Hydro-Québec
TRIENNIAL REVIEW OF RESOURCE ADEQUACY

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1 EXECUTIVE SUMMARY

Introduction

This Report, the Hydro-Québec Triennial 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 June 28th,2001. The time period considered for the Resource Review is five years instead of ten years. As in the previous review it shows that Hydro-Québec has the ability to meet the NPCC reliability criterion as stated below for the five years planning period 2003 through 2007.

Hydro-Québec complies with the NPCC resource adequacy criterion, which reads:

> "Each Area's resources will be planned in such a manner that, after due allowance for scheduled outages and deratings, forced outages and deratings, assistance over interconnections with neighboring Areas and regions, and capacity and/or load relief from available operating procedures, the probability of disconnecting non-interruptible customers due to resource deficiencies, on the average, will be no more than once in ten years”.

The information presented covers the years 2003 to 2007 and is based on Hydro-Québec 2001 load forecast according to the Strategic Plan 2002-2006, issued in November 2001, and the Electricity Supply Plan filed with the Québec Energy Board on October 25th 2001.

Hydro-Québec's new structure

With the Hydro-Québec unbundling context, the highlight of 2001 was the establishment of a new organizational structure. The deintegration of Hydro-Québec into four divisions, each headed by a president, fits the new regulatory framework governing the North American power companies. The four divisions are Hydro-Québec Distribution, Hydro-Québec TransÉnergie, established in 1997, Hydro-Québec Production and Hydro-Québec Ingénierie, approvisionnement et construction.

1.1 Major findings

Slow growth in demand

In term of demand, in the winter 2006-2007 the load could reach 35 240 MW, which is 540 MW less than the 1998 forecast. This reflect the slowdown in population growth and the progress of a post-industrial economy that is more energy-efficient, more diversified and largely composed of new-economy business. This forecast corresponds to an average-growth rate of 1.3 % scenario after energy conservation. It takes into account the economic slowdown that started in 2001 whose ultimate scope is hard to estimate.

For the winter 2001-2002, the annual peak load reached 31 427 MW including firm sales of 1 336 MW to neighboring networks. This annual peak load was 1 415 MW lower than forecasted. A milder winter than normal was the principal reason for the load decline.

Generating Capacity and Adequacy Criterion

Resource capability is similar to as describe in the previous review. Hydro-Québec maintains a diversified portfolio of projects to increase its generating capacity and take advantage of market growth. As well, it secures other sources of supply by such means as long term contracts with independent power producers in Québec with the focus on renewable energy, including wind power. Furthermore, Hydro-Québec Distribution can issue short and long term calls for tenders, according to need.

Construction is underway for a new hydroelectric development to replace the existing facility at Grand-Mère (2004-2005) power plant. Construction also began on hydroelectric generating station on the Toulnustouc River (in-service 2005-2006) and commissioning date of Sainte-Marguerite station has been delayed to 2003.

Interruptible load over the considered period is 1024 MW.

The Hydro-Québec reliability generation adequacy criterion is applied along with planning year from November to October instead of with hydraulic year from October to September. There is no impact resulting from this change.

Finally resource requirements are in the order of 10-11% over the annual peak load compared to 12.2% in the last Triennial Review on account of some change in availability assumptions as explained below.

- Beauharnois and Les Cèdres run-of-river stations are represented differently from the other hydro stations since their capability depend on water availability subdued to ice cover or navigation constraints. In the previous review, power units were represented by their installed capacity. A certain amount of capacity was added to the reserve to take into account the available capacity. These run-of-rivers are now represented by their net dependable capacity instead of the installed capacity .

- Additionally, regarding plants with reservoir, now that the net dependable capacity generating units takes into account the effect of the reservoir level variations, some capacity that was included in the reserves for this purpose is no longer required. This manner is more accurate and reduces the same amount of capacity in both the total reserve required and the available and committed generation.

As was mentioned in the previous review, Hydro-Québec continues not to rely on reserve sharing with other areas unless there are firm reservation or commitment for both generation and transmission. It is Hydro-Québec position that, with the open market, generation and transmission must be secured on a commercial basis to ensure its future availability.

1.2 Major Assumptions and Results

The following Table I sets major assumptions and results.

TABLE I
MAJOR ASSUMPTIONS AND RESULTS

Assumption	**Description**	
Study period	Winter 2002-2003 to Winter 2006-2007	
Reliability Criterion	LOLE 2.4 hours/year : complying with the NPCC Criterion 1 day in 10 year	
Load Model	8760 hourly peak load with uncertainty factors	
Load Growth	2002-2003	2006-2007
- Base Case	33 480 MW	35 240 MW
- High Case	34 730 MW	37 990 MW
Required Reserve	Between 10 - 11 % of Total Peak Demand	
New Generating Capacity Additions	1 665 MW through the study period	
Interruptible Load	1 024 MW through the period	
Forced Outage Rates		
- Hydraulic	1.1 % to 4.8 %	
- Thermal, including nuclear	4 % to 10 %	
Tie Benefits	Not accounting over assistance with neighboring Areas	
Synchronized Spinning Reserve	minimum amount of 250 MW	
Emergency Operating Procedures	not modeled	
Unit Dependable Maximum Net Capability	see Table A-2, page 20	
Maintenance Schedule	see Table A-4, page 23	

Results	LOLE Hours/year **Base Case**	LOLE Hours/year **High Case**
2002-2003	0.61	0.56
2003-2004	0.57	0.47
2004-2005	1.23	1.68
2005-2006	1.08	2.98
2006-2007	1.27	6.26

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3 INTRODUCTION

This resource adequacy report 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.

Information presented covers the 2003-2007 period and is in accordance with the Hydro-Québec 2001 forecast according to the Strategic Plan 2002-2006, released in November 2001, and the Electricity Supply Plan filed with the Québec Energy Board by Hydro-Québec Distribution on October 25th,2001.

In 2001 Hydro-Québec created four divisions, each headed by a president, fitting with the new regulatory framework governing the North American electric industry. The four divisions are Hydro-Québec TransÉnergie (established in 1997), Hydro-Québec Distribution, Hydro-Québec Production and Hydro-Québec Ingénierie, Approvisionnement et Construction (IAC).

Hydro-Québec Distribution develops and operates the Corporation's distribution system and is responsible for sales and services to Québec customers.

Hydro-Québec TransÉnergie develops and operates the Corporation's transmission system and markets its transmission capacity. TransÉnergie ensures also transmission system reliability and long-term operability and growth of its assets. It assumes the responsibilities of Reliability, Balancing and Interchange Authorities in the Québec Control Area in compliance with system reliability rules.

Hydro-Québec Production operates and develops Corporation's generating facilities. It maintains reliability criteria in the management of generating facilities.

Hydro-Québec IAC provides engineering services and carries out construction projects in Québec. It also provides services, especially with respect to procurement and information technology, to Hydro-Québec's business units.

3.1 Previous Triennial Review

The last Hydro-Québec's Triennial Review of Resource Adequacy was submitted in May 1999. Based on that review, NPCC concluded that Hydro-Québec was planning in accordance with the NPCC criterion for resource adequacy.

3.2 Load and Resource Comparison of the 1999 and 2002 Review

In terms of demand, the observed peak load for the winter 2001-2002 is 31 427 MW reached on January 31st,2002 at 6:pm., including 1 336 MW of firm sales to neighboring networks. This annual peak load was 1 415 MW lower than forecasted. A milder winter than normal was the principal reason for the load decline.

In the 1999 review, the 2002-2003 winter peak load forecast was 34 270 MW. The peak load grows at an annual average rate of 1.1 % to reach 35 780 MW by 2006-2007 winter peak (see Table 1 and Figure 1).

In the current review, the 2002-2003 winter peak load forecast is 33 480 MW but grows at a higher annual average rate of 1.3 % to reach 35 240 MW by 2006-2007 winter peak.

As shown in Table 1, comparing to the 1998 demand forecast, 2001 demand forecast are lower. The reduction of the load forecast are about 790 MW for the peak 2002-2003, 270 MW for 2004-2005 and 540 MW in 2006-2007. This reduction reflects the slowdown in population growth and the progress of a post-industrial economy that is more energy-efficient, more diversified and largely composed of new-economy business. The forecast takes also into account the economic slowdown that started in 2001 whose ultimate scope is hard to estimate.

Relating to the planned resources, the previous review indicated 38 850 MW for the winter peak of 2002-2003. Resources remain steady over the period (see Figure 1 and Table 2).

In this 2002 review, the resources are 37 850 MW for the 2002-2003 winter peak. They grow at an annual average rate of 1.1 % to reach 39 570 MW by the winter peak 2006-07. The commissioning date of the Ste-Marguerite 3 power station has been postponed to 2003. The resources difference depicted by Figure 1 is explained by the repowering of existing Outardes-3 plant and the addition of a new plant on the Toulnustouc River. These figures do not include the recent Hydro-Québec Distribution call for tenders for the purchase of long term contracts starting sometime in 2006 or 2007.

Figure 1
WINTER PEAK LOAD FORECASTS
AND ESTIMATED TOTAL RESOURCES

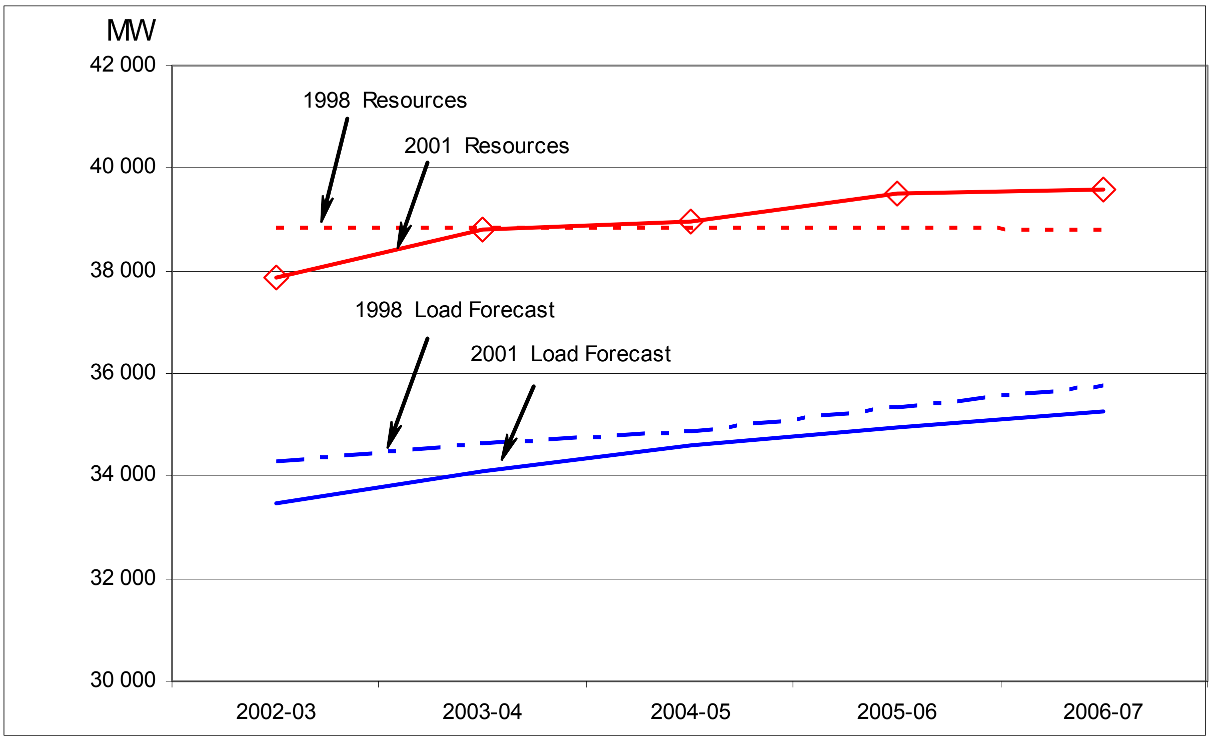

Table 1
COMPARISON OF ANNUAL PEAK LOAD[1] FORECASTS
Based on 2000-2004 and 2002-2006 Strategic Plans
(MW)

Load Forecast			Change in Loads
Year	**1998 Forecast**	**2001 Forecast**	
2002-03	34270	33480	-790
2003-04	34650	34080	-570
2004-05	34860	34590	-270
2005-06	35330	34960	-370
2006-07	35780	35240	-540
Average growth rate	1.1%	1.3%	

Table 2
COMPARISON OF ESTIMATED TOTAL RESOURCES[2]
Based on 2000-2004 and 2002-2006 Strategic Plans
(MW)

Resources Forecast			Difference
Year	**1998 Forecast**	**2001 Forecast**	
2002-03	38850	37850	-1000
2003-04	38840	38800	-40
2004-05	38840	38940	100
2005-06	38830	39500	670
2006-07	38820	39570	750
Average growth rate	0.0%	1.1%	

[1] Annual peak load forecast includes firm exports but does not take into account interruptible power shaving.
[2] Resources include purchases and interruptible power shaving.

4 RESOURCE ADEQUACY CRITERION

4.1 Statement of Hydro-Québec Resource Adequacy Criterion

The Hydro-Québec generation system is planned in accordance with the following criterion :

> “ After due allowance for maintenance, forced outages, hydraulic constraints and generating unit restrictions, forecast uncertainty, spinning reserve requirements and interruptible loads, the probability of disconnecting firm customers due to generation deficiencies, on the average, will be no more than 2.4 hours per year. ”

As stated in the criterion, Hydro-Québec Production does not take into account the interconnection assistance in generating reliability evaluation.

This criterion is the same as the one used in the previous review but the wording differs slightly. It is more explicit concerning the output restrictions by adding the terms "hydraulic constraints and generating unit restrictions". Those restrictions were taken into account in the last review but were not specifically stated.

4.2 Details on Application of Criterion

The basic criterion used in Hydro-Québec generating capacity planning is a Loss of Load Expectation (LOLE) of 2.4 hours/year using an hourly load model.

Due to the shape of the Québec load, most of the expected deficiencies are concentrated during winter months, specifically in January. Figure 2 illustrates the monthly distribution of expected deficiencies for a typical planning year.

The Hydro-Québec planning criterion does not account for emergency procedures such as voltage reduction and customer appeals. However, these actions could be implemented to a certain extent and could actually reduce customer disconnection by Hydro-Québec.

A minimum amount of synchronized spinning reserve of 250 MW[3] is required to ensure safe operation of the system. Load shedding will be implemented to prevent the spinning reserve from dropping below that value. Therefore, this capacity is not considered available to supply load. This value is added to the required resource as calculated by the probabilistic method. The minimum spinning reserve value is the same as in the 1999 review.

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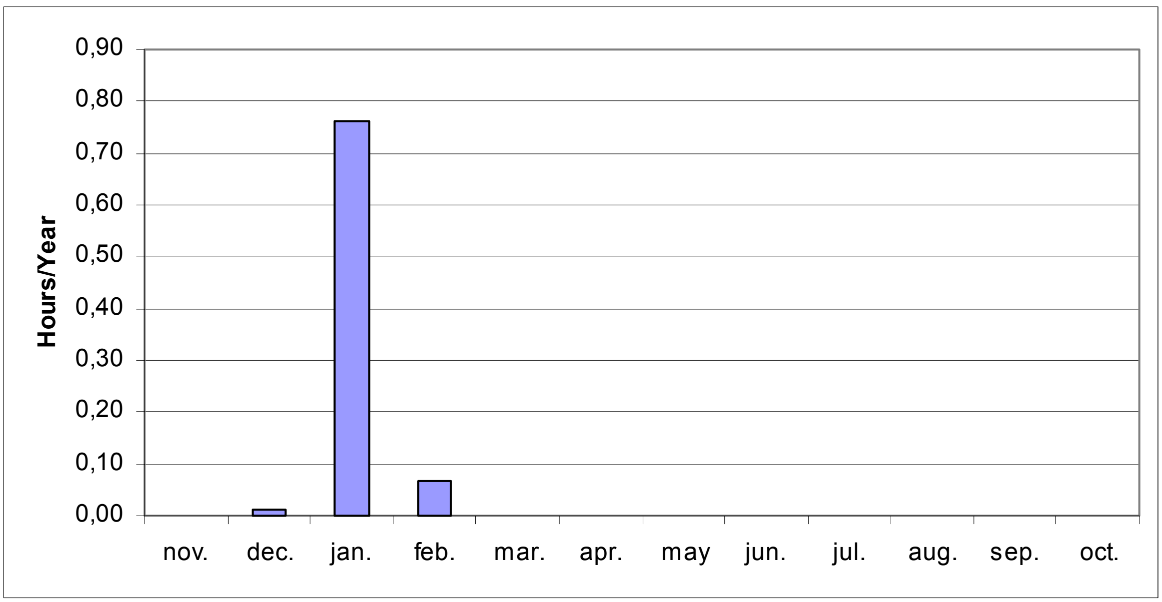
[3] See section 4.4 for more explanation.

Since 2002, the Resource Adequacy criterion is applied annually from November to October instead of from October to September following the hydraulic year. This new period corresponds to the yearly cycle of Winter – Summer and to the operational planning period as well. Under the normal condition, as the October loss of load expectation in one year to another is the same , there is no impact resulting from this change of application period.

Hydro-Québec Production continues to review its scheduled outage practice with the aim of extending generating unit availability. Accordingly, the same forced outage rates as the previous review are maintained.

Figure 2
MONTHLY DISTRIBUTION OF EXPECTED DEFICIENCIES FOR A TYPICAL PLANNING YEAR



4.3 Resource Requirements

The resource requirements are the result of a complete Loss of Load Expectation (LOLE) evaluation done year by year for the power system which meets both the energy and the capacity criteria. The generating capacity adequacy may vary from one year to another depending on the system characteristics such as:

- the load forecast and the expected load duration curves — that change over the years;

- the type, the size and the commitments dates of the new resources;

- the existing and future generating unit availability (scheduled maintenance and outage rates).

As can be seen in Table 3, for the planning year 2002-2003 through 2006-2007, total resource requirements are expressed as a percentage of the annual peak load instead of reserve margin pursuant the NPCC B-8 document.

Based on the Strategic Plan 2002-2006, the resource requirements is 10 to 11% higher than the annual peak load and is mostly supplied by available and committed generation and firm purchases. It shows that planned resources are more than adequate to abide by Hydro-Québec adequacy generating criterion.

Table 3
HYDRO-QUÉBEC RESOURCE REQUIREMENTS
(MW)

Planning Year	2002-03	2003-04	2004-05	2005-06	2006-07
Annual Peak load (1)	33480	34080	34590	34960	35240
Total resource requirements (2)	36840	37685	38380	38820	39020
[(2) – (1)]/(1)	10.0%	10.6%	11.0%	11.0%	10.7%
Planned Resources (3)	37850	38795	38940	39500	39570
[(3) – (1)]/(1)	13.1%	13.8%	12.6%	13.0%	12.3%

4.4 Comparison of Hydro-Québec and NPCC Criteria

The Hydro-Québec criterion is expressed in terms that differ slightly from the NPCC statement. However the planned resource requirements according to the Hydro-Québec criterion meets the NPCC reliability adequacy level.

To be able to compare the Hydro-Québec criterion with NPCC, we have to take into account the following differences.

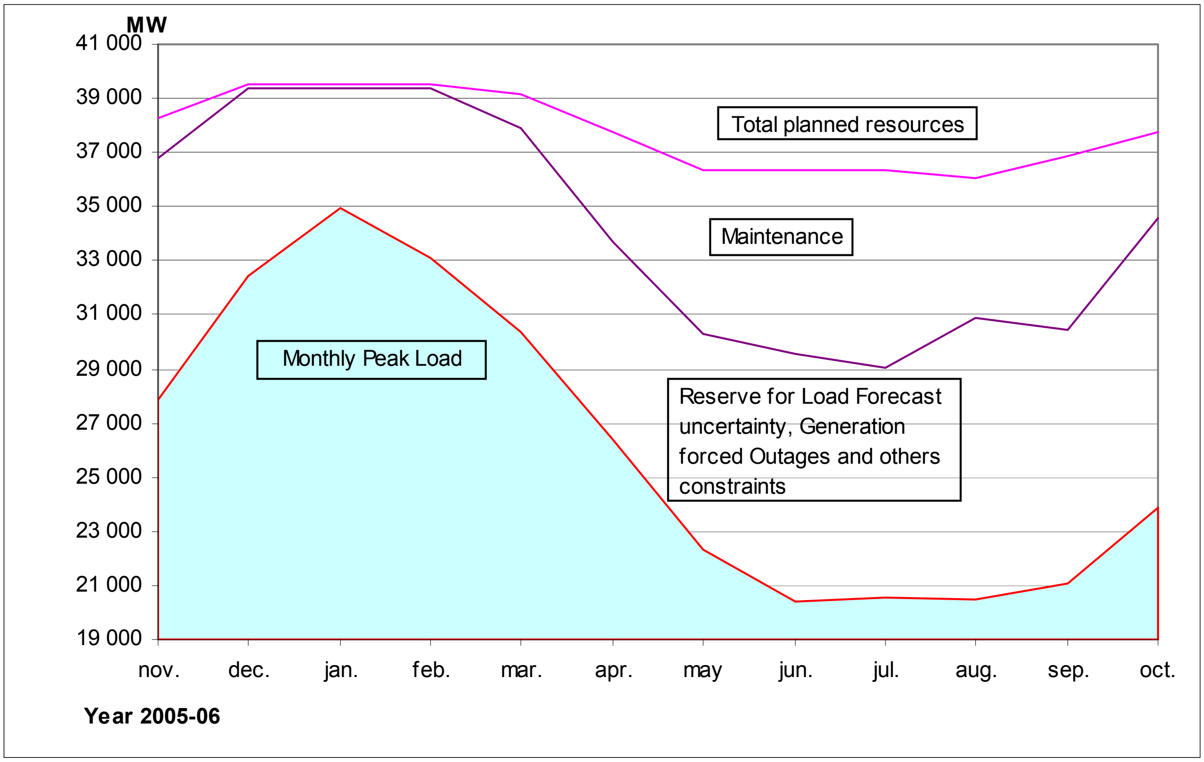
- The NPCC criterion does not indicate how load should be modelled.
- Hydro-Québec Adequacy Criterion does not take into account assistance over interconnections with neighboring Areas.
- The Hydro-Québec resource requirements accounts for a minimum required amount of synchronized spinning reserve of 250 MW. Hydro-Québec will shed load before going under that amount. Under normal operation, a spinning

reserve of 3 % of the available capacity, up to a maximum of 1 000 MW is maintained.

In resource adequacy reliability evaluation, Hydro-Québec uses hourly peak loads with the reliability adequacy criterion of 2.4 hours per year applied for the annual planning period. Hydro-Québec uses also load forecast uncertainty and does not rely on interconnected assistance. This matter gives a more severe constraint for Hydro-Québec.

Hydro-Québec generation system peaks in January, mostly all the LOLE risk is stressed in that month as depicts Figure 2. LOLE in the Summer months is practically zero because the capacity reserve remaining after maintenance is greater than the one during winter months (Figure 3). In comparison, a thermal system that peaks both in summer and winter will have a large part of its maintenance scheduled in spring and fall in a manner to level the LOLE and accordingly spread uniformly the loss of load expectation.

Figure 3
HYDRO-QUÉBEC MONTHLY RESERVE CAPACITY



4.5 Recent Reliability Study

No extensive study was undertaken since the last review.

Resources requirements are re-evaluated every year, pertaining to the normal yearly planning process to integrate the latest information such as new demand forecast, the available updated capacity, the new firm sales and purchases contracts and so on.

As part of the normal planning process and with regard to the Installed Capacity Markets and Auctions (ICAP), resource requirements are updated frequently all year long to reflect the latest information. Other studies may be conducted from time to time on specific themes if need be.

The main assumptions and parameters used for reliability evaluation presented in the next section are the same as in the previous review.

On the other hand, Hydro-Québec fully participate to the different Working Group of the NPCC who regularly conduct reliability studies in which Hydro-Québec generation system is modelled (NPCC Multi-Area Probabilistic Reliability Assessment for summer 2001 and for summer 2002 using MARS[4] model). These studies show invariably that Hydro-Québec Area is complying with the NPCC adequacy reliability criterion.

5 RESOURCE ADEQUACY ASSESSMENT

5.1 Proposed vs. Required Resource for the Most Likely Load Forecast

Based on the 2001 load forecast, Table 4 depicts the required reserve and the planned reserve values for the 2003-2007 period, expressed as a percentage of the total annual peak demand which includes the firm demand, exports and the industrial interruptible loads.

The total available reserve includes the installed reserve and the interruptible power shaving. Total reserves are higher than required reserves throughout the considered period.

Required Reserve margin is 10% to 11% of the annual peak load for maintaining the adequacy criterion. These values do not include the effect of uncommitted resources. Reasons listed below explain the reserve margin decline comparing to 12.2% in the previous review.

- Beauharnois and Les Cèdres run-of-river stations are represented differently from the other hydro stations since their capability depend on water availability subdued to ice cover or navigation constraints. In the previous review, generating units were represented by their installed capacity. A certain amount of capacity was added to the reserve to take into account the available capacity. These run-of-river stations are now represented by their net dependable capacity instead of their installed capacity.

- Additionally, regarding plants with reservoir, now that the net dependable capacity generating units takes into account the effect of the reservoir level variations, some capacity that was included in the reserves for this purpose is no longer required. This manner is more accurate and reduces the same amount of capacity in both the total reserve required and the available and committed generation.

[4] MARS is the GE Multi-Area Reliability Simulation program that allows assessment of the reliability of a generation system comprised of any number of interconnected areas. A sequential Monte Carlo simulation forms the basis for MARS.

Table 4
COMPARISON OF REQUIRED AND PLANNED RESERVE MARGINS
(as percentage of total peak demand)

		PLANNED RESERVE		
PLANNING YEAR	**REQUIRED RESERVE**	**(1)=(2)+(3) TOTAL RESERVE**	**(2) INSTALLED RESERVE**	**(3) INTERRUPTIBLE LOADS**
2002-03	10.0%	13.1%	10.0%	3.1%
2003-04	10.6%	13.8%	10.8%	3.0%
2004-05	11.0%	12.6%	9.6%	3.0%
2005-06	11.0%	13.0%	10.1%	2.9%
2006-07	10.7%	12.3%	9.4%	2.9%

The following Table 5 gives the capacity resource requirements and availability for the peak period 2003-2007.

Available and committed generation includes existing hydro and thermal plants, scheduled improvements to existing capacity and also committed additions of generating facilities. Firm purchases include purchases from Alcan, Churchill Falls (Labrador) Corporation Limited [CF(L)Co], New Brunswick Power and Independent Power Producer in Québec.

Planned resources, which are the sum of available and committed generation, new purchase program of independent power producers and interruptible loads, are more than adequate for the study period to meet the NPCC adequacy criterion.

Indeed, as can be seen from Table 5, with the commissioning of Sainte-Marguerite-3 and Toulnustouc hydro stations by the winter 2003-2004 and 2005-2006, the planned resources are mostly greater by 2.0% over the total resource requirements. Moreover, Hydro Québec Distribution has issued a call for tenders for the purchase of 1200 MW long term contracts starting sometime in 2006 or 2007. This available capacity generating capability provide largely reliable and continuous electricity service to the currently expected levels of demand by the end of 2007.

Table 5
CAPACITY REQUIREMENTS AND AVAILABILITY
(MW)
2003-2007

Planning Year	2002-03	2003-04	2004-05	2005-06	2006-07
Internal Peak load & Exports (1)	33540	34140	34650	35020	35300
Isolated Systems (2)	56	58	59	60	62
Annual Peak load * (1)-(2) = (3)	33480	34080	34590	34960	35240
Available and Committed Generation (4)	30740	31680	31830	32380	32450
Firm Purchases & receivings as per agreement (5)	6092	6092	6092	6092	6092
Interruptible Load (6)	1024	1024	1024	1024	1024
Planned Resources * (4)+(5)+(6)=(7)	37850	38800	38940	39500	39570
[(7) – (3)]/(3)	13.1%	13.8%	12.6%	13.0%	12.3%
Total resource requirements * (8)	36840	37680	38380	38820	39020
Required reserve (8)-(3)=(9)	3360	3600	3790	3860	3780
[(8) – (3)]/(3)	10.0%	10.6%	11.0%	11.0%	10.7%

(*) : *rounded*

Uncommitted Generation

Planning Year	2002-03	2003-04	2004-05	2005-06	2006-07
Uncommitted Resources				36	836
Total (10)				36	836
Total planned resources * (7)+(10)=(11)	37850	38800	38940	39540	40410
[(11) – (3)]/(3)	13.1%	13.8%	12.6%	13.1%	14.7%

(*) : *rounded*

5.2 High Load Forecast

In the Hydro-Québec high load forecast shown in Table 6, the high demographic growth carries along a stronger demand load.

The annual average growth rate for the study period is 2.3% that is 1% stronger than the most likely load growth. In the calculation of the required resource for this case, the load forecast uncertainty is reduced to 3%, representing the weather conditions uncertainty. The upper limit capability of the Québec economy for this time frame is considered and accordingly there is no economic uncertainty in the high load forecast.

Table 6
HYDRO-QUÉBEC ANNUAL PEAK LOAD FORECAST[5]
(MW)

Planning Year	High Load Forecast	Average Load Forecast	Difference
2002-03	34730	33480	1250
2003-04	35530	34080	1450
2004-05	36400	34590	1810
2005-06	37270	34960	2310
2006-07	37990	35240	2750
Average growth Rate	2.3%	1.3%	

Table 7 compares the required reserve to the total reserve. A small resource deficit appears from 2005-2006. However, Hydro-Québec Production has several uncommitted resources available by 2005-2006 and, in addition, Hydro-Québec Distribution could issue calls for tenders for short and long term contracts.

In fact, the first call for tenders was issued in June 2002, for the purchase of 1200 MW in total capacity through long term contracts starting sometime in 2006 or 2007.

5 Annual peak load forecast includes firm exports but does not take into account interruptible loads shaving.

Table 7
COMPARISON OF REQUIRED AND PLANNED RESERVE MARGINS
HIGH LOAD FORECAST
(as percentage of total peak demand)

		PLANNED RESERVE		
PLANNING YEAR	REQUIRED RESERVE	1=2+3 TOTAL RESERVE	(2) INSTALLED RESERVE	(3) INTERRUPTIBLE LOADS
2002-03	6.6%	9.0%	6.0%	3.0%
2003-04	6.5%	9.2%	6.3%	2.9%
2004-05	6.3%	7.0%	4.2%	2.8%
2005-06	6.4%	6.0%	3.2%	2.7%
2006-07	6.0%	4.1%	1.4%	2.7%

5.3 Contingency Plans

The total planned resources will be sufficient to meet both base and high cases load assumptions. In addition, Hydro-Québec Distribution will, at the appropriate time, issue short-term calls for tenders dictated by the need to manage fluctuating demand. Furthermore, Hydro-Québec can also purchase emergency resources on the open market for ICAP.

In 2003, TransÉnergie will add a Variable Frequency Transformer (100 MW) at Langlois substation, on the interconnection to New York through Cedars Rapids Transmission increasing the flexibility to dispatch energy and power between New York and Hydro-Québec systems. TransÉnergie also plans to add a new DC interconnection (1250 MW) between Ontario and Québec for the year 2005.

Table 8 shows the Hydro-Québec typical basic import capability at peak time by system and by type of interconnection. Note that these numbers do not account for generation availability.

Table 8
MAXIMUM-IMPORT CAPABILITY AT PEAK
(MW)

Neighboring Area	Synchronous	HVDC	Radial	Total
CF(L)Co *	5200			5200
Ontario Hydro			500	500
New-Brunswick Power		785		785
NYPP		1000		1000
NEPOOL		690		690
TOTAL	**5200**	**2475**	**500**	**8175**

(*) : Churchill Falls (Labrador) Corporation Limited
Source: A Reliable Transmission Provider, Report of Activities 2001— HQ TransÉnergie

6 PROPOSED RESOURCE CAPACITY MIX

Hydro-Québec is mainly a hydroelectric generation system and plans to continue its hydroelectric development. The breakdown by type of generation is shown in the following Figure 4 for the year 2002. Hydropower represents 77%, while the percentage of the thermal generation is only 6%. The remaining 17% is the purchases in which hydropower counts a large part of 93% since they come from Churchill Falls (Labrador) Corporation Limited.

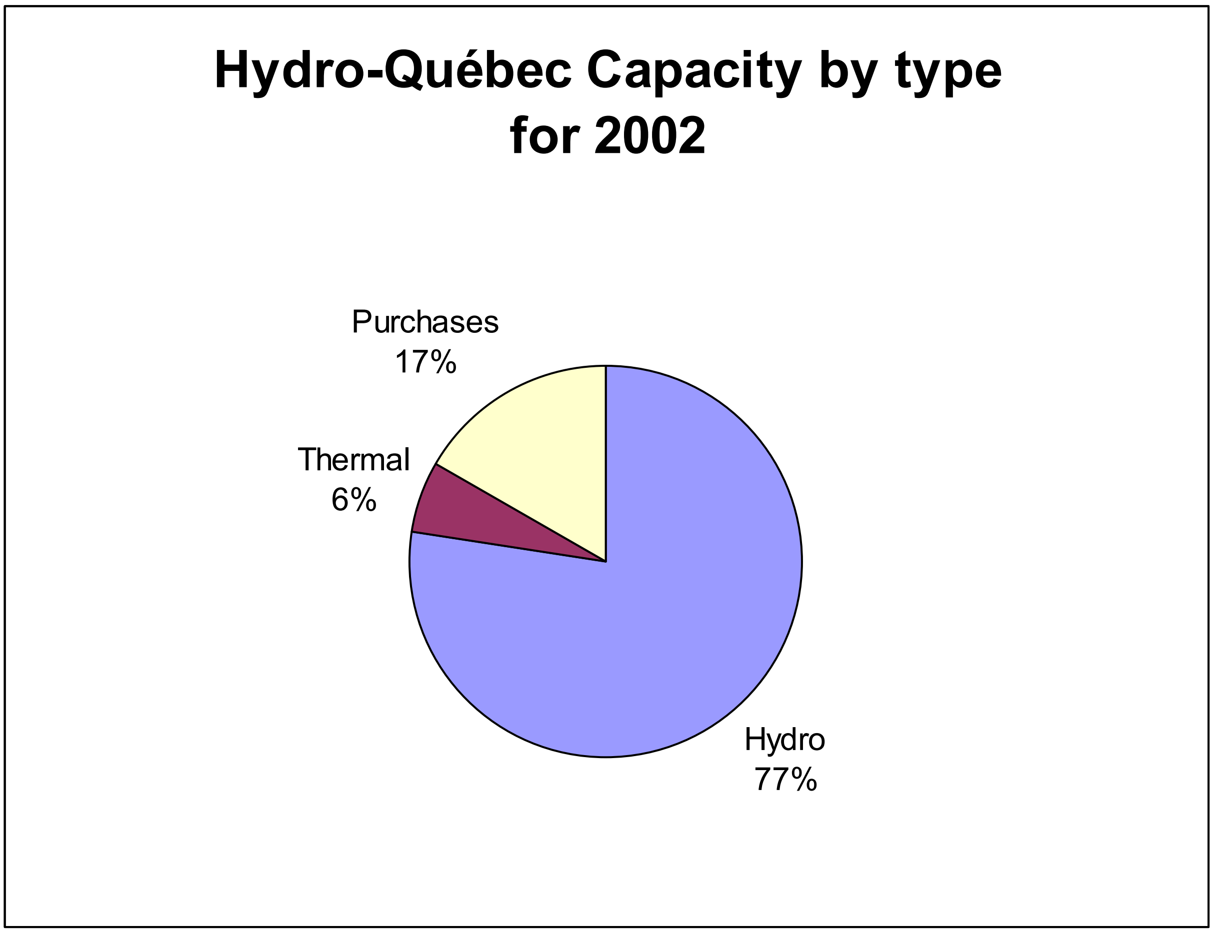
Hydro-Québec hydro stations, mostly with multi-annual storage capability, are located on different river systems geographically distributed throughout the Province of Québec. For long range planning and continuous operation Hydro-Québec can rely on those multi-annual reservoirs (water reserves) and on some other non hydropower resources, allowing it to cope with negative inflow variations. Those resources include, among other means, fossil generation during off peak periods.

In relation with water inflows, our energy reliability criterion states that the Hydro-Québec system should be able to get through a sequence of low inflows having a 2 % probability of occurrence, which is equivalent to the worst two consecutive low inflow years registered since 1943.

Based on the present level of water reserves in the reservoirs and the availability of other non hydropower resources Hydro-Québec don't expect any generation shortage problem.

Even if hydroelectric generation remains the option of choice, Hydro-Québec Production plans to initiate and carry out a number of selected thermal generation projects. On the other hand, relating to the long term supply of electricity, Hydro-Québec Distribution cannot foreseen the electricity type issuing from the calls for tenders.

Figure 4
CAPACITY GENERATION BY TYPE
Percent of total



APPENDIX A

DESCRIPTION OF RESOURCE RELIABILITY MODEL

A DESCRIPTION OF RESOURCE RELIABILITY MODEL

Hydro-Québec uses the Loss of Load Expectation (LOLE) approach in determining generation requirements.

A.1 Load model

A.1.1 <u>Description of the Load Model and Basis of Period Load Shapes</u>

The forecast for electricity is based on the demographic, economic and energy conditions which, according to Hydro-Québec assessment, are most likely to materialise.

The annual peak load forecast over the 2003-2007 period is given in Table A-1. The average growth load for the study period is 1.3% a year.

Table A-1
Peak Load Forecast
(MW)

Planning Year	(1) Internal Peak Load	(2) Firm Exports	(3) Isolated Systems	(1)+(2)-(3) Annual Peak Load *
2002-03	33170	370	56	33480
2003-04	33770	370	58	34080
2004-05	34280	370	59	34590
2005-06	34650	370	60	34960
2006-07	34930	370	62	35240

(*) : rounded

<u>Load Shapes</u>

For the reliability evaluation, the planning year is divided into twelve months. The load is modelled for each month with the individual hourly peak load that is arranged in descending order to form a cumulative load model known as load duration curve.

The isolated systems demand is subtracted from the load and is ruling out in the Loss of Load Expectation evaluation. Accordingly, the diesel generation pertaining to the isolated systems does not appear in the resource units representation.

Hydro-Québec Production Power System Reliability Model performs a conventional analytical calculation to develop the capacity outage probability table, which is then convolved with the system period load duration curve to give an expected risk of loss of load.

A.1.2 Load Forecast Uncertainty

Load Forecast Uncertainty (LFU) is a measure of the error in forecasting the peak demand. It is due to load sensitivity to weather conditions and to Structural[6] Uncertainty caused mainly by the evolution of economic and demographic parameters that affect the total energy in the study period.

To include load forecast uncertainty, the load duration curves are convolved with a distribution curve built from the last thirty years historical data for the weather component and assumed normally distributed for the economic growth component. This operation is done for every month of every planning year.

When combined, these two uncertainty factors are very similar to a normal distribution with a slight asymmetry to the left [$P(x \leq 0)=0.5083$]

The main assumptions related to the LFU remain the same as the previous review. In fact, there are new data available, and based on these new data the LFU tendency would be heading downward. A study will be conducted in the future.

A.2 Generating Resource Unit Representation

A.2.1 Unit Ratings

The following Table A-2 provides a listing of the existing capacity of Hydro-Québec system as of January 2002.

[6] "Structural" uncertainty is defined as all events causing a permanent detachment of the electricity consumption compared to the forecasted trend. By opposition, weather uncertainty, for example, causes a temporary detachment .

Table A-2
Existing Capacity as of January 2002

Station	Numbe r of Units	Dependable Maximum Net Capability in January-MW
1- Hydroelectric Power Plant		
Outaouais River		
Rapide 7	4	44
Rapide 2	4	47
Rapide-des-Quinze	6	83
Rapide-des-Îles	4	132
Première Chute	4	116
Bryson	3	62
Chute-des-Chats	4	90
Hull 2	4	28
Paugan	8	232
Chelsea	5	147
Rapides-Farmers	5	69
Carillon	14	588
Rivière-des-Prairies	6	35
Subtotal	**71**	**1673**
St.Lawrence River		
Beauharnois	36	1175
Les Cèdres	18	38
Subtotal	**54**	**1213**
St-Maurice River		
Rapide-Blanc	6	213
Trenche	6	282
Beaumont	6	264
LaTuque	6	212
Grand-Mère	9	149
Shawinigan	11	353
La Gabelle	5	125
Subtotal	**49**	**1598**
Bersimis River		
Bersimis 1	8	900
Bersimis 2	5	715
Subtotal	**13**	**1615**
Aux-Outardes River		
Outardes 4	4	662
Outardes 3	4	742
Outardes 2	3	446
Subtotal	**11**	**1850**

Station	Number of Units	Dependable Maximum Net Capability in January-MW
1- Hydroelectric Power Plant (cont'd)		
Manicouagan River		
Hart Jaune	3	48
Manic 5	12	2478
Manic 3	6	1149
Manic 2	8	1038
Manic 1	3	197
McCormick	7	347
Subtotal	**39**	**5257**
La Grande River		
Brisay	2	350
Laforge 2	2	283
Laforge 1	6	831
LaGrande-4	9	2670
LaGrande-3	12	2362
LaGrande-2	22	7487
LaGrande-1	12	1285
Subtotal	**65**	**15268**
Stations < 30MW	**40**	**89**
2-Thermal Plant		
Oil		
Tracy	4	600
Subtotal	**4**	**600**
Gas Turbines		
Cadillac	3	162
La Citière	4	280
Bécancour	4	436
Subtotal	**11**	**878**
Nuclear		
Gentilly 2	1	668
Subtotal	**1**	**668**
Total Hydro Power		**28561**
Total Thermal Powe		**2146**
Total system		**30707**

A.2.1.1 Definitions

The capacity definitions used in reliability evaluation are as follows:

- <u>Hydroelectric Stations larger than 30 MW</u>

Dependable Maximum Net Generating Capability (DMNC) is defined as the net output a unit can sustain over a specified period modified for month limitations and reduced by the capacity required for station service or auxiliaries. 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 (1175 MW), Les Cèdres (38 MW) and Carillon (588 MW) generating stations are not modelled according to this definition. This is discussed in section A.4.

- <u>Hydoelectric Stations of 30 MW and less</u>

These generating stations are the run-of-river plants. DMNC is defined as the average power based on operational historical generation.

- <u>Thermal stations</u>

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.

A.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 revised, if need be, the new data on turbine efficiency measurements, the updated operating water head and the temperature of generator cooling water are taken into account . Unit testings are also performed on an as-needed basis.

Thermal Unit Ratings are reevaluated at each unit performance test.

A.2.2 Unit Unavailability Factors

A.2.2.1 Types of Unavailability Factors Represented

- Forced Outages Rates

The basic generating unit parameter used in a conventional reliability evaluation is the unit forced outage rate (FOR). The FOR serves as an estimate of the probability that a generating unit will be unavailable due to forced outage at some time in the future.

Forced Outage Rate:

$$\text{FOR} = \frac{\text{Time on Forced Outage}}{\text{Time on Forced Outage} + \text{Time on Service}}$$

As illustrated in Table A-3, the typical FOR of existing hydraulic equipment are between 1.1% and 4.8% depending on the season and the "maturity" of the units.

Table A-3
Typical Forced Outages Rates[7]

Type of equipment	Forced Outage rate
Hydraulic	1.1% to 4.8%
Thermal, including nuclear	4% to 10%

- Maintenance

Typical monthly percentage maintenance for Hydroelectric Capacity figures on Table A-4. The percentage is applied on the total hydro capacity available (except Beauharnois and Les Cèdres).

Hydro-Québec continues to review its maintenance practices with the aim of extending generating unit availability.

[7] Beauharnois, Les Cèdres and Carillon are not modelled according to these FOR as described in section A.4.

Table A-4
Typical % Maintenance for Hydro Units

Month	Maintenance for the year 2005-06
January	0.4
February	0.4
March	4.4
April	13.7
May	17.7
June	22.5
July	24.9
August	17.1
September	21.6
October	10.5
November	5.3
December	0.4

Thermal power plants are on maintenance during summer, each powerhouse has its own maintenance schedule.

A.2.2.2 Source of Unavailability Factors Represented

The forecast of reliability indices is based on the operational history of the generating units modified pursuant Hydro-Québec quality objective on generating units and the updated Scheduled Outage.

A.2.2.3 Maturity Considerations

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

A.2.2.4 Tabulation of Typical Unavailability Factors

Typical forecast unavailability factors for different type of generating units are contained in Table A-3 and Table A-4 shown above.

A.2.3 Purchases and Export Representation

Purchases and Export are represented as an adjustment to the load, including transmission losses if need be.

A.2.3.1 Purchases

Churchill Falls (Labrador) Corporation Limited (CFLCo)

The capacity purchases are represented according to the contracts between HQ and CFLCo.

For the year 2002 and after, Hydro-Québec has access to around 5050 MW during winter and from 2900 to 4550 MW during the summer time.

Alcan

Alcan has its own generating facilities in Québec. Some of its loads are connected to the Hydro-Québec transmission system and are included in the demand forecast. In 2001, Alcan has commissioned his new aluminum smelter and since became a net buyer of electricity from Hydro-Québec. Accordingly, the equivalent power of 283 MW delivered by Alcan, since 1996-97 is no longer available.

Hydro-Québec has signed a new capacity purchase contract with Alcan. Part of the capacity will come from Alcan generating units in Québec. The rest of the capacity will be available under interruptible power shaving.

New Brunswick Power

Hydro-Québec has a contract to buy 200 MW of peaking capacity from 2002 to 2011.

Independent Power Producers in Québec

In 2002, the total purchase contracts from Independent Power Producers is 387 MW. For the upcoming years, there will have an additional 48 MW available from these producers.

A.2.3.2 Export

Only firm power deliveries, including transportation losses, are represented in the reliability model. If need be, delivery duration curve is represented.

A.2.4 Retirements

No retirement is planned for the period covered by this review. Older stations are rather overhauled.

A.3 Representation of Interconnected Systems

As mentioned above, Hydro-Québec does not rely on neighbouring assistance to meet its adequacy criterion. Accordingly, neighbouring reserve sharing is not modelled in system generating capacity reliability evaluation.

A.4 Modelling of Limited Energy Sources

For most hydro stations, 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 stations, the run-of-river Beauharnois and Les Cèdres stations 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 channelled 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 modelled with a probability distribution based on operational historical generation. This distribution accounts not only for hydraulic conditions but also for maintenance and forced outages.

During the winter period Carillon station has hydraulic constraints due to the small size of the reservoir that need to be refill in night-time. The DMNC could be available for two or three hours per day. An equivalent revised FOR of 25% proved to be an adequate representation of the situation in regard with the LOLE evaluation.