38,527	37,789	-738	40,281	38,491	-1,790
2012 / 2013	39,375	38,248	-1,127	41,404	39,196	-2,208
2013 / 2014		38,660			39,856	
2014 / 2015		39,149			40,674	
2015 / 2016		39,313			41,312	
Average Growth Rate		1.0 %			1.8 %	

Figure 3.2.1 Comparison of Demand Forecasts



As shown in Table 3.2.1, the results of the base case scenario are 738 to 1,127 MW below the forecast presented in the 2008 Comprehensive review. The new compound annual growth rate over the entire period is approximately 1.0 percent. Under the high demand growth scenario, peak load demand forecast is expected to increase by 1.8 percent.

3.2.2. Resources Forecast

Most of resources in Québec area are hydro power generation owned and operated by Hydro-Québec Production (HQP). HQP also operates one nuclear plant (base load) and two gas turbine generation stations (for peaking purposes). One other oil-fired plant is presently mothballed.

Remaining resources are owned and operated by Independent Power Producers (IPPs) and are under long term power purchase agreements with Hydro-Québec Distribution as well as with Hydro-Québec Production. The purchased energy originates from wind power, small hydro and biomass.

New Resource Additions

Since the last comprehensive review, two hydro generating units (Chute Allard and Rapide des coeurs) have been commissioned in 2009 adding 66 MW to the system. Three other hydro generating stations are expected to come on line soon during this assessment period (EM-1-A, 768 MW in late 2011 and La Sarcelle, 150 MW in 2012 – almost a year later than expected in the previous comprehensive review). Finally, the third hydro G.S (La Romaine 2) is under construction and expected to be commissioned for the 2014/15 winter peak period, adding a capacity of 622 MW.

Since the last comprehensive review, Hydro-Québec Distribution launched two call for tenders and one electricity purchase program for new renewable supplies. Another purchase program is to be launched in the next months.

- A call for tenders for generation from biomass was launched in April 2009. The selection process lead to the signature of 6 contracts for an installed capacity of 52 MW, to be commissioned by the end of 2012.
- A call for tenders for wind power from community projects was launched in April 2009. The selection process lead to the signature of 12 contracts for a wind power installed capacity of 291 MW. The projects will be commissioned from 2013 to 2015.
- An electricity purchase program for electricity generated by small hydro plants (50 MW and under) developed in partnership with local and aboriginal communities was launched in July, 2009. The capacity under contract from this program is expected to reach 148 MW. Among the projects selected, three projects (23 MW) are already commissioned, construction began for two of them (48 MW) while contracts regarding other selected projects are still in negotiation. Their commissioning will extend to 2014,
- In the next months, another purchasing program for 150 MW of new supplies from biomass generation will be launched. The new capacity should be commissioned by December 2015.

However, the expected amount of installed wind capacity from call for tenders launched before 2008 was reviewed downward. Some projects were abandoned and some other delayed.

In the previous Comprehensive Review, all wind power in the area was completely de-rated. Since the 2009 interim review, a capacity value at peak equals to 30 percent of installed capacity is used for wind power under contract with Hydro-Québec Distribution. Studies supporting this evaluation have been filed to the Régie de l'énergie du Québec, to the NPCC CP-8 WG and have been presented in 2010 in the 9th International Workshop on Large-Scale Integration of Wind Power into Power Systems. Wind power under contract between Hydro-Québec Production and IPPs is still completely de-rated.

Table 3.2.2-1 below summarizes the installed wind capacity and net capacity values at peak for all years of the present review. In 2014/2015, installed capacity is expected to reach about 3,300 MW. This represents about 8 percent of total installed capacity.

Table 3.2.2-1 Installed Wind Capacity and Values at Peak (MW)

Winter Peak	Wind Installed Capacity			Capacity Value at peak
	HQP [1]	HQD [2]	Area Total	
2011 / 2012	212	845	1,057	254
2012 / 2013	212	1,625	1,837	487
2013 / 2014	212	2,274	2,486	682
2014 / 2015	212	2,740	2,952	822
2015 / 2016	212	3,136	3,348	941

[1]: Completely derated in this review.
[2]: 30% Capacity value at peak.

Finally, expected capacity purchases are increased by 100 MW, using the new Variable Frequency Transformer installed at Langlois substation.

Mothballed, Unavailable and Retired Resources

The Gentilly-2 nuclear station refurbishment of (675 MW) previously planned from spring 2011 to fall 2012 was postponed. It is presently planned between spring 2012 and spring 2014.

Tracy oil-fired G.S unit (150 MW) has been retired and the three other units (450 MW) are mothballed. A six months delay is required to have them back in service, if required.

TransCanada Energy's combined cycle G.S in Bécancour (547 MW) is also mothballed. Each summer, Hydro-Québec Distribution has to make a decision as to whether mothballing will be extended for an additional year or whether the plant will be restarted for the coming winter. In a the base case scenario, the mothballing period is planned to end in December 2015. Operations may restart sooner for capacity requirement purposes.

Purchases from NALCOR at Churchill Falls are reduced by 165 MW (from 4,930 to 4,765 MW).

The load impact of interruptible programs was also adjusted downward according to recent estimations of customer's participation (-70 MW).

Summary of Available Resources

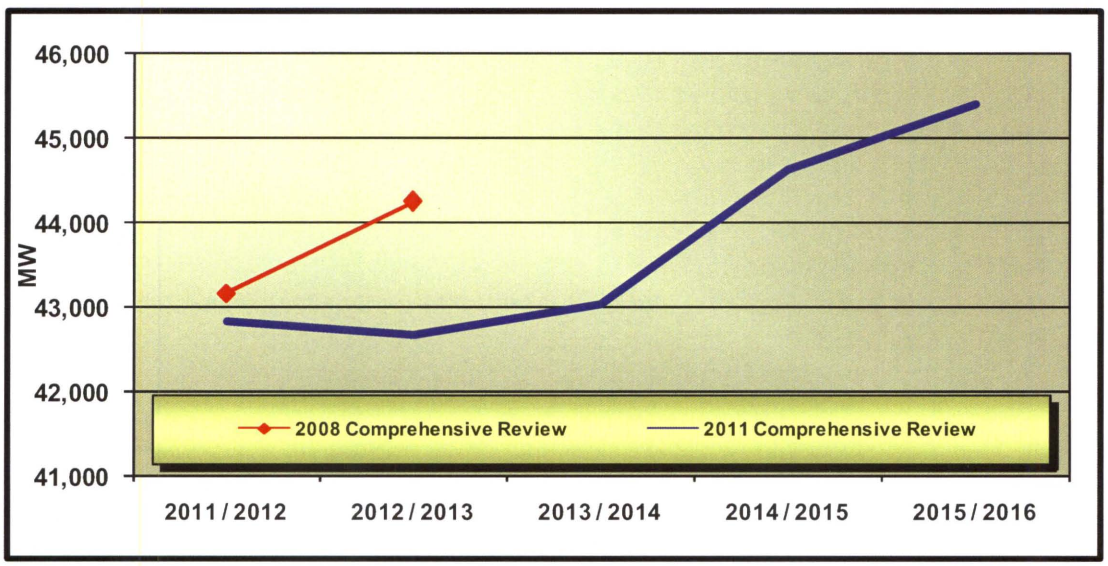
Table 3.2.2-2 and Fig 3.2.2 show the available resources in the Québec area, as forecasted for the horizon covered by this review. They include a comparison with the Forecasted Resources from the previous Comprehensive Review.

Table 3.2.2-2 Comparison of Available Resources 2008 vs 2011 Review (MW)

Winter Peak	2008 Comprehensive Review	2011 Comprehensive Review	Difference
2011 / 2012	43,158	42,828	-330
2012 / 2013	44,236	42,666	-1,570
2013 / 2014		43,029	
2014 / 2015		44,612	
2015 / 2016		45,401	

The difference between the two reviews is -330 MW for the 2011/2012 peak period and -1,570 MW for the 2012/2013 peak period. In conformity with above descriptions, the major factors explaining these differences are the mothballing of Tracy and TCE thermal plants and the rescheduling of Gentilly II nuclear plant refurbishment. These impacts are partially offset by the contribution of wind power which is newly introduced.

Figure 3.2.2 Comparison between 2008 and 2011 Resources Assumptions



4. RESOURCE ADEQUACY CRITERION

4.1 Statement of Resource Adequacy Criterion

In the Québec Balancing Authority Area the NPCC resource adequacy criterion from Directory #1– Design and Operation of the Bulk Power System is used to assess resource adequacy. This criterion reads as follows :

> « The probability (or risk) of disconnecting firm load due to resource deficiencies shall be, on average, not more than one day in ten years as determined by studies conducted for each Resource Planning and Planning Coordinator Area. Compliance with this criterion shall be evaluated probabilistically, such that the loss of load expectation (LOLE) of disconnecting firm load due to resource deficiencies shall be, on average, no more than 0.1 day per year. This evaluation shall make due allowance for demand uncertainty, scheduled outages and deratings, forced outages and deratings, assistance over interconnections with neighboring Planning Coordinator Areas, transmission transfer capabilities, and capacity and/or load relief from available operating procedures. ».

4.2 Statement of How the Criterion is Applied

The reliability criterion is used to assess the adequacy of available resources to reliably supply the Québec area's electricity needs. Also, it is used to establish the appropriate Québec Area Required Reserve Margin.

Consideration can be given to Québec's interconnections with New Brunswick, Ontario, New York and New England and the resultant potential for firm capacity purchases which can be assumed. However, for this study, interconnection assistance was not considered to meet the NPCC reliability criterion. More details on this issue are provided in section 5.1.

Generating unit scheduled and forced outages have been assessed by considering actual historical outage data for the 2006-2010 period.

Before any load disconnection will occur, a series of emergency operating procedures (EOPs) will be invoked. In order to properly represent the system operation, EOPs are modeled considering their dispatching order and the amount of load relief or capacity increase. Table 4.2 summarizes the assumptions regarding the load relief from EOPs used for this study.

Table 4.2 Emergency Operating Procedures

STEP	PROCEDURE	EFFECT	IMPACT VALUE IN MW
1	Interruptible Load Program	Load Relief	1,430
2	Emergency Purchases	Increase Capacity	Varies
3	30-Minute Reserve Reduction	Allow Operating Reserve to decrease	500
4	Voltage Reduction	Load Relief	250
5	10 Minute Reserve to the minimum of 250 MW of spinning reaserve	Allow Operating Reserve to decrease	750
6	Customer Disconnection	Load Relief	As needed

4.3 Resource Requirements to Meet Criterion

For the purposes of this study, the adequacy of Québec area existing and planned resources is assessed through calculation of the annual LOLE and compared with the 0.1 days/year criterion prescribed by the NPCC Directory #1. The resulting Reserve Margin is therefore set as the Québec Area Reserve Margin Reference. Simulation results show that the Reference Reserve Margin for the 2011/2012 winter peak is about 10 percent.

4.4 Comparison of Québec and NPCC Criteria

The Québec Balancing Authority Area reliability criterion for this review is the same as the NPCC criterion, as defined in Section 4.1.

4.5 Resource Adequacy Studies Done Since the 2008 Review

Every year, Hydro-Québec Distribution produces a report on resource adequacy for the Québec Balancing area.

Moreover, every 3 years, Hydro-Québec Distribution submits to the Québec Energy Board, a Supply Plan which outlines, among other things, a resource adequacy evaluation limited to Hydro-Québec Distribution (which is responsible for all internal load supply in the Quebec area) demand and supply positions on a 10-year time horizon. This report does not include internal suppliers positions regarding their exports to neighbouring areas.

Furthermore, for each of the two years following the Supply Plan, HQD files a Progress Report, which includes updated information on demand forecasts, resource availability and a reliability assessment update.

5. RESOURCE ADEQUACY ASSESSMENT

5.1 Reliability Assessment Based on Base Case Demand Forecast

Table 5.1.1 shows the LOLE evaluations for the Base Case demand forecast. According to these results, the Québec area will have adequate resources to meet the NPCC criterion through 2015/2016 winter peak period. This was achieved with the inclusion of 1,100 MW of winter firm capacity purchases.

Each year, the Load Serving Entity (HQD), which is responsible for resource adequacy in Québec, will purchase the required amount of capacity on the markets to meet its requirements. In order to secure the appropriate access to capacity located in neighboring areas, HQD has designated the Massena-Châteauguay (1,000 MW) and the Dennison-Langlois (100 MW) interconnections to meet its resource requirements during winter peak period. The Quebec balancing area limits its planned capacity purchases to capacity accessible from summer peaking neighbouring areas having an organized market structure.

Tie benefit potential for the Quebec area in 2015, which is estimated at 2,900 MW[1], is then not used to comply with resource adequacy criterion.

Results show that the required reserve margin of the Québec area for the 2011/2012 winter peak is around 10 percent.

Table 5.1.1 Planned Resources to meet criteria under Base Case Demand Forecast

Winter Peak	Planned Resources (MW)	Annual peak load (MW)	Planned Reserve			Required Reserve		
			MW	%	LOLE (Days/year)	MW	%	LOLE (Days/year)
2011 / 2012	42,828	37,789	5,039	13.3	0.010	3,638	9.6	0.100
2012 / 2013	42,666	38,248	4,418	11.6	0.064	3,818	10.0	0.100
2013 / 2014	43,029	38,660	4,369	11.3	0.079	4,059	10.5	0.100
2014 / 2015	44,612	39,149	5,463	14.2	0.034	4,448	11.4	0.100
2015 / 2016	45,401	39,313	6,088	15.7	0.021	4,805	12.2	0.100

5.2 High Case Demand Forecast

For the year 2011-2012, the high load scenario is approximately 700 MW higher than the base case load forecast and the difference reaches 2,000 MW for the winter 2015-2016.

[1] NPCC CP-8 Working Group, Review of Interconnection Assistance Reliability Benefits, April 2011, 18 pages. Reported results are based on At "Criteria" assumption.

On average over the forecast period, Québec load is expected to increase by about 1.8 percent annually under the high case demand forecast.

For the last years covered by this review, a significant part of the gap between base case and high case is due to large industrial projects which require special approval for normal tariff application. The rest of the difference is driven by population growth, internal consumption of goods and services, exports, general economic activity and the price of fossil fuels.

The upper bound of the high case scenario has ten percent probability of being exceeded. This is an extreme level that could occur if the economy will show a strong growth.

5.2.1. LOLE Values, High Case Demand Forecast

Table 5.2.1 shows that under the high case demand forecast, the Québec area will have adequate resources to meet reliability criterion of 0.1 days/year of loss of load expectation for the peak periods 2012, 2013, 2015 and 2016 of this assessment. However , the balancing area would need additional resources to achieve reliability level for the peak period 2014.The additional resources needed are estimated to be around 350 MW. Available resources in such a scenario are described in section 5.3.

Table 5.2.1 shows the planned resources to meet criteria under the high case load forecast.

Table 5.2.1 Planned Resources to meet criteria under High Case Demand Forecast

Winter Peak	Planned Resources (MW)	Annual Peak Load (MW)	Planned Reserve		
			MW	%	LOLE (Days / year)
2011 / 2012	42,828	38,491	4,337	11.3	0.028
2012 / 2013	42,666	39,196	3,470	8.9	0.091
2013 / 2014	43,029	39,856	3,173	8.0	0.161
2014 / 2015	44,612	40,674	3,938	9.7	0.080
2015 / 2016	45,401	41,312	4,089	9.9	0.076

5.3 Contingency Mechanisms for Managing Demand and Resource Uncertainties

Supply planning involves some uncertainty related to demand as well as resources. The latter could be limited (few counterparts) or insufficient in relation to the required quantities.

If, in any case, the expected required reserve would fall below critical level, it is possible to call back, within a 6 months delay, some resources which are considered mothballed in this review (TCE combine cycle plant and Tracy oil fired generation). Both resources would add approximately 1,000 MW of installed capacity in the Québec area. These resources are not included in the simulations presented in section 5.2.1. Moreover, in a high case scenario, additional call for tenders could be launched.

5.4 Impacts of Major Proposed Changes to Market Rules on Area Reliability

In the Quebec area, there are no structured short term (daily, hourly or real time) electricity market. Most of new supplies are contracted by HQD through long term PPAs. Neither the quantity of available capacity nor the energy dispatched are based on market ability to react to price signals. There are no expected changes to the existing electricity market structure.

6. PROPOSED RESOURCE MIX

6.1 Reliability Impacts of Capacity Mix, Demand Resource Response, and Transportation or Environmental Considerations

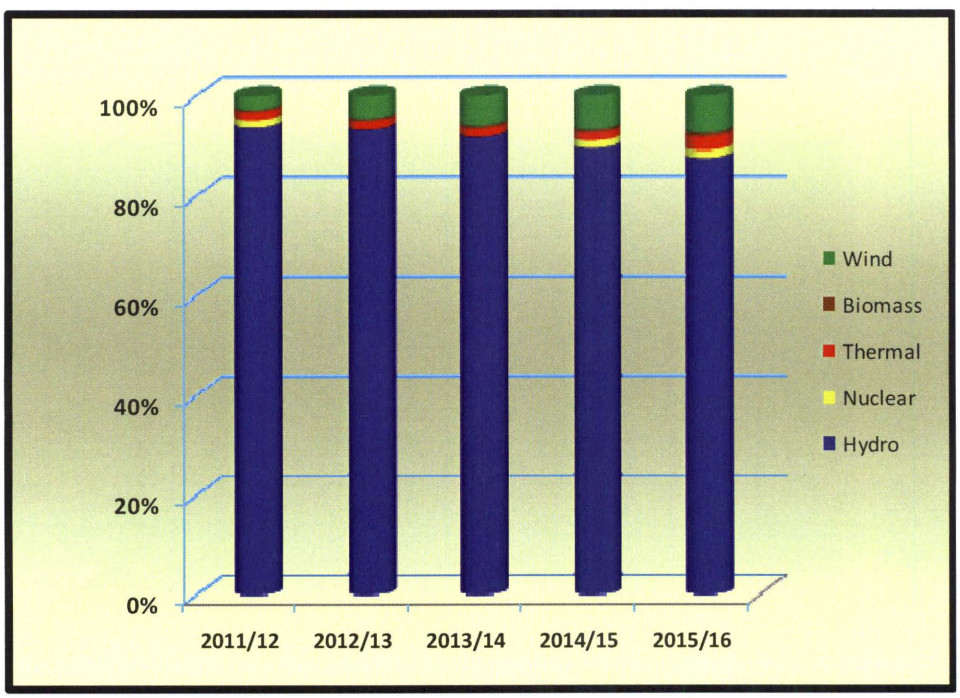
Table 6.1 and Figure 6.1 show the expected available generation capacity mix at winter peak period for each year of this review. The information regarding existing and future resources as of September 2011 have been used for this evaluation.

Table 6.1 Québec Available Capacity Mix by Fuel Type (MW)

Fuel Type	2011 / 2012	2012 / 2013	2013 / 2014	2014 / 2015	2015 / 2016
Hydro	39,393	39,567	39,684	40,377	40,450
Nuclear	620	0	0	700	700
Thermal	716	716	716	716	1,263
Biomass	165	216	267	317	367
Wind [1]	1,057	1,837	2,486	2,952	3,348
Total	41,951	42,336	43,153	45,062	46,128

[1]: For wind, theses numbers correspond to installed capacity.

Figure 6.1 Québec Available Capacity Mix by Fuel Type (%)



6.2 Available Mechanisms to Mitigate Reliability Impacts of Capacity Mix, Demand Resource Response, Transportation and/or Environmental Considerations

Québec area's energy requirements are met for the greatest part by hydro generating stations, located on different river systems and scattered over a large territory. The major plants are backed by multiannual reservoirs (water reserves lasting more than one year).

Due to those multi-year reservoirs, a single year of low water inflow cannot adversely impact the reliability of energy supply. However, a series of few consecutive dry years may require some operating measures as the reduction of exports, or the start-up of Tracy thermal plant which is presently mothballed.

To assess its energy reliability Hydro-Québec has developed an energy criterion stating that sufficient resources should be available to go through a sequence of 2 consecutive years of low water inflows totalling 64 TWh or a sequence of 4 years totalling 98 TWh, and having a 2 percent probability of occurrence. The use of operating measures and the hydro reservoirs should be managed accordingly. Reliability assessments based on this criterion are presented three times a year to the Québec Energy Board. Such documents can be found on the Régie de l'Énergie du Québec website[2].

Fuel supply and transportation is not an issue in Québec. With the exception of Trans-Canada Energy plant (547 MW) which is presently mothballed, fossil fuel generation is used for peaking purpose only and adequate supplies are stored nearby.

Under normal contract provisions, TCE should be operated with firm gas transportation service, in order to ensure the appropriate gas supply over the winter season.

No other conditions that would create supply reductions are expected for the period covered by this assessment.

6.3 Reliability Impacts Related to Compliance with Provincial Requirements

Few years ago, the province of Québec became a member of Western Climate Initiative (WCI). According to the Québec commitments regarding WCI, a system of emission rights has to be implemented in the upcoming years. A preliminary version of rules

[2] http://www.regie-energie.qc.ca/audiences/Suivis/Suivi_HQD_CriteresFiabilite_D-2008-133.html

driving such emission rights was published last summer and provisions included would impose emission fees to electricity generators. However, according to these preliminary provisions, there is no emission cap imposed for electricity industry. Thus, the reliability of supplies from thermal plants would not be adversely affected.

Moreover, in Quebec, the electricity generation is predominantly hydro. Indeed, over 90 percent of production is hydroelectric. Emissions of greenhouse gases from this type of generation, is negligible compared to other generation sources such as combine cycles using natural gas.

APPENDIX : DESCRIPTION OF RESOURCE RELIABILITY MODEL

APPENDIX

The GE MARS model is used for the purpose of this review. This model uses a sequential Monte Carlo simulation to assess the reliability of a system comprised of a number of interconnected areas containing generation and load. This Monte Carlo process simulates each targeted year repeatedly (multiple replications) to evaluate the impacts of a wide range of possible random combinations of load and generator outages. The transmission system is modeled in terms of transfer limits (constraints) on the interfaces between interconnected areas.

Chronological system operating margins are developed by combining randomly generated operating states of the generating units and inter-area transfer limits with the hourly chronological loads. The model can compute various reliability measurements, including Loss Of Load Expectation (LOLE) which is selected as the principal reliability metric.

For each hour of the year, the program computes the isolated area margins based on the available capacity and demand in each area. GE MARS then uses a transportation algorithm to determine the extent to which areas with negative margin can be assisted by areas having positive (excess) margin, subject to the available transfer constraints between the areas. The program collects the statistics for computing the reliability indices, and proceeds to the next hour. After simulating all of the hours in the year, the program computes the annual indices and tests for convergence. If the simulation has not converged to an acceptable level, it proceeds to another replication of the year under study.

1. LOAD MODEL

1.1 Description and Basis of Period Load Shapes

GE MARS model employs an 8760 hours chronological subarea load model. The load model currently used relies on an actual year of historical loads of 2002/2003. This model is then scaled up to the winter peak for the future years being analyzed.

The Québec peak load forecast is based on normal weather conditions. For this purpose, a 36 year long reference period (1971-2006) is used to assess average temperatures. Historical temperature data are adjusted for a global warming effect of 0.30℃ (0.54℉) per decade starting in 1971. Moreo ver, each year of historical climatic data is shifted up to ±3 days to gain information on conditions that occurred during either a weekend or a week day. Such an exercise generates a set of 252 different demand scenarios. The base case scenario is the arithmetical average of the peak hour in each of those 252 scenarios.

1.2 Load Forecast Uncertainty

Load Forecast Uncertainty (LFU) includes weather and load uncertainties. The same set of 252 scenarios described here above are used to assess demand uncertainties resulting from weather. Load uncertainty is due to the inherent inability to perfectly forecast economic variable evolution, demographics, energy and inherent modeling errors. These variables impact the demand forecast. Overall uncertainty is defined as the independent combination of climatic uncertainty and load uncertainty.

In the MARS model, load forecast uncertainty is modeled through the load forecast multipliers. These multipliers are directly derived from the distribution of the load. For each multiplier, a probability of the load level occurring is associated. There is a set of seven probabilities that allows to represent adequately the distribution of the load. The probability distribution of the load is assumed to follow a normal distribution with slight asymmetry. The analysis of the distribution of the load has shown that the probability that the forecast exceeds two standards deviation is very low. Therefore, for load uncertainty modeling purposes, an asymmetric normal distribution limited to two standards deviations is assumed. Reliability indices were calculated at each load level around the mean value (mean, mean -2SD, mean - 1.77SD, mean ±0.88SD, mean +1.97SD, mean+2SD) .

1.3 Demand and Energy Projects of Interconnected Entities

The loads and resources of interconnected entities within the area that are not members of the area were not considered.

1.4 Demand -Side Management

The demand forecast presented in section 3.2.1 takes into account the impact of energy savings on sales and capacity requirements. These consist of:

- Energy efficiency trends already included in the demand forecast models;
- The programs implemented in the past;
- The energy efficiency measures to be deployed and those remain active during the five years covered by this review.

Forecasts also take into account the load shaving resulting from residential dual energy. This program is handled in the same way as energy savings: it is not included as a resource but its impact on peak demand (870 MW) is included in demand forecasts.

Other interruptible load programs specifically designed for peak shaving and fully dispatched by the system operator are included as resources.

In the area of load management and peak shaving, new opportunities can be created by the introduction of advance metering infrastructures and are not taken into account in the forecast used in this review.

A better temporal understanding of customers' consumption profiles will allow Hydro-Québec Distribution to take advantage of new opportunities and develop solutions that take the customers' situation into account, while being beneficial for both the customer and Hydro-Québec Distribution. Hydro-Québec Distribution will also be able to provide its customers with equipment, accessories and measurements in relation to their behavior.

Hydro-Québec Distribution recently filed an application to obtain approval for a remote-metering project. This project consists in replacing the existing fleet of meters over the short term, installing an advanced metering infrastructure, and deploying a telecommunications platform. If the Régie de l'énergie du Québec approves this major project, Hydro-Québec Distribution will be able to identify promising business opportunities and possibly develop load management options provided that these meet actual customers' needs in a cost-effective manner. In the meantime, Hydro-Québec Distribution will be pursuing its monitoring and prospecting activities.

Table A-1.4 Incremantal Impact of Energy Savings on Forecasted Winter Peak Power Requirements (in MW)

Winter Peak	Energy savings (MW)
2011 / 2012	110
2012 / 2013	280
2013 / 2014	440
2014 / 2015	600
2015 / 2016	760

2. SUPPLY-SIDE RESOURCE REPRESENTATION

The MARS model has the capability to model different types of resources used in the Quebec area: hydroelectric, thermal, wind and demand management resources.

For each generation unit modeled, the installation and retirement dates and planned maintenance requirements must be specified. Other data such as maximum rating, forced outage rates, and net modification of the hourly loads depend on the unit type. The planned outages for all types of units in the MARS model can be specified by the user or automatically scheduled by the program on a weekly basis.

2.1.1. Definitions

For Hydro units with installed Capacity larger than 30 MW, *Demonstrated Maximum Net Generating Capability* (DMNC) is defined as the net output a unit can sustain over a specified period modified for month limitations. The DMNC can sustain two consecutive hours per month, for the period October through May, and four consecutive hours per month, for the period June through September. This definition may seem optimistic but proper use of the reservoirs usually make this capacity available daily. DMNC varies from month to month. Beauharnois (1,727 MW), Les Cèdres (119 MW) and Carillon (602 MW) generating stations are not modeled according to this definition. The specific treatment for these power stations will be discuss in section A.4.

For Hydro units with installed capacity less than 30 MW, DMNC is defined as the average power based on operational historical generation.

For thermal units, DMNC is defined as the net output a unit can sustain over a two consecutive hour period. DMNC varies from one month to another subject to ambient temperature changes.

2.1.2. Procedure for Verifying Ratings

Ratings of generating unit are revised periodically. Hydro Unit Ratings are based on operational historical values and are reviewed at least annually. At the time of this ratings revision, if needed, the new data on turbine efficiency measurements, the updated operating water head and the temperature of generator cooling water are taken into account. Unit testing are also performed on an as-needed basis.

Thermal Unit Ratings are reevaluated at each unit performance test.

2.2 Unavailability Factors Represented

2.2.1. Type of Unavailability Factors Represented

Planned maintenance was modeled on a unit basis. Typical monthly percentage maintenance for Hydro units is used. The percentage is applied on the total hydro capacity available (except Beauharnois and Les Cèdres units). Thermal power plants are on maintenance during summer and each plant has its own maintenance schedule.

2.2.2. Source of Unavailability Factors Represented

Equivalent Demand Forced Outage Rate (EFORd) for existing generators are based on actual outage data reflecting historical evolution over the period 2006-2010.

New generators EFORd are based on similar generators with historical data as well as on the data provided by the manufacturer and with the conjunction with averages compiled by the Canadian Electricity Association (CEA) and NERC GADS.

2.2.3. Maturity Considerations and In-Service Date Uncertainty

The reliability model accounts for maturing units. Forced outage rates of new units are higher for the first operational years.

No uncertainty is modeled over the commissioning date of the planned generating units.

Regarding the new hydro units over 30 MW to be commissioned during the period under review, all government permits have been received and the construction is in progress at all of those generating units. No construction delays are expected so there is no uncertainty related to the in-service date. Available capacities of each station are modeled with latest available data. Maintenance, restrictions and outages are taken into account.

Regarding small renewable projects, most of them didn't receive all required government permits. However, the likelihood that these projects receive all required permits is high. Data on these projects are continuously updated to reflect the day to day evolution.

2.2.4. Tabulation of Typical Unavailability Factors

The ranges of EFORds used in this evaluation are presented in Table A-2.2.4. These forced rates values are computed over the period 2006-2010

Table A-2.2.4 Québec Area Forced Outages Rates

Unit Type	EFORd (%)	
	Range of EFORd	Weighted Average EFORd
Hydro	0.04 - 9.04 [1]	1.34
Nuclear	6.91	6.91
Thermal	4.45 - 4.48	4.47
Biomass	N/A	N/A
Wind	N/A	N/A

[1] : The higher value of outage rate is due to a particular event in SM-3 plant where one unit has been out of service for all year long.

2.3 Purchase and Sale Representation

Purchases and sales are represented as an adjustment to the load (load modifiers).

2.4 Retirements

One unit of Tracy oil fired thermal plant (150 MW) is retired.

3. REPRESENTATION OF INTERCONNECTED SYSTEMS

The Québec Area is a separate Interconnection from the Eastern Interconnection, into which the other NPCC Areas are interconnected. TransÉnergie, the main Transmission Owner and Operator in Québec, has interconnections with Ontario, New York, New England and the Maritimes.

There are back to back DC links with New Brunswick at Madawaska and Eel River (in New Brunswick), with New England at Highgate (in New England) and with New York at Châteauguay. The Radisson – Nicolet – Sandy Pond HVDC line ties Québec with New England. Radial load can be picked up in the Maritimes by Québec at Madawaska and at Eel River and at Stanstead feeding Citizen's Utilities in New England. Moreover, in addition to the Châteauguay HVDC back to back interconnection to New York, radial generation can be connected to the New York system through Line 7040. The Variable Frequency Transformer (VFT) at Langlois substation connects into the Cedar Rapids Transmission system, down to New York State at Dennison. The Outaouais HVDC back to back converters and accompanying transmission to the Ottawa, Ontario area are now in service. Other ties between Québec and Ontario consist of radial generation and load to be switched on either system.

Interconnection capacities are established by inter-Area and intra-Area studies as deemed necessary. Table A-3 below shows present interconnection Normal Transfer Capability.

Table A-3 Québec Area Interconnections Limits

Interconnection	Flows Out of Québec (MW)	Flows Into Québec (MW)
New Brunswick	1,029	770
Ontario	2,795	2,055
New England	2,255	170 *
New York	1,668	1,100

*: Transfer capability at Quebec area winter peak period

These limits recognize transmission or generation constraints in both Québec and its neighbors. They are reviewed periodically with neighboring systems and are posted in NPCC Reliability Assessments. For the purpose of this review, the import capability of HVDC Sandy Pond – Nicolet interconnection has been excluded due to its non availability during peak period. Moreover, these limits do not correspond to TTC or ATC values posted on the OASIS; they are only intended to offer a global picture of transfer capabilities to the readers of this assessment.

4. MODELING OF VARIABLE AND LIMITED ENERGY RESOURCES

For most hydro units, energy limitations are considered by using a different value of dependable maximum generating capability (DMNC) for each month accounting the reservoir variation effect on the net head and the generator cooling water temperature. Unlike reservoir hydro units, the run-of-river Beauharnois and Les Cèdres units are operated in parallel on the St. Lawrence river. Their capability depends on water availability and varies according to seasons. Also, during ice cover formation, capacity output must be reduced. Additionally, generation is affected by navigation constraints on the St. Lawrence river. Available water can be channeled through either Les Cèdres or Beauharnois. As the latter station is more efficient, priority is then given to generation at Beauharnois, leaving less water available for Les Cèdres.

Beauharnois and Les Cèdres are modeled in a separate tool, design for this specific purpose. It takes into account a probability distribution based on operational historical generation, This model accounts not only for water restrictions but also for maintenance and forced outages. The results are then transposed in the MARS model which is used for unforced outages simulations.

All wind generation units were considered available to meet daily and monthly peak loads except when they are on planned maintenance or forced outages. A 30 percent value at peak of installed capacity was retained for the wind units under contract with HQD. A specific study supporting this result was conducted three years ago. An approach similar to Effective Load Carrying Capability using chronologically matched data of load and wind power over a 36 years period was applied. The results were presented both to NPCC CP-8 WG and to the Régie de l'Énergie du Québec.

The wind units under contract with HQP are de-rated by 100 percent.

5. MODELING OF DEMAND SIDE RESOURCES AND DEMAND RESPONSE PROGRAMS

For the resource assessments, MARS runs were modeled with the most updated demand response capacity. Forecasted demand takes into account the impact of energy savings and dual energy programs, as described in section 1.4 of the Appendix.

Demand response programs fully dispatched by the system operator are included as resources. In this regard, the Québec area has two types of demand response resources totalling 1,680 MW specifically designed for peak shaving during winter operating periods.

The first type of demand response resource is the interruptible load program, mainly design for large industrial customers. It has an impact of 1,430 MW on peak demand. The second type of demand response resource consists of a voltage reduction scheme having a 250 MW of demand reduction at peak.

Both of these demand response resources are modeled as emergency operation procedures.

6. MODELING OF ALL RESOURCES

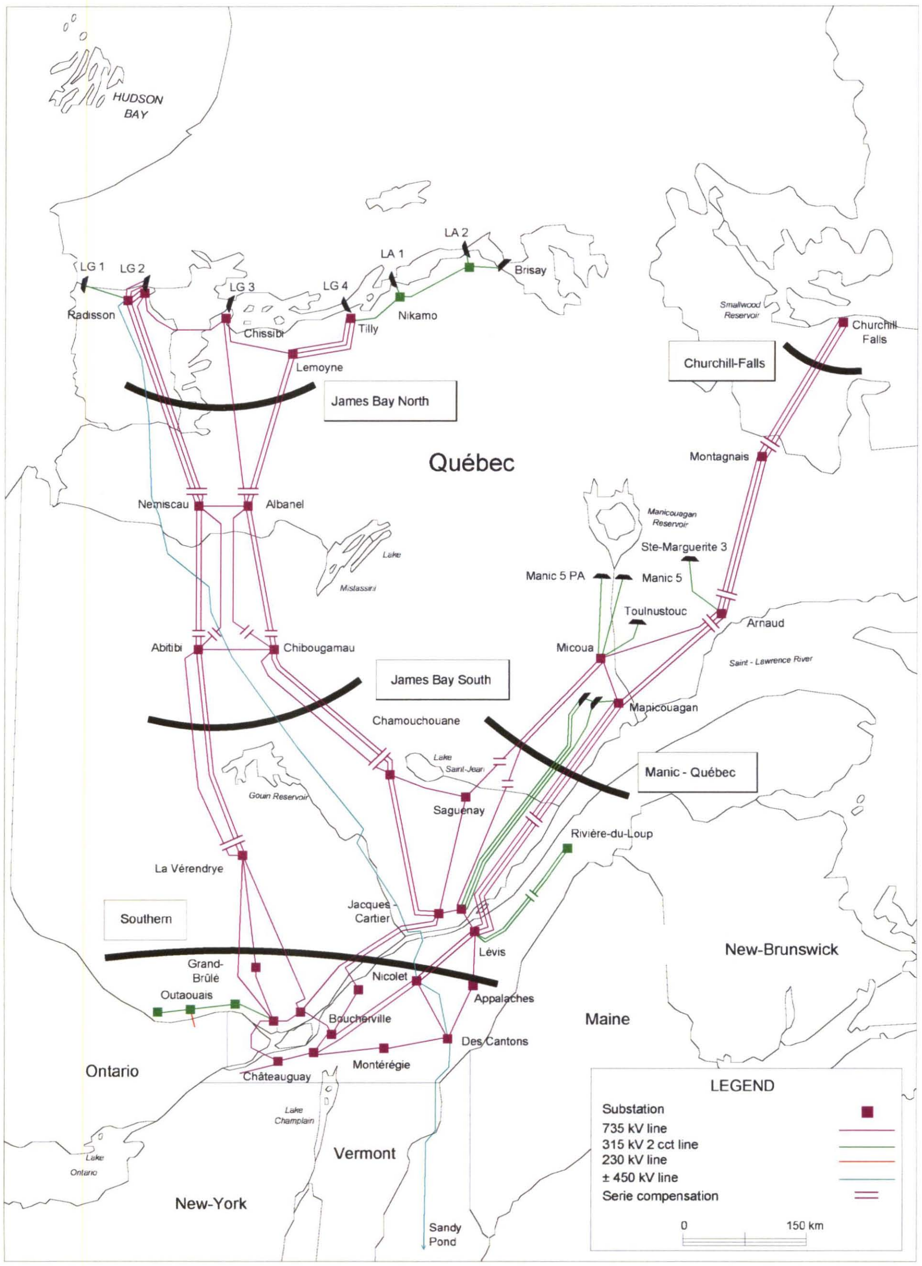
Modeling of resources was as described in the above sections.

7. OTHER ASSUMPTIONS

7.1 Internal Transmission Limitations

The Hydro-Québec Transmission System has five major interfaces where operating limits are defined. The following figure shows the system and its interfaces.

Figure A-7.1 TransÉnergie's 735-kV Transmission System and Interfaces



As can be seen in Figure A-7.1, the system consists of two major branches – one emanating from the La Grande Generation Complex (Western branch) and the other emanating from Churchill-Falls (Eastern branch). These branches join in the southern part of the system near Québec City. The Churchill-Falls branch also picks up generation in the Manicouagan and Outardes complexes. At that point, the Eastern branch goes up from three to five 735-kV lines. Therefore, the Manic – Québec Interface is defined there. Some load is dropped at the Québec City level, but a large amount of generation from both branches is transferred downstream to the Greater Montréal Area. This is where the Southern Interface is defined.

On the Western branch, generation is integrated at the Némiscau substation and load is dropped off at the Abitibi and Chibougamau level, so the James Bay South Interface is defined there.

About 70 % of the internal load is downstream of the Southern Interface whereas most of the generation is upstream. Moreover, most of the interconnections with neighboring Areas except Maritimes and Northern Ontario are also downstream of the Southern Interface.

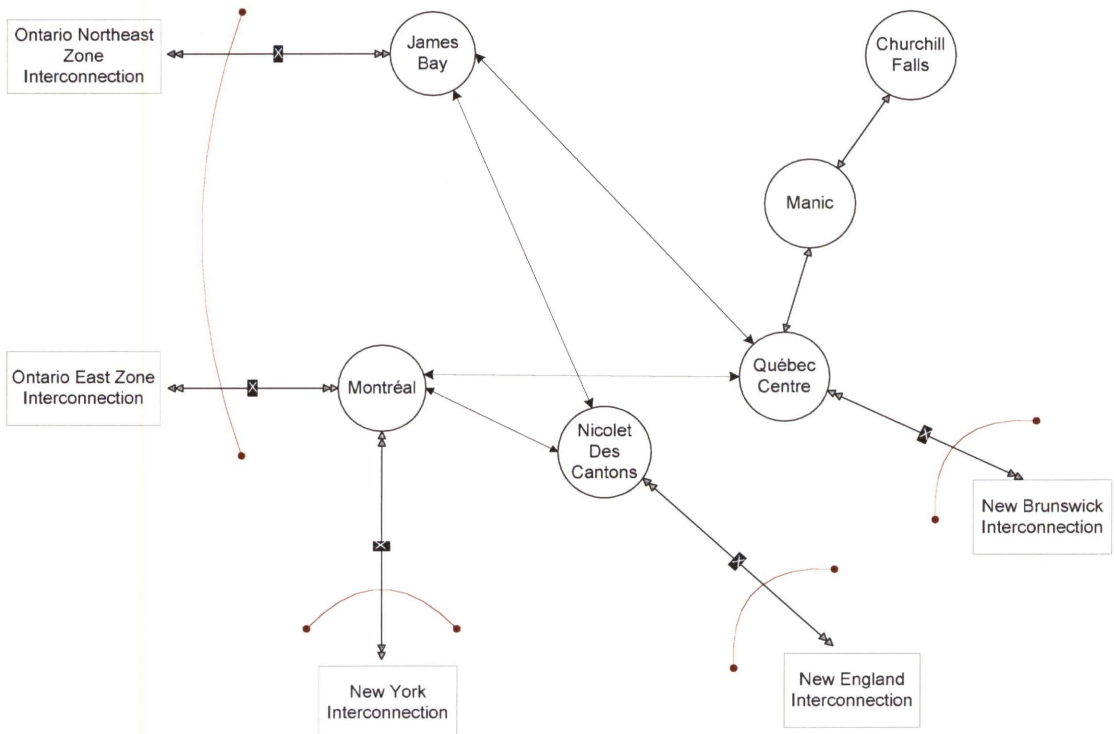
The James Bay North and Churchill-Falls operating limits are defined by transient stability considerations. The James Bay South and Manic-Québec operating limits are defined by both transient and long term stability (voltage stability) considerations. The Southern Interface operating limits are set by voltage stability considerations as well as steady state load flow limits set by available voltage support as a function of the load around the Greater Montréal area. Another interface, somewhat distinct from the others, is defined for the Radisson-Nicolet HVDC line.

For the purpose of this Resource Adequacy Review, the system has been modeled (through the MARS software) into six sub-areas. The areas are each connected by a single line which represents an actual interface. Figure A-7.2 shows this model and Table A-7 shows internal transmission limits used in the model. Actual transmission limits vary continuously as system conditions change over time.

Table A-7 Internal Transmission Limits

Sub area		2008 Comprehensive Review	2011 Comprehensive Review	
From	To		2011/12 winter peak period	2015/16 winter peak period
Churchill Falls	Manicouagan	5,200	5,200	5,200
Manicouagan	Québec Centre	11,750	12,100	12,900
Québec Centre	Montréal	17,750	18,000	22,290
Baie James	Québec Centre	13,800	14,100	15,050
Baie James	Nicolet (CC)	2,250	2,250	2,250
Nicolet (CC)	Montréal	2,138	2,138	2,138

Figure A-7.2 Québec's Internal Interfaces and Interconnections



During the planning process, congestion is not planned into the transmission system, meaning that all generation is integrated on a firm basis at the forefront. Presently, the Romaine generation complex is under construction (640 MW in 2014 and ultimately 1,550 MW in 2020) and a number of wind plants will be coming online through 2015. Consequently, transmission projects are currently under construction and others are planned to integrate this new generation and maintain reliability.

For the 2011/2012 winter peak period, modeled internal transmission limits are close to the previous Comprehensive Review's limits with minor adjustments. For the last year of this review, internal transmission limits are expected to increase as additional generation is commissioned (hydro, wind, biomass), reflecting various transmission projects. Details are available from the NPCC Interim Review of the Québec Transmission System for 2016, approved by the Task Force on System Studies (TFSS) on September 15, 2011. Table 5, pages 13 and 14, lists transmission projects through 2016.

8. RELIABILITY IMPACTS OF MARKET RULES

No reliability impacts due to market rules are anticipated in this review. (see section 5.4)