# 2008 QUÉBEC AREA

# COMPREHENSIVE REVIEW

# OF RESOURCE ADEQUACY

**Approved by the RCC, March 11, 2009**

**Prepared by**

**Planning and Reliability**

**Direction Electricity Supply**

**Hydro-Québec Distribution**

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# 1. EXECUTIVE SUMMARY

## 1.1. Major Findings

This 2008 Québec Comprehensive Review of Resource Adequacy is submitted to the Northeast Power Coordinating Council (NPCC) and prepared in accordance with "Guidelines for Area Review of Resource Adequacy", document B-8 revised November 29th, 2005. As in the previous review, this review shows that the Québec Area has the ability to meet the NPCC reliability criterion for the next five planning years (November 2008 through October 2013). Each planning year, corresponding to a full hydraulic cycle, begins November 1st and ends October 31st of the following calendar year.

The information presented covers November 2008 to October 2013 and is based on the Hydro-Québec 2008 load forecast according to the 2008-2017 Procurement plan progress report filed with the Québec Energy Board on October 31st, 2008. The load forecast also includes all Hydro-Québec Production's sale contracts. Related documents can be found at the following internet address:

http://www.regie-energie.qc.ca/audiences/EtatApproHQD/Etat-avancement_2008_31oct08.pdf

The peak load forecast for 2008-2009 is set at 37,099 MW, about 355 MW lower than forecasted in the 2005 Québec Comprehensive Review. The winter peak load is forecasted to grow at a compound annual growth rate of 1,50% to reach 39,375 MW in 2012-2013. The planned resources are forecasted to grow a bit slower than the load over this period (compound average growth rate of 1.41 %). For the 2008-2009 winter peak, the planned resources are 41,827 MW. This is 1,000 MW less than the previous Comprehensive Review. In 2012-2013, the planned resources are estimated to be 44,238 MW, an anticipated increase of 2,400 MW over the period under review, including the return in service of the TransCanada Energy's natural gas unit in Bécancour (547 MW) and the short term purchases of Hydro-Québec Distribution.

Even if the anticipated increase in resources is lower than the anticipated load increase, the resource increase is more than sufficient to maintain the planned reserve over the required reserve by more than 1,000 MW for the next three years and around 250 MW for the last two years of the assessment period. This Comprehensive Review indicates that the required reserve margin varies in a range of 9.7 % in 2008/09 to 11.7 % in 2012/13 in order to meet the NPCC reliability criterion of a maximum 0.1 day per year of Loss of Load Expectation (LOLE). The planned reserve margin varies in a range from 12.6 % in 2008/09 to 13.7 % in 2010/11.

In the previous 2005 Québec Comprehensive Review, a tie benefits value of 500 MW was included for planning purpose. Each fall before the winter period, Hydro-Québec Distribution re-assesses the needs for short term purchases of capacity and transmission.

In this 2008 Québec Comprehensive Review, tie benefits is replaced by short term purchases and increased to 1,000 MW. Hydro-Québec Distribution has reserved 1,000 MW of transfer capacity over the Châteauguay-Massena interconnection (Line 7040) for a period of 5 years. Before each winter period, when needed, Hydro-Québec Distribution will contract the required capacity for the corresponding winter. For planning purposes, both Hydro-Québec Production and the New York Control Area are expected to sell the required capacity. For the 2008/2009 winter, Hydro-Québec Distribution will buy 340 MW of UCAP [(1)].

In this Review, wind power is completely derated.

The refurbishment of Gentilly-2 nuclear power plant (675 MW) will start in 2011 for a return-to-service in late 2012.

The effective contribution of the Hydro-Québec Distribution's interruptible load program has been upgraded from 70 % of the contracted capacity to 85%.

In New England, the Monroe terminal of the Phase I HVDC interconnection has been retired on March, 31st 2007. Power transmission is now possible only through the Phase II Interconnection (Nicolet to/from Sandy Pond substations). To reflect this reconfiguration, the Nicolet-Des Cantons sub area is now calls Nicolet sub area.

[(1)] : The latest demand forecast is lower by 400 MW for the 2008/2009 winter period, therefore no short term purchases are required for that period. This short term purchase is related to Hydro-Québec Distribution's needs.

Major Assumptions and Results

The following table sets major assumptions and results.

**Table I Major Assumptions and Results**

| **Assumptions** | **Description** | |
|---|---|---|
| Study period | Winter 2008-2009 to Winter 2012-2013 | |
| Reliability Criterion | LOLE 0.1 day/year: complying with once in 10 years NPCC criterion | |
| Load Model | 8,760 houtly peak load with uncertainty factors | |
| Program | GE MARS program | |
| Load Growth | 2008-2009 | 2012-2013 |
| - Base Case | 37,099 MW | 39,375 MW |
| - High Case | 37,621 MW | 41,404 MW |
| Required Reserve (% of Total Peak Demand) | 9.7% | 11.7% |
| Resources Addition | 2,400 MW through the study period | |
| Equivalent Forced Outage Rates | 5 years history (2003-2007). Specific EFORd for each power station | |
| - Hydro | 0.3% to 1.8% | |
| - Thermal, including nuclear | 6.5% to 20.5% | |
| Short Term Purchases | Potential of 1,000 MW (mainly from NYCA) | |
| Spinning Reserve | minimum amount of 250 MW | |
| Emergency Operating Procedures | | |
| - Interruptible Load | 1,515 MW through the study period | |
| - Voltage Reduction | 250 MW through the study period | |
| - 10-minute reserve | 500 MW to 0 MW | |
| - 30-minute reserve | 1,000 MW to 0 MW | |
| Maintenance Scedule | see Table A-2 | |
| **Results** | **LOLE Day/year** | |
| | **Base Case** | **High Case** |
| 2008-2009 | 0.033 | 0.058 |
| 2009-2010 | 0.038 | 0.080 |
| 2010-2011 | 0.051 | 0.121 |
| 2011-2012 | 0.088 | 0.257 |
| 2012-2013 | 0.080 | 0.286 |

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# 3. INTRODUCTION

This resource adequacy review is conducted by Hydro-Québec and submitted to the Northeast Power Coordinating Council (NPCC) in accordance with "Guidelines for Area Review of Resource Adequacy", document B-8 revised November 29th, 2005. Hydro-Québec Distribution is the entity responsible for resource planning in Québec. Information related to Hydro-Québec Production and TransÉnergie activities was submitted to Hydro-Québec Distribution for the purpose of this Review.

Information presented in this Review covers November 2008 to October 2013 and is based on the Hydro-Québec 2008 load forecast included in the 2008-2017 Procurement plan progress report filed with the Québec Energy Board on October 31st 2008.

This Comprehensive Review demonstrates that the Québec Control Area will meet the NPCC resource adequacy criterion (i.e. the probability of disconnecting non-interruptible customers due to resource deficiencies shall be, on average, no more than once in ten years) for the period 2008 to 2013 under the base case assumptions.

This NPCC criterion stipulates that Areas shall take into account internal transmission transfer capabilities. The Québec Area is therefore divided into six sub areas (Baie James, Churchill Falls, Manicouagan, Québec Centre, Nicolet and Montréal).

The General Electric Energy "Multi-Area Reliability System" model (MARS) was used to assess the resource adequacy. (See Appendix A for technical information).

## 3.1 Previous Triennial Review

The last Québec Comprehensive Review was submitted in December 2005 and approved by NPCC's Reliability Coordinating Committee (RCC) on March 2006. Québec's resource adequacy was deemed in accordance with the NPCC criterion for resource adequacy.

## 3.2 Comparison of Current and Previous Triennial review

The Québec Control Area is divided into six sub areas to model the major internal transfer constraints. The values provided in Figure 1 and Table 2 below represent the transfer constraints within the Québec system. This model is consistent with TransÉnergie transmission system with the actual 735 kV architecture of the system and its interfaces as defined in NPCC Transmission Reviews

**Baie James sub area**

This sub area is located in the northwest area of the Québec and includes 16,236 MW of generating capacity mainly from the large Baie James hydro-electric complex. The load in this region is relatively small. The peak load forecast for the 2008-2009 winter is

around 1,155 MW. The transfer capabilities from this sub area to the other sub areas are 16,050 MW.

**Churchill Falls sub area**

The Churchill Falls sub area, located in Labrador, represents Hydro-Québec's contractual rights on Churchill Falls hydro generation (4,930 MW during winter months).

**Nicolet sub area**

The Nicolet sub area has no load and is used to model the HVDC Phase 2 interconnection and its transfer capabilities within the Québec system and/or imports/exports with the New England Control Area.

**Manicouagan sub area**

This sub area, in the northeast, includes 8,850 MW of generating capacity and integrates the Churchill Falls (4,930 MW) generation. The Manic-Outardes generation complex (7,886 MW) is located in this sub area. The next peak load forecast for this sub area is 1,835 MW and is mainly driven by large industrial users. The transfer capability from this sub area to the Québec Centre sub area is 11,750 MW.

**Québec Centre sub area**

This sub area includes the Lac St-Jean, Gaspésie, Québec City and Trois-Rivières regions. The peak load is 9,160 MW and the generating capacity is 2,100 MW. This sub area can receive 13,800 MW from the Baie James sub area and 11750 MW from the Manicouagan sub area. The transfer limit between Québec Centre and Montréal is 17,750 MW.

**Montréal sub area**

This sub area, in the south-western of Québec, includes the Montréal, Outaouais, and Estrie regions. The peak load is 23,891 MW, more than 66 % of the total internal load and the generating capacity is 6,213 MW.

**Figure 1 Québec Internal Transmission Transfer Capabilities at 2008/2009 Peak (in MW)**

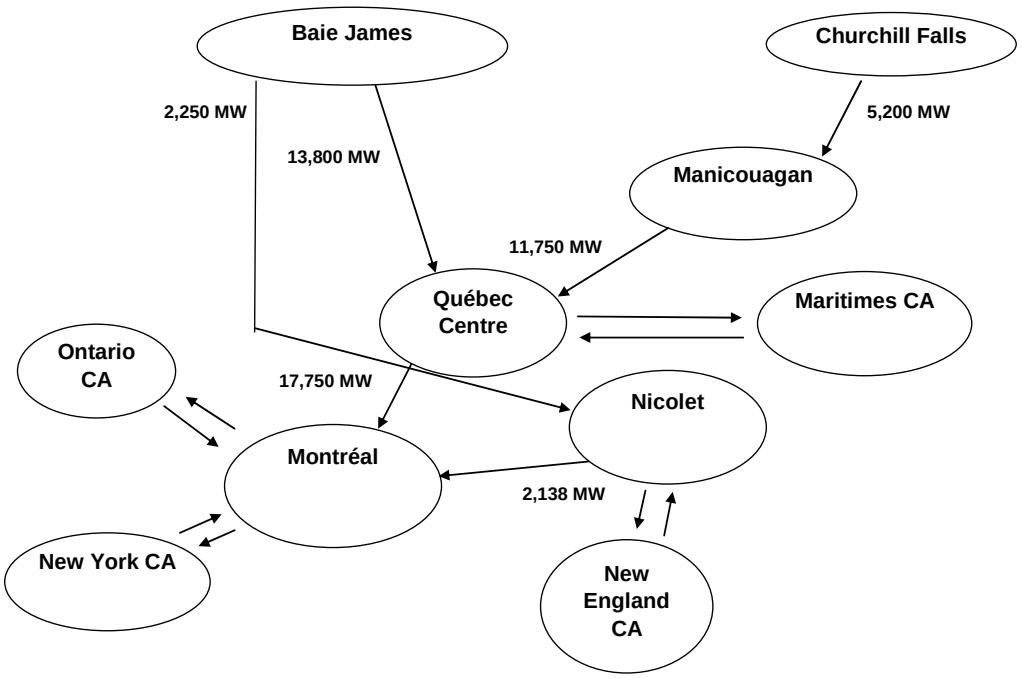



**Table 2 Québec Internal Transfer Capacities**

| Sub area | | Capacity | | | |
|---|---|---|---|---|---|
| Sending | Receiving | MW | # of Circuits | Kv Voltage | Type of Current |
| Churchill Falls | Manicouagan | 5,200 | 3 | 735 kV | AC |
| Manicouagan | Québec Centre | 11,750 | 5 | 735 kV | AC |
| Québec Centre | Montréal | 17,750 | 8 | 736 kV | AC |
| Baie James | Québec Centre | 13,800 | 6 | 737 kV | AC |
| Baie James | Nicolet | 2,250 | 2 | ±450kV | DC |
| Nicolet | Montréal | 2,138 | 2 | ±450kV | DC |

### 3.2.1 Load

The observed peak load for the winter 2007-2008 was 37,941 MW reached on January 21st, 2008 at 8 am, including 2,589 MW of firm sales outside of Québec. This annual peak load was 903 MW higher than forecasted in the previous Québec Comprehensive Review for the same winter year. In this previous Review, capacity sales outside Québec were forecasted to be only 483 MW. Regarding the total internal load, the observed peak was 1,200 MW lower than forecasted. Last year's winter was generally milder than normal, so electric space heating demand was lower than expected.

The shutting down of certain industrial loads such as sawmills and paper mills also accounted for the reduced observed peak load.

In the 2005 Comprehensive Review, the 2008-2009 winter peak load forecast was 37,454 MW and 37,690 MW for the 2009-2010 winter peak (see Table 3 and Figure 2). In the current review, the 2008-2009 winter peak load forecast is set at 37,099 MW and grows at a compound annual growth rate of 1,50 % to reach 39,375 MW by 2012-2013.

Load Forecast Uncertainty (LFU) is a measure of the possible outcome of the load given that variables impacting the load are uncertain. Hydro-Québec Distribution's peak load forecasts are subject to two categories of uncertainty: (1) weather and (2) structural uncertainty caused mainly by the evolution of economic and demographic parameters affecting the load demand. The global uncertainty is the independent combination of these two categories. The global uncertainty, expressed as a percentage of the load is higher in this review than the previous one due to greater uncertainty about the deployment of projects associated with big industrial consumers, including projects in iron, steel and aluminum industries. Also, a higher space heating demand raises weather uncertainty, therefore the global uncertainty.

**Comparison of Load Forecast Uncertainty (%)**

| | Current Year | + 1 Year | + 2 Years | + 3 Years |
|---|---|---|---|---|
| Comprehensive Review 2005 | 4.5% | 4.6% | 5.0% | 5.4% |
| Comprehensive Review 2008 | 4.7% | 5.0% | 5.4% | 5.9% |

**Breakdown of Global Uncertainty of the Peak Load Forecast of Hydro-Québec Distribution**

| | Current Year | + 1 year | + 2 years | + 3 years |
|---|---|---|---|---|
| Weather Uncertainty | 4,3% | 4,3% | 4,3% | 4,3% |
| Forecast Uncertainty | 1,9% | 2,6% | 3,3% | 4,0% |
| **Global Uncertainty** | **4,7%** | **5,0%** | **5,4%** | **5,9%** |

For the two years covered by both reviews, the load forecast has been reviewed downward. This is mainly due to economic difficulties experienced by lumber and paper mill industries. After 2010, expected load growth is relatively high. The price advantage of electricity over fossil fuels is driving upward the electricity demand for heating purposes.

**Table 3 - Comparison of Annual Peak Load Forecast in MW [1]**

| | Comprehensive 2005 | Comprehensive 2008 | Difference |
|---|---|---|---|
| 2005/06 | 36,754 | | |
| 2006/07 | 36,813 | | |
| 2007/08 | 37,038 | | |
| 2008/09 | 37,454 | 37,099 | -355 |
| 2009/10 | 37,690 | 37,620 | -70 |
| 2010/11 | | 38,130 | |
| 2011/12 | | 38,527 | |
| 2012/13 | | 39,375 | |
| Average growth rate | 0.63% | 1.50% | |

[1] : Annual peak load forecast includes firm exports but does not take into account interruptible power shaving.

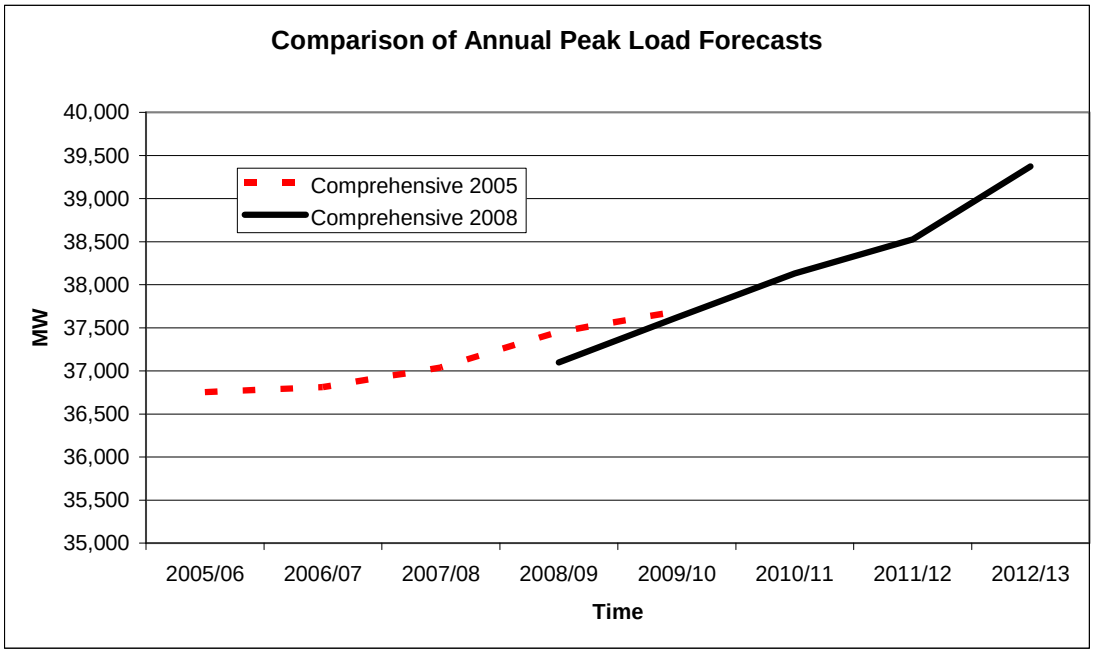
**Québec Area - Annual Peak Load Forecast in MW (1)**

| | 2008/2009 | 2009/2010 | 2010/2011 | 2011/2012 | 2012/2013 |
|---|---|---|---|---|---|
| **A) Peak Load Forecast of HQD** | 36,040 | 36,781 | 37,291 | 37,688 | 38,597 |
| - New England | 329 | 329 | 329 | 329 | 268 |
| - Ontario | 154 | 154 | 154 | 154 | 154 |
| - New Brunswick | 220 | | | | |
| **B) External Sales(2)** | 703 | 483 | 483 | 483 | 422 |
| **C) Deliveries in Québec by HQP** | 356 | 356 | 356 | 356 | 356 |
| **D) Annual Peak Load Forecast (A+B+C)** | **37,099** | **37,620** | **38,130** | **38,527** | **39,375** |

(1) : Interruptible power programs are not taken into account;

(2) : Exportation Sales include losses.

**Figure 2 Comparison of Annual Peak Load Forecasts in MW**




### 3.2.2 Resources

The planned resources for the 2008-2009 winter peak are 41,827 MW. This is 1,000 MW less than the previous Québec Comprehensive Review for the same winter peak (See the Table below for the detail of this reduced resourced). The resources are planned to reach 44,238 MW for the 2012-2013 winter peak, representing an increase of 2,411 MW.

| | Planning Year 2008/09 | | |
|---|---|---|---|
| | **2008 Review** | **2005 Review** | **Difference** |
| **Available and Committed Generation** | 33,395 | 33,548 | -153 |
| **Purchases** | | | |
| - Québec Private Producers | 1,475 | 2,078 | -603 |
| - Short term purchases (HQD) | 340 | 500 | -160 |
| - Churchill Falls | 4,930 | 5,064 | -134 |
| - Millbank | 200 | 200 | 0 |
| **Interruptible Load** | 1,237 | 1,235 | 2 |
| **Voltage Reduction** | 250 | 200 | 50 |
| **Planned Net Resources - Total** | **41,827** | **42,825** | **-998** |

New resources are coming from capacity increases in hydroelectric power plants (940 MW). All government permits have been received and construction is in progress in all of those generating stations. No construction delays are expected so there is no uncertainty related to the commissioning date.

The Gentilly II nuclear plant (675 MW) will be unavailable during 2011-2012 winter peak for refurbishment. Independent Private Producers (HQD) increases include the Bécancour cogeneration plant (547 MW) which is presently shut down and will be restarted on January 1st, 2010.

A new interconnection between Québec and Ontario (1,250 MW) will be put in-service in 2009.

## Table 4 Québec Estimated Total Resources in MW

**Québec Area Estimated Total Resources in MW**

| | 2008/2009 | 2009/2010 | 2010/2011 | 2011/2012 | 2012/2013 | Variations over the period |
|---|---|---|---|---|---|---|
| Available Capacities | 33,395 | 33,374 | 33,369 | 33,374 | 34,335 | |
| Churchill Falls | 4,930 | 4,930 | 4,930 | 4,930 | 4,930 | |
| **A) Available Capacities - Total** | 38,325 | 38,304 | 38,299 | 38,304 | 39,265 | 940 |
| Long Term Purchases - HQP | 1,631 | 1,666 | 1,681 | 1,473 | 1,442 | |
| Long Term Purchases - HQD | 44 | 591 | 591 | 616 | 766 | |
| Short Term Purchases - HQD | 340 | 400 | 1,000 | 1,000 | 1,000 | |
| **B) Purchases - Total** | 2,015 | 2,657 | 3,272 | 3,089 | 3,208 | 1,193 |
| Interruptible Program - HQP | 515 | 515 | 515 | 515 | 515 | |
| Interruptible Program - HQD | 722 | 1,000 | 1,000 | 1,000 | 1,000 | |
| Voltage Reduction | 250 | 250 | 250 | 250 | 250 | |
| **C) Emergency Operaring Procedures - Total** | 1,487 | 1,765 | 1,765 | 1,765 | 1,765 | 278 |
| **D) Total Resources (A+B+C)** | 41,827 | 42,726 | 43,336 | 43,158 | 44,238 | 2,411 |

**Variations over the period for :**

| **A) Available Capacities - Total** | | **In-service Date** |
|---|---|---|
| - EM-1 A hydro unit | 768 | November 2011 |
| - La Sarcelle hydro unit | 150 | November 2011 |
| - Chute Allard hydro unit | 31 | November 2009 |
| - Rapides des Cœurs hydro unit | 35 | November 2009 |
| - Deration of Existing Capacities | -78 | |
| - Gentilly - 2 | 34 | Late 2012 |
| **A) Available Capacities - Total** | **940** | |

The Eastmain-1 A / La Sarcelle project will add 918 MW in capacity and 8.5 TWh in annual energy. The project comprises:

- Eastmain-1 A powerhouse, located next to Eastmain-1 generating station;

- La Sarcelle powerhouse, at the outlet of Opinaca reservoir (built in the 1970s as part of the La Grande complex);
- Structures built to partially divert the Rupert River.

Water from the Rupert River will be turbined at Eastmain-1 A or Eastmain-1 before flowing naturally on to the La Sarcelle powerhouse and the three generating stations in the lower La Grande complex.

These figures do not include the wind power capacities. In 2009-2010, the wind power installed capacity is estimated at 1,047 MW. The forecasted wind power installed capacity is approximately 2,700 MW for 2012-2013.

**Québec - Wind Generation Forecast Installed Capacity in MW**

| 2008/2009 | 2009/2010 | 2010/2011 | 2011/2012 | 2012/2013 |
|---|---|---|---|---|
| 532 | 1,047 | 1,158 | 1,891 | 2,686 |

Wind power capacity credit evaluations are presently performed. Results are expected by the end of next year. In this Review, wind power is completely derated.

On November 3rd, 2008, there was a fire in a cable shaft at the Churchill Falls hydro plant. Two generating units were impacted by the fire (500 MW each). Based on the latest technical evaluation, a unit is supposed to be back on line February 1st, 2009 and the other unit March, 15th, 2009. Because the gap between planned and required reserves for the next winter period (see Table 7) is more than 1,100 MW, the loss of 1,000 MW at Churchill Falls unit leaves Québec Area within the NPCC resource adequacy criterion.

**Table 5 Comparison of Estimated Total Resources[3]**

| Year | Comprehensive 2005 | Comprehensive 2008 | Difference |
|---|---|---|---|
| 2005/06 | 40,658 | | |
| 2006/07 | 41,987 | | |
| 2007/08 | 42,334 | | |
| 2008/09 | 42,825 | 41,827 | -998 |
| 2009/10 | 42,981 | 42,726 | -255 |
| 2010/11 | | 43,336 | |
| 2011/12 | | 43,158 | |
| 2012/13 | | 44,238 | |
| Average annual growth rate | 1.40% | 1.41% | |

[3]Resources include purchases and interruptible power shaving.

Mercier and Eastmain-1 hydro generating stations have been committed as forecasted in the previous review (November 2006). The Péribonka generating unit has been fully put in-service (408 MW) in May 2008. The TransCanada Energy (Bécancour) natural gas unit has also been put in service as planned in the previous 2005 Comprehensive Review, but because of lower forecasted energy needs, this unit has been mothballed for calendar years 2008 and 2009.

# 4. RESOURCE ADEQUACY CRITERION

## 4.1 Statement of Québec Resource Adequacy Criterion

Québec Area reliability criterion complies with the NPCC Resource Adequacy Criterion, which is stated as followed:

> "Each Area's probability (or risk) of disconnecting any firm load due to resource deficiencies shall be, on average, not more than once in ten years. 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 rates and deratings, assistance over interconnections with neighboring Areas and Regions, transmission transfer capabilities, and capacity and/or load relief from available procedures. "

## 4.2 Application of Québec Resource Adequacy Criterion

To assess its resource adequacy, the Québec Control Area uses a Loss of Load Expectation criterion (LOLE) of 0.1 day per year. An hourly load system is represented in the simulation model.

Due to the shape of the Québec load curve, most of the expected deficiencies happen during January, where the annual peak load is expected to occur.

Emergency operating procedures are listed in Table 6 and are described below, according to their order of priority.

Interruptible load over the considered period is 1,515 MW.

The 30 minutes reserve (500 MW) is reduced to zero.

A voltage reduction procedure has been instated and used as an emergency operating procedure. Tests have been done during the last two winters to confirm the potential of 250 MW in reduction capability.

The 10 minutes reserve (1,000 MW) is reduced to 250 MW, the minimum of spinning reserve required to ensure safe operation of the system. Then, load shedding will be implemented to prevent the spinning reserve from dropping below 250 MW.

**Table 6 Emergency Operating Procedures**

| Step | Procedure | Effect | MW |
|---|---|---|---|
| 1 | Interruptible Load (1) | Load Relief | 1,515 |
| 2 | 30-minute reserve to zero | Allow operating reserve to decrease | 500 |
| 3 | Voltage Reduction | Load Relief | 250 |
| 4 | 10-minute reserve to zero (2) | Allow operating reserve to decrease | 750 |

(1) : for 2008/09, 1,237 MW derated to 975 MW.
For the rest of the period, 1,515 MW derated to 1,210 MW.

(2) : the 10-minute reserve is 1,000 MW, but 250 MW of spinning reserve must be available at all time.

## 4.3 Statement of Required Reserve

The reliability criterion application in Québec doesn't refer to a required reserve margin. Application of resource adequacy criterion results from a complete Loss of Load Expectation (LOLE) evaluation done year by year for the power system which meets both the energy and capacity criteria. The resource capacity adequacy may vary from year to year depending on the system characteristics such as:

- Load forecast, load forecast uncertainty and time frame;
- Type, size and commitment dates of new resources;
- Existing and future generating unit availability (scheduled maintenance and outages rates).

As depicted in Table 7, Section 5.1, total resource requirements are expressed as a percentage of the annual peak load for the years 2008-2009 through 2012-2013.

The resource requirements are 9.7 to 11.7 % higher than the annual peak load and are mostly supplied by available and committed generation and firm purchases. It shows that planned resources are more than adequate to abide by Québec Area Resource Adequacy criterion.

## 4.4 Comparison of Québec and NPCC Resource Adequacy Criteria

Québec Area Resource Adequacy criterion is the same as the NPCC Resource Adequacy Criterion, as stated in NPCC Document A-2 "Basic Criteria for Design and Operation of Interconnected Power Systems".

## 4.5 Recent Reliability Studies

Resource requirements are evaluated each year, pertaining to the normal yearly planning process to integrate the latest information such as demand forecast, available capacity, firm purchases and sales contracts.

Hydro-Québec Distribution has the obligation to demonstrate its resource adequacy to the Québec Energy Board in November of each year.

The Québec Control Area fully participates in the different NPCC Working Groups that regularly conduct reliability studies in which the Québec system is modelled. These studies show that the Québec Area complies with the NPCC Resource Adequacy Criterion

# 5 RESOURCE ADEQUACY ASSESMENT

## 5.1 Planned and Required Resources for the Base Case Load Forecast

Based on the 2008 load forecast, Table 7 indicates the required reserve and the planned reserve values during the period under review, expressed as a percentage of the total annual peak demand which includes internal firm demand and firm sales to neighbouring Control Areas.

The planned resources include installed capacity, firm purchases, voltage reduction and interruptible power programs. Planned reserves are higher than required reserves throughout the reference period.

The Required Reserve margin over the annual peak load is 9.7% in 2008/09 and 11.7% for 2012/13. Required reserve margins are a bit higher than in the 2005 Québec Comprehensive Review. Internal transfer capabilities are not a constraining factor. Transmission planning is in full conformance with NPCC criteria as shown in the NPCC Comprehensive Review of the Québec Transmission System for 2012, approved by the RCC in May, 2008. The maintenance programs are adapted to various system conditions without repercussions on its reliability.

**Table 7 Planned and Required Reserves (Base Case)**

| | Planned Resources | Annual Peak Load | Planned Reserves | | LOLE | Required Reserves | |
|---|---|---|---|---|---|---|---|
| | MW | MW | MW | % | (Day/year) | MW | % |
| 2008/2009 | 41,827 | 37,099 | 4,728 | 12.7% | 0.033 | 3,608 | 9.7% |
| 2009/2010 | 42,726 | 37,620 | 5,106 | 13.6% | 0.038 | 3,902 | 10.4% |
| 2010/2011 | 43,336 | 38,130 | 5,206 | 13.7% | 0.051 | 4,106 | 10.8% |
| 2011/2012 | 43,158 | 38,527 | 4,631 | 12.0% | 0.088 | 4,381 | 11.4% |
| 2012/2013 | 44,238 | 39,375 | 4,863 | 12.4% | 0.080 | 4,588 | 11.7% |

Planned and committed resources include existing hydro and thermal plants, scheduled improvements to existing capacity and also committed generating facility additions. Firm purchases include purchases from Alcan (a private electric producer in Québec), Churchill Falls Corporation Limited (CFLCo), New Brunswick Power, Québec's independent power producers and short term purchases. Interruptible load programs are also included as resources.

The planned resources provide reliable and continuous electricity service over the currently forecasted levels of load through the end of 2013.

## 5.2 Planned and Required Reserves (High Load Case)

For the 2008/09 planning year, the high load scenario is 543 MW higher than the base case load forecast and the difference reaches more than 2,000 MW for the 2012/13 planning year.

For planning years 2011/2012 and 2012/2013, a significant part of the gap between both forecasts 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, general economic activity, exports and the price of fossil fuels.

The load forecast uncertainty, in the high load case, is limited to weather uncertainty only.

**Table 8 Québec Annual Peak Load Forecasts under Base and High Scenarios[5]**

| Planning Year | High Load Forecast | Base Load Forecast | Difference |
|---|---|---|---|
| 2008/09 | 37,642 | 37,099 | 543 |
| 2009/10 | 38,614 | 37,624 | 990 |
| 2010/11 | 39,562 | 38,134 | 1,428 |
| 2011/12 | 40,281 | 38,531 | 1,750 |
| 2012/13 | 41,404 | 39,379 | 2,025 |
| **Average Growth Rate** | 2.41% | 1.50% | |

[5] Annual peak load forecast includes firm exports but does not take into account interruptible load shedding.

**Québec Area - Annual Peak Load Forecast - High Case Scenario - in MW(1)**

| | 2008/2009 | 2009/2010 | 2010/2011 | 2011/2012 | 2012/2013 |
|---|---|---|---|---|---|
| **A) Peak Load Forecast of HQD (High Case Scenario)** | 36,583 | 37,775 | 38,723 | 39,442 | 40,626 |
| - New England | 329 | 329 | 329 | 329 | 268 |
| - Ontario | 154 | 154 | 154 | 154 | 154 |
| - New Brunswick | 220 | | | | |
| **B) External Sales(2)** | 703 | 483 | 483 | 483 | 422 |
| **C) Deliveries in Québec by HQP** | 356 | 356 | 356 | 356 | 356 |
| **D) Annual Peak Load Forecast (A+B+C)** | **37,642** | **38,614** | **39,562** | **40,281** | **41,404** |

(1) : Interruptible power programs are not taken into account;

(2) : Exportation Sales include losses.

**Table 9 Planned Resources, Annual Peak Loads, Planned Reserves and LOLE (High Case)**

| Planning Year | Planned Resources MW | Annual Peak Load MW | Planned Reserves | | Required Reserves | | LOLE (Day/year) |
|---|---|---|---|---|---|---|---|
| | | | MW | % | MW | % | |
| 2008/2009 | 41,827 | 37,622 | 4,205 | 11.2% | 3,590 | 9.5% | 0.058 |
| 2009/2010 | 42,726 | 38,613 | 4,113 | 10.7% | 3,675 | 9.5% | 0.080 |
| 2010/2011 | 43,336 | 39,561 | 3,775 | 9.5% | 3,775 | 9.5% | 0.121 |
| 2011/2012 | 43,158 | 40,280 | 2,878 | 7.1% | 3,777 | 9.4% | 0.257 |
| 2012/2013 | 44,238 | 41,404 | 2,834 | 6.8% | 4,034 | 9.7% | 0.286 |

As can be seen in Table 9, during the first two planning years, resources are sufficient to cope with a high load forecast scenario while respecting the NPCC reliability criterion.

For the year 2010-2011, an additional purchase of 700 MW in December 2010 is sufficient to cope with the reliability criterion.

For the last two planning years of this Comprehensive Review, some additional purchases (between 750 and 1,250 MW per month) are required for the months of December, January, February and March.

**Required Additionnal Purchases for the High Load Forecast Scenario in MW**

| | 2010-2011 | | | 2011-2012 | | | 2012-2013 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Base Case | High Case | Difference | Base Case | High Case | Difference | Base Case | High Case | Difference |
| December | | 700 | 700 | 650 | 1,500 | 850 | 1,000 | 1,750 | 750 |
| January | 1,000 | 1,000 | 0 | 1,000 | 1,900 | 900 | 1,000 | 2,200 | 1,200 |
| February | 1,000 | 1,000 | 0 | 1,000 | 1,900 | 900 | 1,000 | 2,200 | 1,200 |
| March | | | | | 1,250 | 1,250 | | 1,250 | 1,250 |

## 5.3 Contingency Plans

For the next two winter periods, the total planned resources will be sufficient to meet both base and high case load assumptions.

In the coming months, Hydro-Québec Distribution is planning for a capacity long term call for tender to be in service in the winter 2012/13. Should the high case scenario load forecast materialise, the quantity of the call for tender will be revised.

Table 10 shows Québec's typical import capability at peak time from neighboring Areas. These numbers do not account for transmission unavailability.

TransÉnergie and Hydro One Network are building a new interconnection (1,250 MW) between Québec and Ontario, the in-service date will be spring 2009.

**Table 10**

**Maximum Import Capability at Peak (MW) - 2008/2009**

| Neighboring Area | Synchronous | HVDC | Radial | Total |
|---|---|---|---|---|
| CF(L)Co* | 5,200 | | | 5,200 |
| Ontario | | | 702 | 702 |
| New-Brunswick | | 785 | | 785 |
| New York** | | 1,100 | | 1,100 |
| New England | | 0 | | 0 |
| **Total** | **5,200** | **1,885** | **702** | **7,787** |

* : CF(L)Co : Churchill Falls (Labrador Corporation Limited.

** : 100 MW through the VFT at Langlois substation.

**Maximum Import Capability at Peak (MW) - 2012/2013**

| Neighboring Area | Synchronous | HVDC | Radial | Total |
|---|---|---|---|---|
| CF(L)Co* | 5,200 | | | 5,200 |
| Ontario | | 1,250 | 702 | 1,952 |
| New-Brunswick | | 785 | | 785 |
| New York** | | 1,100 | | 1,100 |
| New England | | 0 | | 0 |
| **Total** | **5,200** | **3,135** | **702** | **9,037** |

* : CF(L)Co : Churchill Falls (Labrador Corporation Limited.

** : 100 MW through the VFT at Langlois substation.

# 6 PROPOSED RESOURCE CAPACITY MIX

## 6.1 Planned Resource Capacity Mix

Québec Area is mainly an impoundment hydroelectric generation. The breakdown by type is shown in Figure 3 for the 2009-2010 winter period. Hydropower represents 94 % and thermal generation 6 %.

Hydropower relies on adequate water inflows to reliably meet the annual energy consumption.

The Québec Area will have 3,216 MW of wind power installed capacity in 2012-2013 winter period. The contribution of wind power capacity is currently not included in this review. Hydro-Québec is analysing wind power contribution during peak and off peak periods and evaluating its capacity and energy contributions. Wind technology is planned

to be operational over different Québec winter peak conditions that can be severe (wind, temperature and duration).

## 6.2 Reliability Impact of Resource Capacity Mix

Hydro-Québec's energy requirements are mostly met by hydro generating stations, which are located on different river systems scattered over a large territory. The major plants are backed by multi-year reservoirs (water reserves lasting more than one year). Québec's system can rely on those multi-year reservoirs and on some other non-hydraulic sources, including fossil generation, allowing it to cope with inflow variations.

Hydro-Québec Production's hydro generating units can be classified into three categories: run-of-river units, annual reservoir and multi-annual reservoir hydro generating units. Each category copes with low water inflows in a different way:

- Run-of-river units: these units have hydraulics restrictions relatively constant from year to year;
- Annual reservoir hydro units: during a year with normal water inflows, these reservoirs are almost full at the beginning of the winter. If annual water inflows are low, hydraulic restrictions increase;
- Multi-annual reservoir hydro units: the target level for multi-annual reservoirs is approximately 50 to 60 % full in order to compensate or store inflows during periods of below or above normal water inflows. Hydraulic restrictions increase during a period of low inflows.

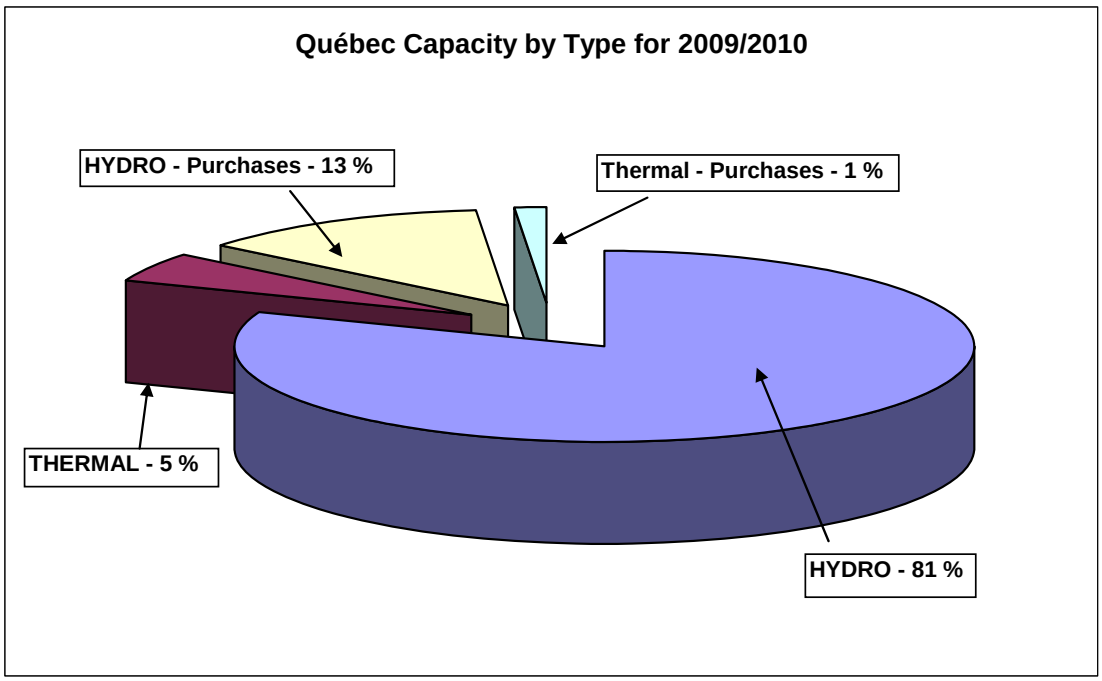
After a long drought having a 2% probability of occurrence, Québec's generating system would have additional hydraulic restrictions in the order of 500 MW above the restrictions under normal conditions. Stream flows, levels of storage and snow cover on the ground are constantly tagged alone allowing Hydro-Québec Production to have a margin to cope with drought periods.

To assess its energy reliability, Hydro-Québec developed an energy criterion that states that sufficient resources should be available to run through sequences of 2 or 4 years of low inflows having a 2% probability of occurrence. Hydro-Québec must demonstrate three times a year to the Québec Energy Board its ability to meet this criterion.

To smooth out the effects of a low inflow cycle, different means are identified:

- reduction of the energy stock to a minimum of 10 TWh in May;
- external energy sales reductions;
- production of thermal generating units during an extended period of time;
- purchases from neighboring Areas.

**Figure 3 Capacity Generation by Type for winter 2009/2010 in %.**



# Appendix A

# Description of Resource Reliability Model

## A. Description of Resource Reliability Model

### A.1.1 Load Model

*A.1.1.1 Description of Load Model*

GE MARS software uses a sequential Monte Carlo simulation to compute the reliability of a system comprised of a number of interconnected sub areas containing generation and load. The MARS model simulates the year repeatedly (multiple replications) to evaluate the impacts of a wide-range of possible random combinations of generator outages and load uncertainty. MARS employs an 8,760 hour chronological zonal load model. The load forecast currently used is based on demographic, economic and energy conditions, which are most likely to materialise.

*A 1.1.2 Load Forecast Uncertainty*

Load forecast uncertainty was determined by analysing Québec's internal load over the 1971 to 2006 period.

*A 1.1.3 Loads of interconnected entities within the Area*

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

*A 1.1.4 Demand Side Management*

There are two interruptible load programs in Québec. Each program has it own customers.

Hydro-Québec Production's program cannot be called twice a day and not more than 100 hours per winter period. Therefore, a derate factor (30%) is applied to model operational constraints for planning purposes.

Hydro-Québec Distribution's program totals 722 MW for winter 2008/09 and 1 000 MW for the rest of the assessment period. Because conditions for this interruptible program are more flexible, a smaller reserve ratio (15%) is applied.

The 15% ratio was recently reassessed using a sequential Monte-Carlo model (FEPMC). The model allows a simulation of interruptible load dispatching according the specific program provisions. The results were presented to the CP-8 working group and to the TFCP Task Force of the NPCC.

## A 1.2 Resource Unit Representation

*A 1.2.1 Unit Ratings*

*A 1.2.1.1 Definitions*

The capacity definitions used in the reliability evaluation are as follows:

- For hydroelectric generating stations of 50 MW and above

Dependable Maximum Net Generating Capability (DMNC) is defined as the net output a unit can sustain over a specified period modified for monthly limitations and reduced by the capacity required for station service or other auxiliaries. The DMNC must be sustainable for a minimum of two consecutive hours. The proper management of the reservoirs usually makes this capacity available on a daily basis. DMNC varies monthly.

- For hydroelectric generating stations less than 50 MW

These generating stations are the run-of-river plants. DMNC is based on historical generation.

- For thermal generating stations

DMNC is defined as the net output a unit can sustain over a two consecutive hour period. DMNC varies monthly subject to ambient temperature change.

*A 1.2.1.2 Procedure for Verifying Ratings*

The generating station ratings are based on annual maximum net output tests conducted between November and February of the following year. The procedure is in conformance with :

- NERC Reliability Standards TOP-002-00 and VAR-001-00;
- Criterion A-13, NPCC Verification of Generator Gross and Net Real Power Capability;
- Procedure C-07, NPCC Monitoring Procedures for the Guide for Rating Generating Capability.

*A 1.2.2 Unit Unavailability Factors*

*A 1.2.2.1 Unavailability Factors Represented*

Québec represents forced outage rates, planned outages, maintenances outages, and restrictions (hydraulic, electrical and mechanical) for each resource in the Resource Adequacy Assessment. To depict the states of the generating unit, an equivalent demand

forced outage rates (EFORd) is used. With the equivalent forced outage rates State Transition Rates for each unit of the generating station are determined.

*A 1.2.2.2 Source of Unavailability Factors*

- Forced Outage Rates

To depict the 4 states of the generating unit, an equivalent demand forced outage rates (EFORd) is used.
For existing Capacity resource, EFORd is determining for each specific Power Plant unit from the 5 year historical performance data (2003 to 2007).
The EFORd serves as an estimate of the transition rates in the studied period.

$$\text{EFORd} = \frac{Fr.FOH + Fp.(EFOH - FOH)}{SH + Fr.FOH}.$$

Where

$$\text{Fr = Full factor} = \frac{(1/r) + (1/T)}{(1/r) + (1/T) + (1/D)}$$

$$\text{Fp} = \frac{ServiceHours}{AvailableHours}$$

r = Average forced outage duration
T = Average reserve shut-down time between periods of need
D = Average in-service time per occasion of demand
FOH = Full Forced Outage Hours
EFOH = Equivalent full Forced Outage Hours i.e the number of hours a unit was involved in an outage expressed as equivalent hours of full forced outage at its maximum net dependable capability
SH = Service Hours

- Maintenance

A daily representation of a generator's scheduled outages is modeled for each unit, based on the 2008 schedules for planned outages.

Unit outage data is based on historical data for the years 2003-2007.

*A 1.2.2.3 Maturity Considerations*

Hydro units not having a complete 5-year historical data were given an outage rate equal to the historical average of hydraulic units in Québec.

*A 1.2.2.4 Tabulation of Unavailability Factors*

Table A-1 Equivalent Forced Outage Rates

| Unit Type | Comprehensive Review 2005 FOR | Comprehensive Review 2008 EFORd |
|---|---|---|
| Hydro Unit | 1.1% to 1.8% | 0.3% to 1.8% |
| Thermal Unit | 4% to 9% | 6.5% to 20.5% |

Maintenance

2008 schedules for planned outages are used. The monthly volumes are comparable to historical volumes shown in the following table.

Table A.2 – Typical Maintenance for Power Station

| Month | Maintenance Comprehensive Review 2005 | Maintenance Comprehensive Review 2008 |
|---|---|---|
| January | 0.4% | 0.2% |
| February | 0.4% | 0.7% |
| March | 4.4% | 0.9% |
| April | 13.7% | 7.8% |
| May | 17.7% | 16.9% |
| June | 22.5% | 21.2% |
| July | 24.9% | 18.6% |
| August | 17.1% | 19.5% |
| September | 21.6% | 15.7% |
| October | 10.5% | 10.1% |
| November | 5.3% | 5.1% |
| December | 0.4% | 0.4% |

*A 1.2.3 Purchase and Sale Representation*

**Purchases**

Based on Hydro-Québec Distribution procurement policies, suppliers located outside the Québec Control Area must be treated on the same basis as local suppliers, as long as they provide an equivalent quality of service. Hydro-Québec Distribution calls for tenders are open to existing or new power units as well as to new demand response programs. All suppliers must provide a guarantee that the resources offered are not committed elsewhere.

The capacity purchases from other Control Areas and sales to other Control Areas are shown in Table A.2.

## Table A.2

**Firm Purchases and Firm Sales in MW**

| Firm Purchases | 2008/2009 | 2009/2010 | 2010/2011 | 2011/2012 | 2012/2013 |
|---|---|---|---|---|---|
| - New York CA | 340 | | | | |
| - Maritimes CA | 200 | 200 | 200 | | |
| **Total Purchases** | 540 | 200 | 200 | 0 | 0 |

| Firm Sales | 2008/2009 | 2009/2010 | 2010/2011 | 2011/2012 | 2012/2013 |
|---|---|---|---|---|---|
| - Maritimes CA | 220 | | | | |
| - New England CA | 329 | 329 | 329 | 329 | 268 |
| - Ontario CA | 154 | 154 | 154 | 154 | 154 |
| - Québec CA | 356 | 356 | 356 | 356 | 356 |
| Total New Generation | 1,059 | 839 | 839 | 839 | 778 |

Churchill Falls Corporation Limited (CFLC0)

The capacity purchases are represented according to the contracts between Hydro-Québec and CFLCo.

Québec has access to 4,930 MW during winter and from 2,900 to 4,200 MW during the rest of the year.

Alcan

Alcan has its own generating facilities in Québec. Some of its loads are connected to the TransÉnergie system and are included in the internal load forecast. Hydro-Québec Production and Alcan have contracted for 890 MW of capacity purchases from Alcan, but the capacity is reduced by 267 MW during the winter period to account for availability constraints.

Maritimes CA

Hydro-Québec Production has a purchase contract for 200 MW of peaking capacity until October 2011.

Independent Power Producers in Québec

In 2008-2009, the purchase contracts from Independent Power Producers amount to 585 MW. For the upcoming years, there will be an additional 733 MW available from these producers for a total of 1,318 MW at the 2012/2013 winter peak. This total includes the return in-service of the TransCanada Energy natural gas unit (547 MW) in January 2010.

Short term purchases

For the winter period 2008-2009, Hydro-Québec Distribution will buy 340 MW of capacity from New York Control. These short term purchases for winter peak period only can reach a 1,000 MW as soon as winter 2010/2011.

**Sales**

Québec has three firm export contracts. One contract is with New England Control Area, (329 MW losses included). The export will be reduced to 268 MW beginning November 2012. This export contract is delivered through the Highgate interconnection (225 MW capacity), the Derby Line (50 MW capacity) and the NEPOOL Phase II. The second contract is with the Ontario Control Area (154 MW losses included), the deliveries take place through the Cedars Rapids Transmission System (Lines CD11 and CD12). Finally, the third contract is with New Brunswick Power for the Winter 2008-2009 only and represents a capacity of 110 to 220 MW including losses. This sale will be delivered over both interconnections between Québec and New Brunswick, based on the transmission systems configurations in real time.

Hydro-Québec Production has compensation agreements (356 MW) with industrial customers operating hydro generating stations in Québec.

*A 1.2.4 Retirements*

An agreement to temporarily suspend generation at TransCanada Energy natural gas unit in Bécancour (547 MW) is effective for the calendar years 2008 and 2009. Deliveries under the original contract with TransCanada Energy will resume on January 1st 2010.

The Cadillac gas turbine units (162 MW) were withdrawn from service in November 2008 by Hydro-Québec Production.

## A 1.3 Interconnected Systems

Neighbouring systems are not modeled in this Comprehensive Review. The 1,000 MW short term purchases from 2010-11 to 2012-2013, will be procured from New York CA and/or Hydro-Québec Production. This purchase or tie benefit is well under the potential evaluated through the latest NPCC Tie Benefits study (see Table 10).

## A 1.4 Modeling of Limited Energy Resources

For most hydro generating stations, energy limitations are modeled by using a different monthly value of dependable maximum generating capability (DMNC). This accounts for the effect on the net head of the reservoir level variations and generator cooling water temperature.

Unlike hydro generating stations with reservoirs, the run-of-river Beauharnois and Les Cèdres generating stations are operated in parallel on the Saint-Lawrence River. Their capability depends on water availability and varies according to seasons. Moreover, during ice-cover formation, capacity output must be reduced. Ice-cover formation restrictions are also modeled for all generating stations where they may apply.

## A 1.5 Modeling of Interruptible Resources

Québec models 1,515 MW of interruptible power contracts with industrial customers. A description of interruptible contracts and reserves applicable is given in section A 1.1.4.

## A 1.6 Modeling of all Resources

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

### A 1.7 Others Assumptions

The TransÉnergie system and its maintenance and up-grade programs, included in this Review, have been submitted and approved by the NPCC.

In this Comprehensive review for resource adequacy, Québec completely derates wind power. Wind power capacity credit evaluations are presently performed. Results are expected by the end of next year. The results of these evaluations will be included in the next Interim Review.

### A 1.8 Impacts of market Rules on Reliability

The Québec capacity purchases contracted through request for proposals in other Areas are secured by procedures put in place with the neighbouring NPCC Control Areas.