

New Brunswick System Operator  
Exploitant du réseau du Nouveau-Brunswick



**10-Year Outlook:**

**An Assessment of the Adequacy of  
Generation and Transmission Facilities**

**In**

**New Brunswick**

**2007 - 2016**

## 1.0 EXECUTIVE SUMMARY

The New Brunswick System Operator (NBSO) is an independent not-for-profit statutory corporation that was created under New Brunswick's *Electricity Act* on October 1, 2004. The *Act* transferred the responsibility for the adequacy and reliability of the integrated electricity system from NB Power to NBSO, and also made NBSO responsible for facilitating the development and operation of the New Brunswick Electricity Market. These responsibilities take the form of operation of the NBSO controlled grid and administration of the Open Access Transmission Tariff (OATT) and the Market Rules.

This document, *10-Year Outlook: An Assessment of the Adequacy of Generation and Transmission Facilities in New Brunswick 2007 – 2016*, is the third of an annual series of such reports from NBSO. The intent of this document is to inform existing and potential Market Participants of the current and future outlook for the market and for the adequacy of the electricity system. The report forms a baseline plan using committed supply resources and recommended transmission plans for new projects and transmission upgrades that may be required. It does not deal with power costs, rate structures, economics, or business risks of the electric industry in New Brunswick, but focuses on adequacy and reliability of supply. With this information, Market Participants will be able to assess potential market opportunities for themselves and their customers from a common base.

New Brunswick's electricity system faces both significant challenges and potential opportunities over the next 10 years. One of the challenges is the uncertainty regarding plans for new generation resources to support load growth. Some recent announcements regarding new generation projects in New Brunswick include:

- On July 29, 2005, the Province announced that it would proceed with the planned refurbishment of the Point Lepreau nuclear station, with Atomic Energy of Canada Limited (AECL) as the general contractor. This 18-month refurbishment is to begin in April 2008, and results in a 558 MW capacity reduction for the system during the refurbishment period. NB Power Distribution and Customer Service is in the process of identifying ways to reliably make up for this lost resource.
- On January 1, 2007 NB Power and TransAlta Corporation signed a 25-year power purchase agreement for 75 MW of wind power in 2008. TransAlta Corporation will construct, own and operate the Kent Hills wind farm, located in Albert County. The wind farm will consist of 25 wind turbines that will provide approximately 220,000 MWh of wind electricity per year, enough to supply approximately 13,600 homes per year.
- On March 1, 2007 NB Power and Vector Wind Energy Inc. signed a 20-year power purchase agreement for up to 21 MW of wind power in 2008. Vector will construct, own and operate the Fairfield Hill wind farm, located in Westmorland County.

Opportunities for the New Brunswick electricity system include the continued evolution of the Electricity Market that allows for participants to independently buy and sell power through bilateral contracts. Open access to the transmission system makes it possible for developers to build power projects in New Brunswick, and the increased transfer capability provided by the planned second 345 kV interconnection project with New England provides New Brunswick power producers with more opportunities to export power. This second 345 kV interconnection project with New England is currently under construction, with a targeted in-service date of Dec. 1, 2007. The increase in import capability provided by the second interconnection also enhances the competitiveness of the Electricity Market by providing load serving Market Participants a greater choice of suppliers. Open access to the transmission system and the planned second interconnection project also provide opportunities for other areas in the northeast by increasing the potential for wheeling through New Brunswick.

The 10-year load forecast predicts that the electrical energy to be supplied to New Brunswick customers will increase from 15,651 GWh in 2007/08 to 17,683 GWh in 2016/17. This increase of 2,032 GWh represents an annual net energy growth rate of 1.4%. The load forecast for the hourly peak demand shows an increase from 3,229 MW in 2007/08 to 3,701 MW in 2016/17. This increase of 472 MW represents an annual peak demand growth rate of 1.5%.

The only committed generation addition in this 10-year Outlook is 96 MW of wind project capacity targeted for 2008/09. Generation retirements include 98 MW at Courtenay Bay in 2006/07, and 57 MW at Grand Lake in 2010/11 which are offset by the termination of 198 MW of export capacity to Hydro Quebec in 2011/12.

The outlook on generation resources shows that the New Brunswick system requires an additional 346 MW in 2008/09 to meet the long term NBSO capacity based reserve criterion. This deficit is reduced to 280 MW if the projected Demand Side Management (DSM) and the projected additional wind capacity meet their targets. The primary cause of this capacity shortage is the planned 18-month refurbishment of the Point Lepreau Generating Station that is scheduled for April 2008 to November 2009. The current net capability of this nuclear station is 570 MW, which will increase to 658 MW after refurbishment.

The 346 MW deficit during the refurbishment outage is reduced to 280 MW if the projected Demand Side Management (DSM) and the projected additional wind capacity meet their targets and no other deficits occur in the 10 year period. Details of the load and resources review are provided in the table below for the planning period.

### Load and Resources Review 2007/08 to 2016/17

		Fiscal Year Ending									
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
A	Load Forecast	3,229	3,275	3,317	3,317	3,381	3,447	3,514	3,575	3,637	3,701
B	Non-Firm Industrial	140	140	140	140	140	140	140	140	140	140
C	Required Reserve $C = 20\% * (A - B)$	618	627	635	635	648	661	675	687	699	712
D	Interconnection Contracts (+Export/-Import)	279	218	248	248	50	50	50	50	50	50
E	Total Supply Resources excluding Wind	4,164	3,605	4,263	4,207	4,207	4,207	4,207	4,207	4,207	4,207
F	Committed Wind	0	96	96	96	96	96	96	96	96	96
G	Committed Wind (@ 30% capacity credit)	0	29	29	29	29	29	29	29	29	29
H	Total Supply Resources including Wind $H = E + G$	4,164	3,634	4,292	4,235	4,235	4,235	4,235	4,235	4,235	4,235
I	(+Surplus/-Deficit) $I = H + B - A - C - D$	178	-346	231	175	296	217	137	63	-11	-88
J	Projected DSM from Efficiency NB	20	35	50	65	80	95	110	125	140	155
K	Projected Wind	0	104	104	137	171	204	237	271	304	304
L	Projected Wind (@ 30% capacity credit)	0	31	31	41	51	61	71	81	91	91
M	Projected (+Surplus/- Deficit) $M = I + J + L$	198	-280	312	281	427	373	318	269	220	158

Projected DSM from Efficiency NB shown in the table are estimates related to the following programs:

- Existing Homes Energy Upgrades Program
- Energy Efficient New Homes Program
- Upgrades Program for Multi-Unit Residential Buildings
- Retrofit Program for low-income households

Projected wind capacities are based upon NB Power announcements that they intend to have 200 MW (equals 60 MW after derated by a 30% capacity factor) of wind capacity by 2009, and 400 MW (equals 120 MW @ 30% capacity factor) of wind capacity by 2016. According to the NB Energy Market Rules, wind projects in New Brunswick have their capacity values derated to their seasonal (winter and summer) capacity factors. The purpose of derating wind capacity is to approximate its reliability contribution to the grid, and 30% is a conservative estimate of the expected capacity factor of a new wind project. Once a wind project is built and its seasonal capacity factors demonstrated, its accredited capacity is adjusted accordingly.

While the report identifies current generation emission standards it makes no assumptions regarding altered future environmental requirements and the effects that they could have on future generation resource adequacy. In particular regulations limiting greenhouse gas emissions are expected and could pose a risk for the future utilization of fossil fuelled generation. NBSO notes however that it will be tracking such standards as they are implemented and may conduct analyses in the future regarding their impact on generation adequacy.

Major projects in the planning period that impact the bulk transmission system include:

- the building of a second 345 kV tie between New Brunswick and New England by 2007 that will increase the transfer capability to and from ISO New England by about 300 MW, and
- installation of the Newcastle Terminal 345/230 kV tie transformer in the 2010-2014 time period for system security and back-up to the Bathurst 345/138 kV transformer.
- refurbishment of the Eel River HVDC station (converter controls, synchronous condensers and various other station upgrades). The purpose of this project is to replace aging technology and extend the life of the HVDC station by 20 years. Two years will be needed to procure all necessary equipment, and the installation of the new equipment will require 8 weeks of station outage (4 weeks/circuit). The estimated cost of this project is \$20,000,000.

Several other transmission projects are identified in this report to maintain supply reliability to customers served from the 138 kV and 69 kV systems.

In addition to analysis of committed generation and planned transmission in New Brunswick the 10-Year Outlook report reviews the various regional development opportunities that are currently under study by ISO-New England, Newfoundland and Labrador Hydro, NB Power and Maine utilities. As part of its participation in these regional studies, NBSO is undertaking scenario analysis in order to determine the most efficient expansion of the New Brunswick transmission system interconnections with ISO-NE in order to accommodate increased exports of potential future generation from nuclear, wind, hydro, cogeneration and natural gas. It is anticipated that NBSO will complete this study during the summer of 2007.

This 10-Year Outlook fulfills NBSO's obligation under Market Rule 9.2 to develop and publish an annual baseline plan for the New Brunswick Electricity Market. It includes an assessment of the potential need for investments in transmission facilities and other actions that may be required to maintain reliability of the SO-controlled grid, to improve performance of the market, and to reduce the costs associated with transmission constraints on the SO-controlled grid. Under Market Rule 9.4, third parties may contact NBSO to bid on the projects identified in this report, or they may propose alternative solutions to these projects that may include, but are not limited to, transmission, generation, distribution, and energy efficiency projects.

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### 3.0 INTRODUCTION

On October 1, 2004 New Brunswick's *Electricity Act* was proclaimed and the electric utility industry in New Brunswick was restructured. Competitive supplier choice for municipal utilities and large industrial customers served from the transmission system was provided; the Electricity Market under Market Rules issued by the Minister of Energy was opened; and a new corporation called New Brunswick System Operator (NBSO) was created.

NBSO is an independent not-for-profit statutory corporation separate from the NB Power group of companies. It is led by a CEO and governed by an independent Board of Directors. The primary responsibilities of NBSO are to ensure the security and reliability of the integrated electricity system, and to facilitate the development and operation of a competitive electricity market. These responsibilities take the form of operation of the SO controlled grid and administration of the Open Access Transmission Tariff (OATT) and the Market Rules. They also include contract and agreement development, market monitoring, system studies, accounting, settlement, interconnection issues, and Regional Transmission Organization (RTO) development.

The original OATT was approved by the New Brunswick Board of Commissioners of Public Utilities (PUB) in its decision of March 13, 2003, and was updated in its decision of April 26, 2005. It specifies the terms, conditions and rates for use of the NBSO controlled transmission system. Any future changes and additions to the OATT will be made by NBSO and submitted for regulatory approval to the newly created Energy and Utilities Board (EUB). The Market Rules govern the rights and obligations of entities participating in the Electricity Market (Market Participants). The initial Market Rules were issued by the Minister of Energy effective October 1, 2004 and are based on principles recommended by the Market Design Committee in April 2002 and accepted by government. Several rule adjustments have been made in the last two years to improve pricing flexibility and market transparency, and also to allow demand bidding. Any future changes and additions to the Market Rules, similar to the past changes, will be made by NBSO after consultation with stakeholders through the Market Advisory Committee (MAC). The MAC includes representatives from a wide range of interested parties (large industrial customers, municipal utilities, generators, transmission operators, transmission users, environmental groups, small consumers, etc.). The role of the MAC is to review and propose potential changes to the OATT and Market Rules and make appropriate recommendations to the NBSO Board of Directors regarding their implementation.

In addition to being the operating authority for the reliable operation of the New Brunswick electricity system, NBSO is responsible for its long-term planning and development. Under the Market Rules, NBSO is required to publish annually a 10-year outlook regarding the current and future adequacy of the NBSO controlled integrated electricity system. This is the third such report and it includes the most recent official 10-year load forecast, and the current outlook for new generation and transmission projects.

The intent of this document is to inform existing and potential Market Participants of the current and future state of the electricity system so that they will be able to assess potential market opportunities for themselves and their customers from a common base.

## 4.0 LOAD FORECAST

The load forecast represents the current 10-year forecast of the electricity requirements of in-province customers for 2007/08 to 2016/17. It is prepared based on a cause and effect analysis of past loads, combined with data gathered through customer surveys and an assessment of economic, demographic, technological and other factors that affect the utilization of electrical energy. This forecast incorporates the effects of the availability of natural gas in New Brunswick, energy efficiency and conservation measures, and changes in industrial customer self-generation.

Energy requirements and peak hour demand are affected by weather conditions, the most significant being temperature. The energy forecast is based on 30-year average temperatures (1971-2000) with the annual peak hour demand determined for a design temperature of  $-24^{\circ}\text{C}$  over a sustained 8-hour period.

### 4.1 Annual Requirements

The 10-year load forecast in this report is based on the NB Power document *Load Forecast 2007 – 2016*. Table 1 shows the 10-year load forecast of annual energy and peak load requirements for New Brunswick. System net energy has a forecast growth rate of 1.4% per year, and the peak hourly demand is forecast to grow at 1.5% per year.

The highest months of energy consumption in New Brunswick are December through February due to the electric heating load in the province. The months with the lowest energy consumption are June through August due primarily to warmer temperatures.

Although January represents the peak month for energy consumption, the peak hourly demand in New Brunswick is forecast to occur in the first week of February. The forecast for a February peak hourly demand occurs because, historically, the January peak load has been lowered through curtailments of interruptible customers on the coldest days, and these curtailments have occurred more often in January than in February.

Table 2 shows a summary of major assumptions built into the load forecast.

Figure 1 shows the forecast consumption of annual system net energy on a monthly basis.

Figure 2 shows how the monthly peak loads are forecast to vary as a percentage of the annual forecast peak load.

Table 3 shows a summary of load forecast sensitivities for the year 2010/11.

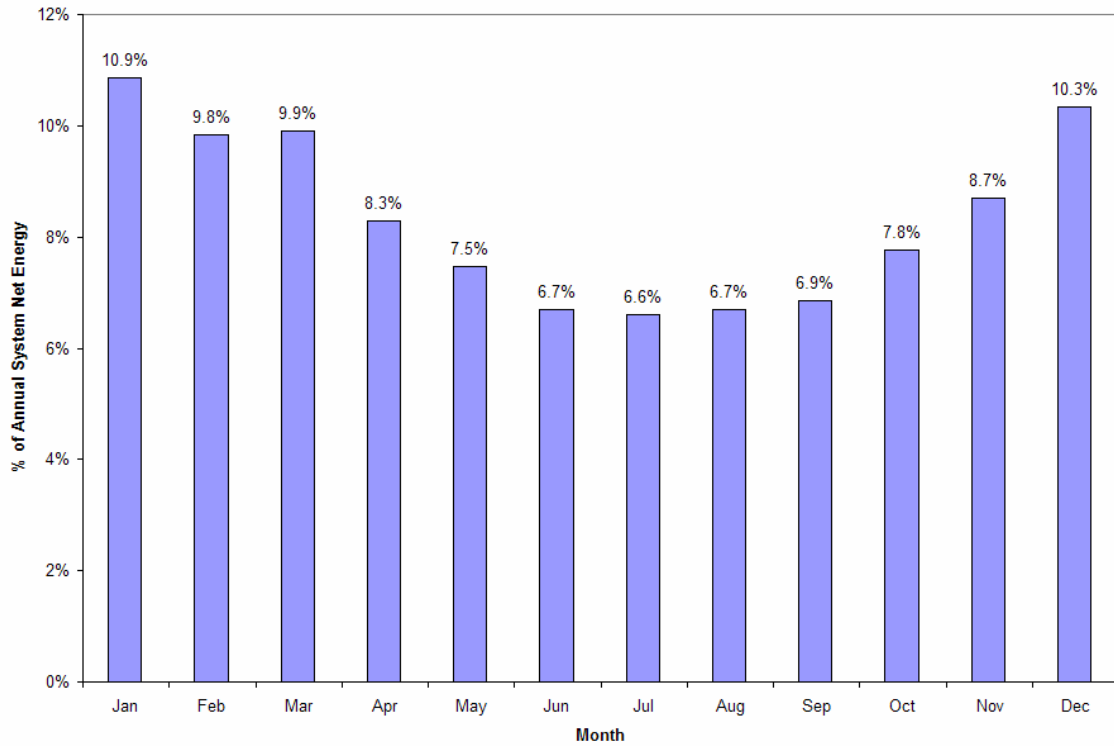
**Table 1: New Brunswick 10-year Load Forecast**

Year	System Net Energy (GWh)	Peak Hourly Demand (MW)
2007/08	15,651	3,229
2008/09	15,884	3,275
2009/10	16,105	3,317
2010/11	15,950	3,317
2011/12	16,220	3,381
2012/13	16,507	3,447
2013/14	16,812	3,514
2014/15	17,101	3,575
2015/16	17,394	3,637
2016/17	17,683	3,701
Overall Increase (from 2006/07)	2,032	472
Average Annual Growth Rate	1.4%	1.5%

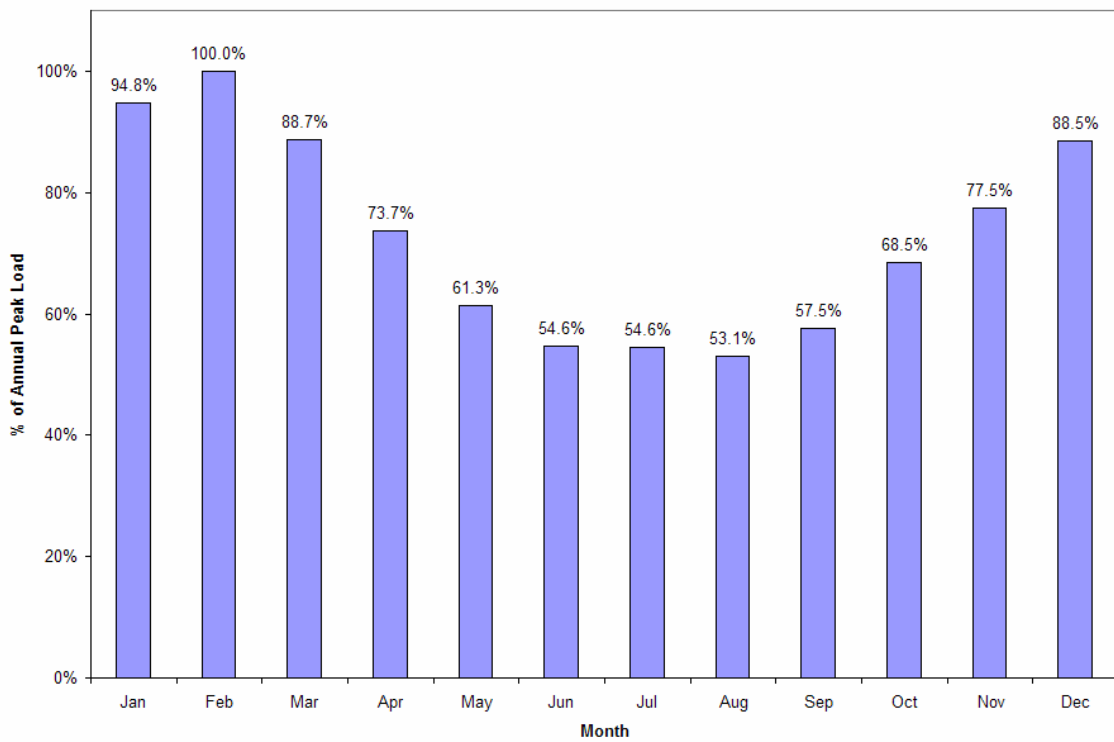
**Table 2: Major Load Forecast Assumptions**

Parameter	Description
GDP Growth	<ul style="list-style-type: none"> <li>2.2% per year (from NB Dept of Finance)</li> </ul>
Temperatures	<ul style="list-style-type: none"> <li>Temperature at peak is -24 degrees Celsius</li> <li>Annual energy forecast is based on 30-year average temperatures</li> </ul>
Residential Growth	<ul style="list-style-type: none"> <li>1.3% per year load growth</li> <li>Flat population growth</li> <li>Declining household size from 2.43 people/house to 2.15.</li> </ul>
General Service Growth	<ul style="list-style-type: none"> <li>2.8% per year load growth</li> </ul>
Street Lighting Growth	<ul style="list-style-type: none"> <li>0.6% per year load growth</li> </ul>
Industrial Load Growth	<ul style="list-style-type: none"> <li>0.9% per year load growth</li> </ul>
Natural Gas Availability	<ul style="list-style-type: none"> <li>Gas territory forecast as available to 30% of NB population.</li> </ul>
Energy Efficiency Assumptions	<ul style="list-style-type: none"> <li>Home heating improvement of 0.5% per year</li> <li>Customer replacement of old appliances with more efficient ones.</li> </ul>

**Figure 1: Monthly Consumption of Annual System Net Energy**



**Figure 2: Monthly Peak Loads as a Percentage of Annual Peak Load**



**Table 3: Sensitivities of Load Forecast Assumptions**

Sensitivity	Impact in year 2010/11	
	Energy GWh	Demand MW
Temperature colder by one degree Celsius at peak	n/a	+32
± 100 degree days per year	± 102	n/a
± 1000 residential customers per year	± 22	± 7
Eliminating or doubling natural gas usage	± 162	± 45
0.1% change in rate of GDP growth	± 20	± 4
Loss of any one of ten largest customers (average)	- 520	-90
±1%/Year change in real residential and general service rates (± 5% total, incremental to forecast inflation)	± 86	± 16

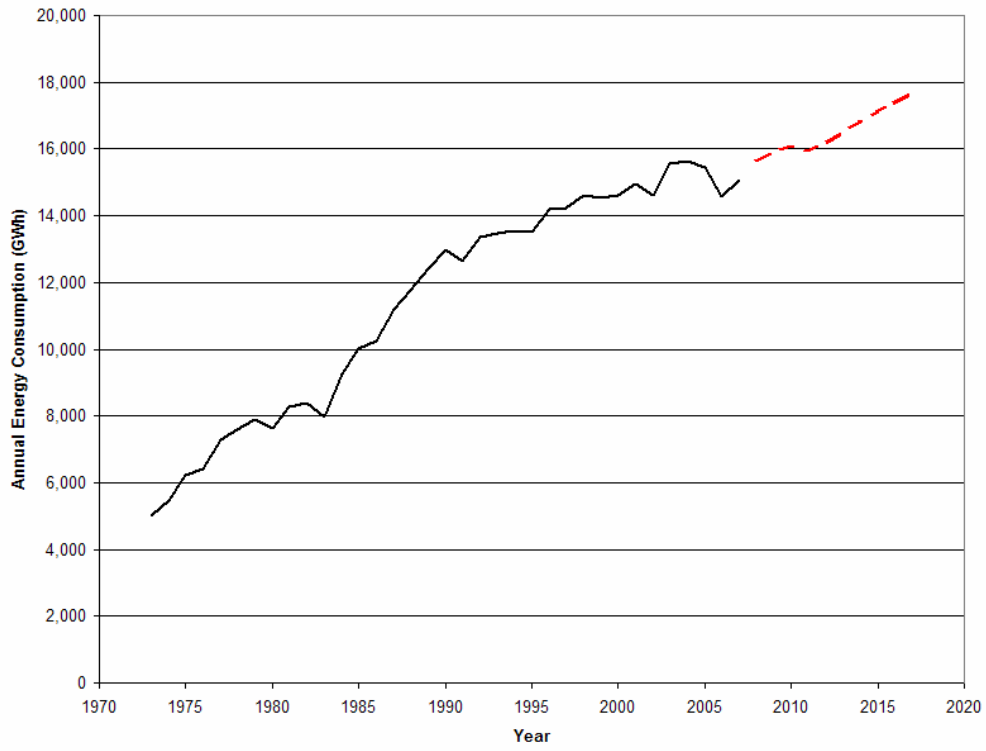
#### 4.2 Historical and Forecast Requirements

NB Power Distribution and Customer Service (DISCO) currently serves 99.8% all of New Brunswick customer load, except for Perth Andover whose 0.2% of New Brunswick load is served by WPS Energy Services Inc. in Maine. Each year DISCO prepares a load forecast that represents the long term projection of in-province customer requirements for demand and energy. This forecast reflects the fact that the New Brunswick economy is very electrically intensive, due in large measure to the forestry and mining industries. In 2005/06, large industrial loads accounted for 40% of NB Power's in-province energy sales. Modernization efforts have increased industrial consumption in recent years, and that trend is expected to continue.

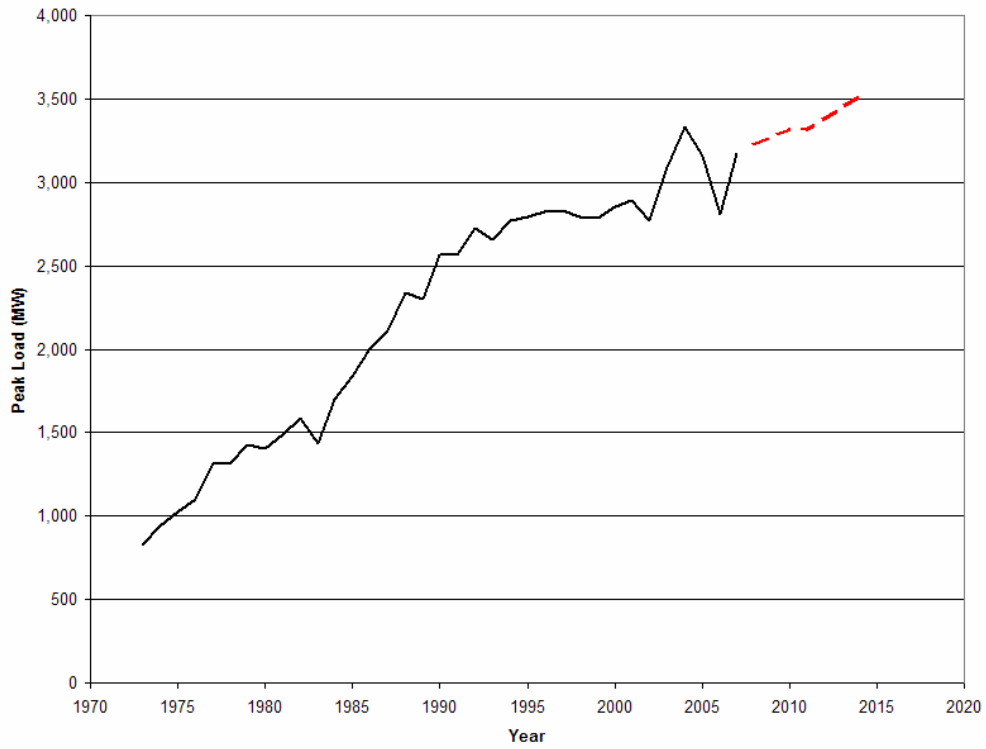
Figure 3 shows the actual annual energy consumption from 1973 to 2007, and the forecast annual energy consumption for 2008 to 2017.

Figure 4 shows the actual peak hourly demand from 1973 to 2007, and the forecast peak hourly demand for 2008 to 2017.

**Figure 3: New Brunswick Annual Energy Consumption**



**Figure 4: New Brunswick Peak Hourly Load**



#### 4.3 Demand Side Management Forecast

Efficiency NB is the New Brunswick energy efficiency and conservation agency. Its mission is to offer sound advice and practical solutions to help New Brunswickers use energy more efficiently, make better energy choices, manage energy expenses and lessen the impact of energy use on the environment.

Projected DSM from Efficiency NB for 2007/08 is roughly estimated to be 20 MW, then increasing by 15 MW per year throughout the forecast period resulting in 155 MW by 2016/17. This estimate is based upon projected participation related to the following programs:

- Existing Homes Energy Upgrades Program
- Energy Efficient New Homes Program
- Upgrades Program for Multi-Unit Residential Buildings
- Retrofit Program for low-income households

More information regarding Efficiency NB can be found at its website <http://www.energycnb.ca>.

## 5.0 GENERATION RESOURCES

### 5.1 Existing Generation Resources

New Brunswick's generation plants comprise one of North America's most diverse generating systems. The mix of fuel types includes oil, hydro, nuclear, coal, natural gas, Orimulsion®, biomass, and diesel powered stations. Table 4 lists the New Brunswick generators along with their fuel types and capacities as of March 31, 2007.

**Table 4: New Brunswick Generation Resources**

Plant	Unit	Type	Net Capacity MW	Notes
Point Lepreau	1	Nuclear	570	Planned Refurbishment starting in April 2008
	SG1&2	Diesel	5	
Belledune	2	Coal	457	
Coleson Cove	1	Oil	324	
	2	Oil	324	
	3	Oil	324	
Dalhousie	1	Orimulsion® / Oil	96	
	2	Orimulsion® / Oil	203	
Bayside	6	Natural Gas	263	Capacity includes Combined Cycle Operation
Grand Lake	8	Coal	57	
Grand Manan	3	Diesel	28	
Millbank	1	Diesel	99	Tied to Sale Contract Until Nov 2011 Tied to Sale Contract Until Nov 2011
	2	Diesel	99	
	3	Diesel	99	
	4	Diesel	99	
Ste Rose	1	Diesel	99	
Grandview	1,2	Natural Gas	90	
Frasers	1	Biomass	38	
St. George	1,2	Hydro	15	
Musquash	1,2	Hydro	5	
Mactaquac	1	Hydro	110	
	2	Hydro	110	
	3	Hydro	110	
	4	Hydro	115	
	5	Hydro	113	
	6	Hydro	113	
Beechwood	1	Hydro	36	
	2	Hydro	36	
	3	Hydro	41	
Grand Falls	1	Hydro	16	
	2	Hydro	16	
	3	Hydro	16	
	4	Hydro	16	
Tobique	1	Hydro	10	
	2	Hydro	10	
Sisson	1	Hydro	9	
Milltown	1	Hydro	4	
<b>TOTAL CAPACITY</b>			<b>4175</b>	Total Capacity as of March 31, 2007

The bulk of the energy produced by hydro facilities usually comes during the spring run-off period when the snow melts in the watersheds in the upper reaches of the Saint John River. New Brunswick does not have major storage capability in its river system, and as a result, hydro facilities are not always fully available to supply at maximum power

output on a continuous basis. The hydro system does serve a vital role in meeting short term peaking needs as well as providing immediate replacement power in the case of a sudden trip-off of another generating unit.

## 5.2 Changes in Capacity

At this time, there are no firm plans for major conventional generation additions in New Brunswick. New Brunswick's first commercial wind power projects, a 75 MW wind farm in Kent Hills, and a 21 MW wind farm in Fairfield Hill, have target in-service dates in late 2008. The proposed 20 MW Grand Manan wind farm announced by NB Power and Eastern Wind Power Inc. in June 2004 has been delayed indefinitely. Due to the intermittency of wind power, the capacity credit assigned to wind projects by NBSO is derated to the wind project's capacity factor averaged over the three most recent years of operation.

Planned generation retirements in the next 10 years include 98 MW at Courtenay Bay in 2006/07, and 57 MW at Grand Lake in 2010/11. The replacement of some feeder tubes at Point Lepreau is expected to derate that facility by 12 MW in 2007/08.

A planned 18-month refurbishment of the Point Lepreau nuclear station is targeted for April 2008. The loss of this generator results in a 558 MW capacity decrease for the system during the refurbishment period. The scheduled completion date for the project is November 2009, and the refurbished net capability of the generator is to be 658 MW. Approval to proceed with this project was given by the Province in July 2005, with Atomic Energy of Canada Limited (AECL) as the general contractor. NB Power Distribution and Customer Service is in the process of identifying the capacity requirement for the refurbishment period, and is looking at ways to meet this requirement. Table 5 provides a summary of the generation capacity changes from January 2007 to December 2010.

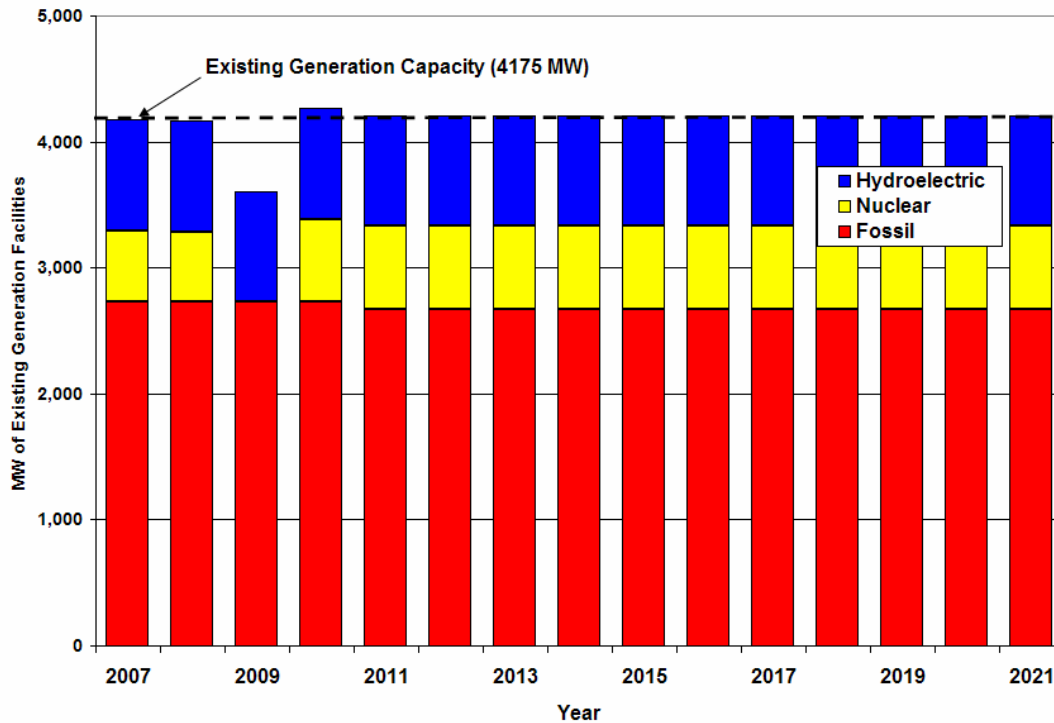
**Table 5: Summary of New Brunswick Generation Changes**

Year	January Capacity MW	December Capacity MW	Capacity Change MW	Explanation
2007	4,175	4,164	-12	Point Lepreau derated (-12 MW)
2008	4,164	3,634	-530	Point Lepreau refurbishment begins April 2008 (-558 MW), Wind capacity added (96 MW * 30% = 29 MW)
2009	3,634	4,292	+658	Point Lepreau refurbishment ends October 2009 (+658 MW)
2010	4,292	4,235	-57	Grand Lake retired (-56 MW)
2011	4,235	4,235	+0	

### 5.3 The Need for New Resources

Over time, the aging of the existing fleet of New Brunswick generators will result in additional retirements that will require either new generation resources or refurbishment of existing resources. Figure 5 illustrates the forecasted remaining service life of the existing generation facilities in New Brunswick until 2021.

**Figure 5: Forecast of Remaining Service Life of New Brunswick Generators**



### 5.4 System Impact Studies

Under the Market Rules, NBSO is required to perform Connection Assessments for proposed projects that wish to connect to the SO-controlled grid at 69 kV or higher voltage. NBSO is required to conduct all System Impact Studies that are required for such projects. A listing of completed and queued studies is available on the NBSO website at <http://www.nbso.ca/en/ConnectionApplications/SystemImpactStudies.htm>

Connection Applications for System Impact Studies are placed into two separate queues; (i) the generation SIS queue, and (ii) the load and Point to Point SIS queue. The generation SIS queue will include all projects that involve the connection of new non-embedded generation to the SO-controlled transmission grid. The load and Point to Point SIS queue will include all other projects, including the connection of load projects, embedded generation projects, and assessments of new Point to Point transmission service.

Table 6 shows the System Impact Study list of queued projects as of April 2007.

**Table 6: NBSO List of Queued System Impact Studies (April 2007)**

<b>Number</b>	<b>Project Name</b>	<b>Project Location</b>	<b>Project Size (MW)</b>	<b>Project Type</b>	<b>Company Name</b>	<b>SIS Initiation Date</b>
1	Pokeshaw 200 MW Wind Farm	Pokeshaw, NB	200	Generation	Gale Force Energy	Feb 16, 2006
2	Garvie Mountain Wind Farm	Garvie Mountain, NB	30	Generation	UPC Canada Wind, Inc.	Apr 25, 2006
3	West Cape Wind Farm	West Cape, PEI	200	Generation	Ventus Energy Inc.	May 04, 2006
4	Bayfield Wind Farm	Bayfield, NB	101	Generation	SkyPower Inc.	May 11, 2006
5	Maisonette Wind Farm	Maisonette, NB	101	Generation	SkyPower Inc.	May 11, 2006
6	Hopewell Cape Wind Farm	Hopewell Cape, NB	25	Generation	J.D. Irving, Limited	Jul 07, 2006
7	Upham Mountain Wind Farm	Upham Mountain, NB	60	Generation	J.D. Irving, Limited	Jul 07, 2006
8	Pokeshaw 37.5 MW Wind Farm	Pokeshaw, NB	37	Generation	Gale Force Energy	Jul 11, 2006
9	Burnt Church 27 MW Wind Farm	Burnt Church, NB	27	Generation	Atlantic Wind Power Corporation (2005) Ltd	Sep 05, 2006
10	Blue Mountain Wind Farm	Blue Mountain, NB	101	Generation	Invenergy Services Canada ULC	Dec 08, 2006
11	Lower Churchill – Quebec Option	Quebec/NB border to NB/New England border	740	Point to Point	Newfoundland and Labrador Hydro	April 18, 2007
12	Lower Churchill – Quebec Option	Salisbury, NB to NB/New England border	740	Point to Point	Newfoundland and Labrador Hydro	April 18, 2007

### 5.5 Impact of Greenhouse Gas Emissions

On May 9, 1992, Canada was one of 150 world governments to adopt the United Nations Framework Convention on Climate Change. Building upon the climate change convention, in 1997, the world governments adopted the Kyoto Protocol with its legally binding constraints on greenhouse gas (GHG) emissions. Canada has ratified the Kyoto

Protocol on climate change with a commitment to reduce greenhouse gas emissions by 6% of 1990 levels during the period between 2008 and 2012. Russia ratified the Kyoto Protocol in December, 2004, and it came into effect February 16, 2005.

While New Brunswick accounts for 3% of Canada's GHG, all jurisdictions will be called upon to address climate change. Approximately 90% of New Brunswick's 20 million tonnes of carbon dioxide emissions come from the combustion of fossil fuels with electricity generation accounting for 47% or nine million tonnes.

In addition to the Kyoto Protocol, the New England Governors and Eastern Canadian Premiers agreed in 2001 to a Climate Change Action Plan to reduce regional GHG in a manner that is cost effective while maintaining reliable energy supplies. That plan set regional reduction targets:

- Reduce regional GHG emissions to 1990 emission levels by 2010;
- Reduce regional GHG emissions by at least 10% below 1990 emissions by 2020 and establish a five-year process in 2005 to adjust or establish future emissions reductions goals; and
- Reduce regional rate of emissions by 20% per MWh by 2025 from 2000 rate.

According to its 2005 Environmental performance Report, NB Power's greenhouse gas (CO<sub>2</sub>) emissions for that year were 8.79 million tonnes. To meet its 1990 level of 8.3 million tonnes would require a reduction of 0.49 million tonnes. To achieve the goal of 10% below 1990 emissions by 2020, New Brunswick emissions from the electricity sector would have to be reduced down to 7.5 million tonnes, which equates to a reduction of 1.29 million tonnes from 1990 levels.

A GHG reduction plan for Canada is expected to be released soon by the Federal Government and it likely will impose limiting standards on the utility industry. While the exact nature of the emission regulations are not known they are expected to impact fossil fuelled generation to some degree. This is a risk for fossil generation that could affect future resource adequacy in New Brunswick. It is the intention of NBSO to track these GHG regulations as they are implemented and to analyse their impact on system adequacy.

## 5.6 Clean Air Initiative

A new federal initiative for clean air has just been released, but has yet to pass through Parliament and become law. It is intended to set new standards for particulate, acid rain gases (SO<sub>2</sub> and NO<sub>x</sub>), volatile organic compounds (VOCs), mercury, and other heavy metals. These standards are not expected to pose any significant risk to the operating capability of fossil generators in New Brunswick. With the planned retirement of the Grand Lake plant in 2010, along with major environmental emissions controls already installed at other plants, New Brunswick's fossil generators are expected to perform well above these new standards.

## 6.0 RESOURCE ADEQUACY

### 6.1 Operating Reserve Criterion

NBSO is responsible for determining the capacity needs of the integrated electricity system, and for ensuring that Market Participants procure and provide sufficient capacity to meet these needs. The capacity required by the system is the sum of the NBSO forecasts for load, required reserve, and firm capacity sales. The capacity available to the system is the sum of the installed capacity, firm capacity purchases, and interruptible load, minus any capacity that is derated or unavailable due to a planned maintenance outage.

NBSO regularly performs assessments of operational resource adequacy for each capability period and for the next 18 months (done each quarter). The main operational criterion is to have sufficient reserve capacity to meet 100% of the largest contingency plus 50% of the next largest contingency. The 18-month assessments by NBSO of the capacity and adequacy of the integrated electricity system are published quarterly at <http://www.nbso.ca> in the *Reports and Assessments* section.

The capability period assessment takes place 6 months prior to the start of each of two capability periods. The winter capability period starts November 1 and ends March 31. The summer capability period starts April 1 and ends October 31. NBSO forecasts the capacity requirements for the total system for the respective capability period and allocates those requirements to all load-serving Market Participants on the basis of their non-coincident peak demands. It is then the responsibility of the load-serving Market Participants to demonstrate to the satisfaction of NBSO that they have secured capacity equal to or in excess of their individual capacity obligations at least 4 months prior to the start of the capability period.

### 6.2 Planning Reserve Criterion

To assess the long-term generation resource adequacy of the system, NBSO applies a capacity based reserve criterion that is equal to the higher of the largest contingency or 20% of the firm load.

As a member of the Northeast Power Coordinating Council (NPCC), NBSO also reports its resource adequacy with respect to meeting the NPCC generation reliability criterion, which states:

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 shall be, on average, no more than 0.1 days per year. This evaluation shall make due allowance for demand uncertainty, scheduled outages and deratings, forced outages and deratings, assistance over interconnections with neighboring areas and regions, transmission transfer capabilities, and capacity and/or load relief from available operating procedures.

NBSO submits a comprehensive resource adequacy review to NPCC every three years, and interim reviews of resource adequacy are submitted in the years subsequent to completing the comprehensive review. In the most recent comprehensive review, the *2004 Maritimes Area Triennial Review of Resource Adequacy* [1], it was found that the 20% planning reserve criterion used by the Maritimes Area combined with 50 MW of additional capacity provided through interconnection support would meet the NPCC criterion for the existing system. This confirmed that the NBSO capacity based criterion is acceptable under the NPCC standard.

### 6.3 Load and Resources Review

The load and resources review looks at whether the sum of the generation resources and non-firm industrial load customers are adequate to meet the sum of the forecast requirements for peak load, firm interconnection contracts, and required planning reserve. A surplus indicates that the planned resources are adequate, whereas a deficit indicates that the planned resources are not adequate.

Table 7 summarizes the load and resources outlook from 2007/08 to 2016/17. It shows that the New Brunswick system will be short 346 MW of capacity in the 2008/09 fiscal year due to the planned refurbishment of Point Lepreau. Beyond the refurbishment period, the outlook forecasts capacity deficits of 11 MW in 2015/16, and 88 MW in 2016/17. Deficits are expected to grow beyond 2017.

**Table 7: Load and Resources Review for New Brunswick 2007/08 to 2016/17**

		Fiscal Year Ending									
		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
A	Load Forecast	3,229	3,275	3,317	3,317	3,381	3,447	3,514	3,575	3,637	3,701
B	Non-Firm Industrial	140	140	140	140	140	140	140	140	140	140
C	Required Reserve C = 20%*(A - B)	618	627	635	635	648	661	675	687	699	712
D	Interconnection Contracts (+Export/-Import)	279	218	248	248	50	50	50	50	50	50
E	Total Supply Resources excluding Wind	4,164	3,605	4,263	4,207	4,207	4,207	4,207	4,207	4,207	4,207
F	Committed Wind (@ 30% capacity credit)	0	29	29	29	29	29	29	29	29	29
G	Total Supply Resources including Wind G = E + F	4,164	3,634	4,292	4,235	4,235	4,235	4,235	4,235	4,235	4,235
H	(+Surplus/-Deficit) H = G + B - A - C - D	178	-346	231	175	296	217	137	63	-11	-88

Other than DISCO's obligation to provide standard offer service, there is no prescribed requirement under the Market Rules for specific Market Participants to make up any deficit indicated by this long term review. The purpose of the 10-year load and resources review is to provide information to Market Participants and potential Market Participants of any forecasted deficiency. For example, the future need for replacement capacity during the planned Point Lepreau refurbishment outage to meet the planning criterion is indicated by the load and resources review, but action by specific Market Participants in that timeframe is not prescribed by the Market Rules. Similarly, the results of the 18-month assessments do not prescribe actions by specific Market Participants or trigger sanctions, but do provide important information to NBSO and the marketplace about impending deficits.

As noted in Section 6.1, both winter and summer capability periods are assessed. The Market Rules require Market Participants for load facilities to secure capacity resources equal to or greater than their obligation 4 months prior to each capability period. Non-compliance on the part of a Market Participant may lead to sanctions.

#### 6.4 Strengths and Weaknesses

The geography of New Brunswick provides significant advantages towards the development of a vibrant energy market. An advantage for new thermal power projects is that they can be sited at many high quality coastal locations in the province that have access to low temperature cooling water. Another geographic advantage is that the strong interconnections between New Brunswick and neighbouring power systems in Quebec, New England, Nova Scotia, PEI, and Northern Maine enhance the opportunities for New Brunswick Market Participants to buy and sell power. These opportunities are also enhanced due to the seasonal diversity of the winter peaking New Brunswick load and the summer peaking New England load.

The cost of electrical supply in New Brunswick is stabilized with a diversified generation mix of hydro, nuclear, and thermal sources. However there is a weakness in the lack of indigenous power generation resources, especially hydro power reservoirs and low cost, low sulphur coal reserves. Extensive reliance on thermal generation leads to high dependency on thermal fuels that can be subject to disruption in supply, wide price swings and the need to meet stringent emission standards.

The geographic dispersion of the people of New Brunswick and the lack of population density makes for a complex and sophisticated transmission system connecting generating stations to substations distributing electricity to customers throughout the province.

## **7.0 TRANSMISSION SYSTEM**

### **7.1 System Evolution**

The existing transmission has evolved over the past century. It began mainly as 69 kV lines connecting small generating stations to municipal distribution systems in the first half of the 20<sup>th</sup> century. Following the Second World War as loads grew and additional stations were constructed, the 138 kV system was expanded to form a figure eight network around the province by the 1960's. Expansion continued into the early 1970's with completion of a 230 kV tree connecting from the northeast (Dalhousie-Bathurst-Newcastle) area to Keswick in the west and across the province past Grand Lake to Salisbury in the southeast. The main bulk system voltage increased to 345 kV with the completion of the New England interconnection and the Coleson Cove Generating Station in the late 1970's. Through the 1980s and 1990s the 345 kV system has expanded to encircle the province and extend into Nova Scotia.

Today the system is very robust with generation dispersed at different system locations and sufficient transmission capacity to economically dispatch generation for exports as well as all in province load levels. As a result congestion is rare except under extreme contingency conditions and power can be transferred in significant quantities in all directions.

### **7.2 Interconnections to External Systems**

New Brunswick is interconnected to neighboring power systems in Quebec, New England, Nova Scotia, Prince Edward Island, Northern Maine, and Eastern Maine. Similar to the development of the internal transmission system these interconnections have evolved over time. The first interconnections were constructed at the 69 kV and 138 kV levels with the Maine Public Service Company in Northern Maine and Nova Scotia Power Inc in the 1950s. The initial interconnections with Quebec, New England and Prince Edward Island were completed as part of the major transmission expansions of the 1970s. Addition of the 345 kV interconnection to Nova Scotia and a second Quebec interconnection occurred in the 1980s. Further expansion of the New England interconnection with a second 345 kV transmission line will occur in 2007/08.

The two interconnections with Quebec are through High Voltage Direct Current (HVDC) stations and there is the ability at each to radially connect a portion of the New Brunswick load directly to the Quebec system. This enables increased transfer capability from Quebec to New Brunswick. All other interconnections are synchronous AC transmission lines and they connect the Maritimes Area systems as part of the very large Eastern Interconnection of North America.

Table 8 shows the transfer capability between New Brunswick and its neighboring systems.

**Table 8: Interconnection Transfer Capability**

Neighboring System	Transfer Capability to New Brunswick (MW)	Transfer Capability from New Brunswick (MW)
Quebec	1185	735
New England	100 <sup>†</sup>	700
Nova Scotia	350 <sup>††</sup>	300 <sup>††</sup>
Prince Edward Island	124	222
Northern Maine	90	100
Eastern Maine	15	15

<sup>†</sup> transfer capability from New England varies according to New Brunswick’s largest contingency, load levels in Maine, status of area 345 kV MVAR resources, and the generating status of units near Orrington, Maine.

<sup>††</sup> transfer capability to and from Nova Scotia is constrained by the import and export limits of the Nova Scotia electricity system.

## 8.0 TRANSMISSION PLAN

### 8.1 Transmission Planning Responsibilities

The Transmission Plan represents an analysis of the existing high voltage transmission network, and the development required to meet the forecast load in compliance with the established transmission planning criteria.

NBSO is responsible for ensuring that the integrated electricity system, at all times, has adequate capacity to satisfy all applicable reliability criterion. NBSO is also responsible for addressing congestion issues that impact the efficient operation of the Electricity Market.

NBSO, upon identifying a system adequacy issue or a congestion issue, will consult with Transmitters and Market Participants to develop technically feasible options for addressing the issue. These options will then be published on the NBSO website, along with a notice of intent by NBSO to request proposals to resolve the issue. Transmitters and Market Participants may then participate in a formal Request for Proposals (RFP) process leading to the final selection by NBSO of the preferred project.

### 8.2 Transmission Planning Criteria

The New Brunswick bulk transmission system is planned, designed and operated in accordance with single contingency criteria. The overall system quality of supply, as it relates to frequency and duration of interruption to customers and/or generation and voltage magnitude and waveform, is primarily a function of the accepted System Design Criteria in Appendix A.

NBSO policy is to use the transmission planning criteria widely accepted and used by North American utilities, and the system reliability criteria to which NBSO is obliged to conform through its participation in NPCC. NPCC's role in monitoring conformance with the *NPCC Basic Criteria for Design and Operation of Interconnected Power Systems* [2] is limited to those instances where non-conformance could result in adverse consequences to more than one Area.

These criteria can be summarized as follows:

1. Voltage Criterion

Under all normal (no contingency) heavy or light load operating conditions, there should be sufficient reactive support to enable the 230 kV and 138 kV load bus voltages to be held in the range of 95% to 105% of rated value. This includes the condition of peak load in combination with maximum hydro generating capability and also the condition of reduced load (50% variable +

100% industrial load) in combination with minimum hydro generating conditions.

## 2. Single Contingency Criterion

A single contingency is defined as an event leading to the loss of one or more system components. The most common interpretation of this definition is the assumption of the loss of one transformer or one transmission circuit or one generator. The loss of both circuits on a double circuit structure is considered a single contingency as required by NPCC for stability tests.

Each 138 kV area load should have less than one 1.0 hour/year expected outage on the loss of the most significant supply. For evaluation under this criterion, all transmission line loadings shall be within the limits where the CSA Code ground clearances can be maintained, and/or the conductor does not exceed 100 degree C, at 2 feet/sec. wind speed.

Under single contingencies, transformers can be loaded up to 119% of their forced cooled 65 degree C rating during the winter months when ambient temperatures does not exceed zero degree C.

### 8.3 Transmission Planning Methodology

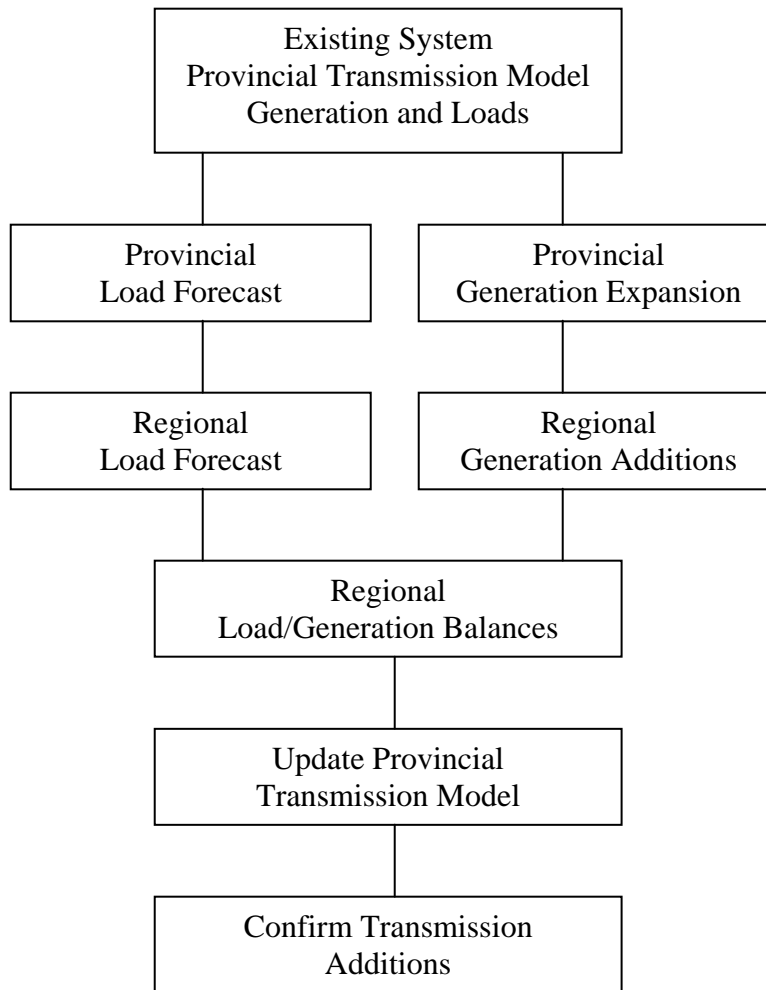
The System Design Criteria, upon which the needs for the recommended system reinforcements are based, are presented in Appendix A. The NPCC Basic Criteria for Design and Operation of Interconnected Power Systems, upon which are based the design of the 345 kV (Bulk) Transmission expansion, are available at <http://www.npcc.org/PublicFiles/Reliability/CriteriaGuidesProcedures/A-02.pdf> .

The planning of the major transmission system has to respond to the forecast load growth and the integration of new generating stations. The objective of transmission planning is, therefore, twofold. It has to satisfy the transmission of power from generating stations to load centres, and has to satisfy the interconnection and integration of generating stations to enable economic and reliable utilisation of the generating capability available to the market.

In the process of transmission planning, the geographic location of loads and generating stations play a role equally important to that of the magnitude of load and capacity of generating stations. Moreover, the planning methodology has to address imbalances between load and generation in any region as well as dynamics (e.g. fault conditions, stability) in order to provide reliable supply to customers.

Figure 6 illustrates the transmission planning process.

**Figure 6: Transmission Planning Process**



There are three inputs to the transmission planning process.

1. A computer model of the base year for the existing system is required that includes generation, loads, transmission lines and substations. This model simulates generating unit capacities, loads concentrated at load centres, transmission lines and transformers with their transmission characteristics and capabilities. This model, commonly referred to as the load flow model, is used to test the system for satisfactory transmission capability.
2. The second component is the load forecast. The in-province load forecast provides year by year prediction of loads at existing and future substations down to the 69 kV transmission level. Load information is compiled on individual substation peak loads that may or may not occur at the time of system peak. The prediction of sales to and purchases from neighbouring

utilities, based on actual contracts and expected sales or purchases is also an important aspect of the forecast.

3. The third component is the size and location of the present and proposed future generating units and stations.

As major transmission requirements are related to the balance of loads and generation in a geographic region, the first step in planning is to allocate loads and generation to regions. Such regions or transmission planning areas are defined on the basis of general load concentrations. The five regions in New Brunswick defined by NB Power Transmission for major transmission planning purposes are:

1. Northern including, Miramichi, Bathurst, Caraquet, Belledune, Eel River and Dalhousie
2. Western including Edmundston, Iroquois, Saint Andre, Grand Falls, Beechwood, and Woodstock
3. Central including Keswick, Fredericton, Millville, Grand Lake, Marysville, and Mactaquac
4. Southern including Saint John, Courtenay Bay, Pennfield, Oak Bay, Coleson Cove, Norton and Point Lepreau
5. Eastern including Salisbury, Moncton, Memramcook and Murray Corner

The loads and generating capabilities are allocated to the above regions annually during the planning period and the balance, positive or negative, is a measure of transmission capability required into the region to meet load demand or out of the region to transmit surplus generation. This balance is calculated not only for the annual peak hour demand, but also for intermediate load levels

The regional balances give an indication of the magnitude of transmission requirements and provide an appreciation of the long-term variation of such requirements.

To ensure an adequate level of reliability in the northeast part of the continent and across North America, criteria have been established to guide utilities in the design, operation and maintenance of their power systems. Member areas of NPCC agree to abide by guidelines and criteria that have been established by experience over the years. It is these guidelines that form the basis for operation and maintenance of the bulk power system in New Brunswick.

The essential requirement is to provide service continuity to customers, and to avoid jeopardising the reliability of neighbouring power systems in the event of loss of a major

transmission component, line or transformer, or loss of a generating unit. This is commonly referred to as the 'single contingency' planning criterion.

#### 8.4 Determination of Regional Loads for Transmission Planning Studies

Consistent with the overall planning methodology, this section presents the regional non-coincident peak loads for 2006/07. In 2005/06, NB Power Distribution and Customer Service (DISCO) switched from NB Power Transmission's five region structure to its own three region structure as follows:

- Central – headquartered in Fredericton (Marysville) with operating centres in Fredericton, Miramichi, Woodstock, Grand Falls and St. Stephen
- Eastern – headquartered in Moncton with operating centres in Moncton, Bouctouche, Shediac, Sackville, Sussex and Rothesay
- Northern – headquartered in Bathurst with operating centres in Bathurst, Tracadie and Eel River

Table 9 shows the in-province firm loads for the DISCO regions. The total system load as seen by the generating units is the sum of the area loads plus the transmission losses. The peak system losses have been found to be approximately 4%, including the losses in the 345 kV, 230 kV, 138 kV and 69 kV networks. The sum of the loads and losses is the total system load. As the area peak loads may not occur exactly at the same time, the coincident system load as seen by the generation is less than the total load determined by the summation of non-coincident area loads and losses. The diversity factor is calculated by dividing the coincident peak by the sum of the non-coincident peak substation loads. For 2006/07, the diversity factor was found to be 92%.

**Table 9: Non-coincident Peak Loads by Region**

DISCO Region	2006/07 Non-Coincident Peak Load (MW)	Regional Percentage
Central		
Distribution	787	77%
Large Industrial	192	19%
Wholesale	42	4%
Eastern		
Distribution	885	62%
Large Industrial	295	21%
Wholesale	231	16%
Other Substation	11	1%
Northern		
Distribution	497	57%
Large Industrial	369	43%
Subtotal		
	3309	
Transmission Losses 4%	132	
Total Non-Coincident Peak	3441	
Total Coincident Peak (Jan 2007)	3169	
Diversity Factor	92%	

## 8.5 Transmission Development 2006 to 2015

This section summarizes the project plans for the 345 kV transmission system, and the 345/230 kV and 345/138 kV transformer projects that impact the development of the 345 kV transmission system. It also lists the plans for 138 kV lines, 69 kV lines, and the 138/69 kV transformation additions connecting into bulk transmission terminal stations. Under Market Rule 9.4, third parties may contact NBSO to bid on the projects identified in this report, or they may propose alternative solutions to these projects that may include, but are not limited to, transmission, generation, distribution, and energy efficiency projects.

### 1. Stage 2007/08

Construction of a second 345 kV interconnection between New Brunswick and New England began in 2006/07. This new line will connect Point Lepreau, New Brunswick to Orrington, Maine, and it has a targeted in-service date of December 1, 2007. As a result of this project (including series and shunt capacitors in Maine), the maximum transfer capability between New Brunswick and New England is increased from 700 MW to 1000 MW. The firm import capability will be raised from zero to 300MW and the conditional firm import will be raised from 100 MW to 500 MW. This second interconnection also significantly improves the reliability of the Maritimes system since loss of either of the two

interconnections to New England will no longer result in the separation of the Maritimes from the interconnected New England power system.

2. Stage 2007/08

A new 138/69 kV tie transformer (87/115/144 MVA) will be installed at the Bathurst Terminal to replace one of the existing transformers during the summer/fall of 2007. The remaining transformer will be replaced in the summer of 2008. The loss of an existing transformer causes overloading of the other transformer. The new transformers will each be capable of carrying the full 69 kV load in the Bathurst area.

3. Stage 2008/09

The Marysville terminal 138/69 kV tie transformer T1 (50 MVA) will be replaced with a new transformer (87/115/144 MVA) capable of supporting the area load on peak. T1 is undersized and was built in 1957. The new transformer will also help to reduce loading on Marysville transformer T4 which has almost reached its maximum operating rating (134 MVA) during normal peak conditions.

4. Stage 2008/09

Construction of a new 138 kV transmission line (approximately 25 km in length) is planned for connecting the proposed 75 MW Kent Hills wind farm to the Salisbury 138 kV terminal.

5. Stage 2008/09

Construction of a new 69 kV transmission line (approximately 2 km in length) is planned for connecting the proposed 21 MW Fairfield Hill wind farm to the 69 kV line 0118.

6. Stage 2009/10

Construction of 69 kV Line 0150 from Iroquois Terminal to East Edmundston Substation is required due to increased loading on the existing Line 0070 supplying the East Edmundston Substation and the neighbouring substations.

7. Stage 2009/10

There is a planned rebuilding of 69 kV Line 0013 from Six Roads to Line 0133 (near Shippagan). This project is a restoration of a 50+ year old 69 kV line that has been exposed to some of New Brunswick's harshest weather conditions. This line rebuilding will require sections with new right-of-ways. The line will be rebuilt to 138 kV standards to allow for proper spacing and safer crew working conditions.

8. Stage 2009/10

There is a planned refurbishment of 69 kV Line 0015 from Moncton line 0003 to Hillsborough substation). This life extension project will involve the replacement of poles, guy wires and cross arms and the capping and butt treatment of usable poles as needed. It is expected that this work will extend the life of the line by at least 10 years.

9. Stage 2009/10

There is a planned development of a 138/69 kV terminal at Norton. The goal of this terminal expansion is to provide voltage support for central areas of the province and to allow for the retirement of the aging Brookville switching station.

10. Stage 2009/10

There is a planned installation of a second 138/69 kV tie transformer at Grand Lake. The purpose of this transformer installation is to provide backup for the loss of the existing Grand Lake transformer T1. Without backup, the loss of T1 during peak loading conditions results in low voltage problems on the local 69 kV network.

11. Stage 2009 to 2013

There is a planned refurbishment of the Eel River HVDC station (converter controls, synchronous condensers and various other station upgrades). The purpose of this project is to replace aging technology and extend the life of the HVDC station by 20 years. Two years will be needed to procure all necessary equipment, and the installation of the new equipment will require 8 weeks of station outage (4 weeks/circuit). The estimated cost of this project is \$20,000,000.

12. Stage 2009 to 2012

There are planned installations of additional 345 kV breakers at Norton, Eel River and Belledune. The installation of these breakers will increase the reliability of the bulk 345 kV power system.

13. Stage 2010/11

A new 21.6 MVAR capacitor bank is to be installed on the Grand Lake 69 kV bus in order to provide back-up voltage support to that area. During peak conditions, an outage of the Grand Lake 138/69 kV tie transformer causes the 69 kV voltage in the area to dip below the acceptable level of 0.9 per unit. The addition of a new capacitor bank would help relieve the voltage problem caused by the loss of this transformer.

14. Stage 2010 to 2014

A 345/230 kV, 450 MVA, transformer will be required at Newcastle terminal for system security and backup of the contingency loss of the Bathurst 345/138 kV transformer. The timing of this project is dependent on the load growth rate in the Bathurst and Newcastle areas, and it is projected to become necessary within the 2010 to 2014 time period.

15. Stage 2007 to 2013

A new 138 kV transmission line from Salisbury to Memramcook is planned to relieve loading on Line 1156 and Line 1157. Consultation with Customer Services on substation location, route planning and design, and environmental requirements will take many years to complete. Therefore, a 6-year completion date is expected.

16. Stage 2008 to 2013

A transformer replacement at Tinker is being considered by WPS Canada Generation, Inc. (WPS) in order to alleviate congestion issues within Northern Maine. The current 138/69 kV transformer, built in 1966, has a nameplate rating of 50 MVA. The planned upgrade would see this rating double to 100 MVA. The exact timing of this potential upgrade is still uncertain as the project is currently being assessed. Its implementation is dependent on a joint study involving NBSO, WPS, and the Northern Maine Independent System Administrator (NMISA).

17. Stage 2012 to 2015

It is planned to build a new 345 kV transmission line from Coleson Cove to Salisbury. The objective of this project is to provide backup for the loss of 345 kV line 3004 and line 3013. It is anticipated that this backup will be vital since this 345 kV transmission network section interconnects between large load and high generation areas.

## 8.6 Transmission Region Requirements

This section gives a summary of transmission adequacy issues and options at the subtransmission level (138 kV and below) to service area loads.

### 1. Western Region

This region, along with the Northern region, has the highest percentage of distribution substations supplied at 69 kV (approximately 90%). Limitation of the load growth on a few of the 69 kV transmission lines will be required in order to

prevent future 138/69 kV tie transformer additions and construction of new 69 kV lines.

Conversion of existing 69 kV substations to 138 kV is required in order to prevent some transmission line over-loading. Line 0020 supplying the Woodstock area is becoming heavily loaded, and this loading has increased with the new 69 kV substation supplying the new Regional Hospital located very close to the Woodstock terminal.

Supplying more loads from 138 kV substations instead of 69 kV substations would result in lower transmission losses for the region and would relieve loading on the area's 138/69 kV tie transformers.

NB Power Transmission is planning the construction of Line 0150 to supply East Edmundston Substation. The new line will be built to 138 kV standards for the possible future conversion of East Edmundston Substation to 138 kV.

## 2. Central Region

Fredericton Area - The single contingency loss of the Grand Lake 138/69 kV tie-transformer will soon require subtransmission reinforcement. The new tie transformer planned for Marysville and the installation of a second 138/69 kV tie transformer and capacitor bank at Grand Lake will help provide the area with voltage support and improved reliability.

Miramichi Area - The conversion of some 69 kV substations to 138 kV substations will soon be required to alleviate the loading on the local 69 kV transmission lines. The East Chatham Substation is a candidate for such a conversion, but there are no plans for converting any of this area's substations at this time.

## 3. Eastern Region (Moncton - Memramcook Area)

The Eastern Region has had significant 69 kV to 138 kV substation conversions in the past 5 years. These improvements were necessary in order to prevent serious 69 kV transmission deficiencies. Additional conversions will be required in the future in order to prevent a reoccurrence of the problem.

The construction of an additional 138 kV transmission line from Salisbury to Memramcook is recommended to relieve loading on Line 1156 and Line 1157. It is projected that that the Moncton area load will continue to grow, thus additional transmission capacity will be needed to reliably meet demand.

The ageing 69 kV line 0015 between Moncton line 0003 and Hillsborough substation requires life-extension work.

#### 4. Northern Region (Bathurst - Eel River Area)

The replacement of the two 138/69 kV tie transformers in Bathurst Terminal is required due to the heavy loading on the local 69 kV network.

The ageing 69 kV line 0013 section between Six Roads and line 0133 needs to be replaced/rebuilt.

#### 5. Southern Region

The development of a 138/69 kV terminal at Norton is recommended in order to provide voltage support to central areas of the province that are susceptible to voltage regulation problems.

### 8.7 Life Extension of Transmission Lines

Once designed and constructed, transmission lines are inevitably affected by the effects of time, the environment, repeated mechanical and electrical loading, etc. Transmission system reliability incorporates dependability and security. Dependability relates to the continuity of electricity to customers. In the event of equipment failure, system security ensures that system failures are localized and long-term damage is minimized. As would be expected, older systems normally provide less reliability and security.

The New Brunswick transmission system uses four different voltage levels. Higher voltage transmission lines provide greater power carrying capacity and lower losses.

1. 345 kV for "bulk" transmission delivery
2. 230 kV and 138 kV for "underlay" transmission
3. 138 kV for "underlay" support as well as transmission delivery to local areas
4. 69 kV for transmission delivery to local distribution areas

The 345 kV transmission system is comprised of 1267 km of steel tower transmission lines that are relatively new and are forecast to provide sufficient capacity to ensure reliable, economic delivery of electricity for the current planning period. The second interconnection between New Brunswick and New England is the only planned expansion for this system.

The 230 kV transmission system has 540 km of transmission lines (wood poles) and the 138 kV transmission system comprises some 2404 km of transmission lines (majority wood poles) that are generally near the midpoint of their estimated 45-year useful life.

The 69 kV transmission system has 2497 km of transmission lines and transmits power to the majority of in-province loads. These facilities have an average age of 39 years.

The average age of the 138 kV and 69 kV facilities has created the need for a comprehensive maintenance program. NB Power Transmission has recognized this need and is in the middle of an eight year program designed to improve reliability and extend the useful life of the 69 kV lines. This program includes preventive maintenance activities, such as:

- pole replacement
- cross arm and guy wire replacement
- capping and butt treatment of older poles
- using the latest methodology to determine the remaining useful life

Plans have been implemented to carry out a similar program for the 138 kV and 230 kV transmission lines.

Contingency plans are in place in the event of the loss of any single element of the bulk transmission system. This requires the 230 kV and 138 kV underlay system to be maintained in top form.

To further emphasize the need for a strong maintenance program for the 69 kV, 138 kV and 230 kV transmission lines; the single source radial supplied substation load within New Brunswick totals some 83% of the total system load. Percentage breakdowns are: 48% at the 69 kV level, 33% at the 138 kV level and 2% at the 230 kV level.

## 9.0 REGIONAL SYSTEM DEVELOPMENT

Under the Electricity Act and the Market Rules, NBSO is responsible for undertaking and coordinating power system planning and development responsibilities to maintain and ensure the adequacy and reliability of the integrated electricity system for present and future needs, and for the efficient operation of the market. Studies and future scenario analyses are regularly conducted by NBSO to assess possible system and market impacts of potential local New Brunswick projects as well as potential major projects in neighbouring areas affecting the NBSO system.

Some of the scenarios studied by NBSO include the potential for greater energy exports from New Brunswick. The Province announced in its 2007 throne speech that it intends to grow the energy sector in New Brunswick, and it will examine opportunities to sell more energy to markets in Atlantic Canada and the New England states. The Province has announced that it is also studying the feasibility of a second nuclear reactor at Point Lepreau, and the potential of sending natural gas to the northern area of New Brunswick.

Projects for which NBSO is undertaking and coordinating studies and future scenario analyses, both independently or in partnership with other system operators and utilities, include the following:

### 9.1 2<sup>nd</sup> Tie Project Studies

The new 345 kV interconnection between New Brunswick and New England is currently under construction with a targeted in-service date of December 1, 2007. Studies involving this project that are to be completed in 2007/08 include:

- Final determination of the import/export transfer capabilities between New Brunswick and New England.
- A comprehensive area transmission review of the New Brunswick Bulk Power System.
- Revision of all operating procedures concerning the NBSO/ISO-NE interface.

### 9.2 Possible Generation Expansion Projects

In conjunction with studying the possibility of greater electricity exports from New Brunswick, possible new sources of generation must be modelled to provide the increased exports. The possible generation projects that NBSO includes in these studies are publicly known to be under some degree of consideration, but NBSO makes no representation that its analysis of these projects shows that they have been committed to in any respect.

The following are possible generation expansion projects that NBSO is considering in its studies of greater electricity exports:

- Wind development in the Maritimes Area (500 to 1000 MW)
- Second nuclear facility at Point Lepreau (700 to 1000 MW)

- Second generator at Belledune (500 MW)
- Liquefied natural gas co-generation in Saint John (500 to 750 MW)
- 2<sup>nd</sup> Refinery co-generation in Saint John (200 MW)
- Lower Churchill Project import from Quebec and export to new England (740 MW)
- Lower Churchill Project interconnection at Salisbury, NB and export to New England (740 MW)

### 9.3 ISO New England Scenario Analysis

In the fall of 2006, ISO New England (ISO-NE) began a scenario analysis initiative in order to consider the future supply needs of its area, and to consider all of the potential supply options available in order to meet those needs. ISO-NE has identified that New England's need for resources will grow by more than 4,000 MW by 2015. Some of the scenarios being studied by New England include increasing the amount of power it currently imports from Canada, including New Brunswick. NBSO is participating in this study process, and it is anticipated that Phase I of the study will be completed by June 2007. Phase I will identify and analyze alternative resource scenarios, along with the implications for cost, reliability, and the environment.

### 9.4 Maine/NB MOU to Enhance the Mutual Benefits of the Maine/NB Electrical Interconnections

On February 9, 2007 the Governor of Maine and the Premier of New Brunswick announced that they had signed a Memorandum of Understanding (MOU) to explore and set forth actions enhancing cross-border cooperation on electrical interconnections. This agreement directs Maine and New Brunswick to explore expansions of generation capacity, including renewables, and transmission opportunities by agreeing to jointly undertake the following tasks:

1. Study the feasibility of expanding generation capacity and transmission infrastructure to increase electrical flows across borders;
2. Identify processes and systems to provide transparency and efficiency in Maine and New Brunswick markets;
3. Study the feasibility of developing common market rules that could be applied in Maine and New Brunswick;
4. Explore the potential benefits and technical and legal impediments to the common provisioning of control area services (including balancing, dispatch and reserve sharing);
5. Explore the tariff and governance structures required for a regional transmission organization for Maine and New Brunswick; and
6. Examine the opportunities for compatible greenhouse gas emissions reduction regimes in the electricity sector.

NBSO will be participating in these undertakings, and it is anticipated that complete detailed assessments of all tasks will be presented to the respective governments in a final report no later than January 1, 2008.

#### 9.5 Northern Maine Interconnection Study

In early 2007, Central Maine Power (CMP) and Maine Public Service (MPS) commissioned a study to analyse the Northern Maine transmission system and develop alternative transmission interconnections to the MEPCO and New England transmission systems to improve MPS system reliability without adversely affecting the New Brunswick – Maine transmission interface transfer capability. This study will examine the goal of connecting Northern Maine to the New England market, as Northern Maine is presently interconnected only with the New Brunswick transmission system. Some issues that will impact the scenarios considered in this study include:

- Aroostook Wind Energy, Inc. has submitted a request to connect a 500 MW wind project to the MPS system; and
- The recent Maine-New Brunswick MOU requires the parties to study the feasibility of expanding the transmission infrastructure to increase electrical flows across borders.

NBSO is participating in this study work, and it is anticipated that it will be completed during the summer of 2007.

#### 9.6 NBSO Study Regarding Transfer Capability Expansion

As part of its participation in various studies, NBSO is undertaking scenario analysis in order to determine the most efficient expansion of the New Brunswick transmission system in order to accommodate increased exports to neighbouring markets. These scenarios include the possible generation expansion projects identified in section 9.2, and this work will complement NBSO's participation in the studies identified in sections 9.3, 9.4, and 9.5. It is anticipated that NBSO will complete this study during the summer of 2007.

## 10.0 SUMMARY OF RESULTS

### Load Forecast

- The New Brunswick load forecast for the 10-year planning period has an average growth rate of 1.4% per year for system net energy. This equates to an overall increase of 2,032 GWh for the planning period.
- The load forecast has an average growth rate of 1.5% per year for the peak hour demand, and this equates to an increase of 472 MW for the planning period.
- Energy consumption in New Brunswick is much higher in the winter versus the summer due to the electric heating load in the province. January is the month with the highest forecast for energy consumption. It is 64% higher than it is for July, the month with the lowest forecast for energy consumption.
- The month with the highest forecast for peak hour demand is February. It is 84% higher than it is for August, the month with the lowest forecast for peak hour demand.

### Generation Resources

- As of March 31, 2007 the total capacity of New Brunswick generation resources was 4,175 MW, and at this time there are no plans for new major conventional generation additions to the New Brunswick system.
- Planned generation retirements 98 MW at Courtenay Bay in 2006/07, and 57 MW at Grand Lake in 2010/11.
- On January 1, 2007 NB Power and TransAlta Corporation signed a 25-year power purchase agreement for 75 MW of wind power in 2008. TransAlta Corporation will construct, own and operate the Kent Hills wind farm, located in Albert County. The wind farm will consist of 25 wind turbines that will provide approximately 220,000 MWh of wind electricity per year, enough to supply approximately 13,600 homes per year.
- On March 1, 2007 NB Power and Vector Wind Energy Inc. signed a 20-year power purchase agreement for up to 21 MW of wind power in 2008. Vector will construct, own and operate the Fairfield Hill wind farm, located in Westmorland County.
- There is a planned 18-month refurbishment of the Point Lepreau nuclear station for April 2008. This project was approved by the Province in July 2005, with Atomic Energy of Canada Limited (AECL) as the general

contractor. NB Power Distribution and Customer Service is in the process of identifying the capacity requirement for the refurbishment period, and is looking at ways to meet this requirement. The anticipated replacement of some feeder tubes at Point Lepreau in the next few years is expected to derate its 570 MW capacity by 12 MW in 2007/08. The scheduled completion date for the refurbishment project is November 2009, and the refurbished net capability of the generator is to be 658 MW.

### Load and Resource Balance

- The load and resources review shows that the New Brunswick system will be short 346 MW of capacity in the 2008/09 fiscal year due to the planned refurbishment of Point Lepreau. Beyond the refurbishment period, the outlook forecasts capacity deficits of 11 MW in 2015/16, and 88 MW in 2016/17. Deficits are expected to grow beyond 2017.

### Transmission Projects

- Construction of a second 345 kV interconnection between New Brunswick and New England began in 2006/07. This new line will connect Point Lepreau, New Brunswick to Orrington, Maine, and it has a targeted in-service date of December 1, 2007. As a result of this project (including series and shunt capacitors in Maine), the maximum transfer capability between New Brunswick and New England is increased from 700 MW to 1000 MW, and the import capacity from New England to New Brunswick is expected to be raised from 100 MW to 400 MW. This second interconnection also significantly improves the reliability of the Maritimes system since loss of either of the two interconnections to New England will no longer result in the separation of the Maritimes from the interconnected New England power system.
- A new 138/69 kV tie transformer (87/115/144 MVA) will be installed at the Bathurst Terminal to replace one of the existing transformers during the summer/fall of 2007. The remaining transformer will be replaced in the summer of 2008. The loss of an existing transformer causes overloading of the other transformer. The new transformers will each be capable of carrying the full 69 kV load in the Bathurst area.
- The Marysville terminal 138/69 kV tie transformer T1 (50 MVA) will be replaced in 2008/09 with a new transformer (87/115/144 MVA) capable of supporting the area load on peak. T1 is undersized and was built in 1957. The new transformer will also help to reduce loading on Marysville transformer T4 which has almost reached its maximum operating rating (134 MVA) during normal peak conditions.

- Construction of a new 138 kV transmission line (approximately 25 km in length) is planned in 2008/09 for connecting the proposed 75 MW Kent Hills wind farm to the Salisbury 138 kV terminal.
- Construction of a new 69 kV transmission line (approximately 2 km in length) is planned in 2008/09 for connecting the proposed 21 MW Fairfield Hill wind farm to the 69 kV line 0118.
- Construction of 69 kV Line 0150 from Iroquois Terminal to East Edmundston Substation is required in 2009/10 due to increased loading on the existing Line 0070 supplying the East Edmundston Substation and the neighbouring substations.
- There is a planned rebuilding in 2009/10 of 69 kV Line 0013 from Six Roads to Line 0133 (near Shippagan). This project is a restoration of a 50+ year old 69 kV line that has been exposed to some of New Brunswick's harshest weather conditions. This line rebuilding will require sections with new right-of-ways. The line will be rebuilt to 138 kV standards to allow for proper spacing and safer crew working conditions.
- There is a planned refurbishment in 2009/10 of 69 kV Line 0015 from Moncton line 0003 to Hillsborough substation). This life extension project will involve the replacement of poles, guy wires and cross arms and the capping and butt treatment of usable poles as needed. It is expected that this work will extend the life of the line by at least 10 years.
- There is a planned development in 2009/10 of a 138/69 kV terminal at Norton. The goal of this terminal expansion is to provide voltage support for central areas of the province and to allow for the retirement of the aging Brookville switching station.
- There is a planned installation in 2009/10 of a second 138/69 kV tie transformer at Grand Lake. The purpose of this transformer installation is to provide backup for the loss of the existing Grand Lake transformer T1. Without backup, the loss of T1 during peak loading conditions results in low voltage problems on the local 69 kV network.
- There is a planned refurbishment in the 2009/13 timeframe of the Eel River HVDC station (converter controls, synchronous condensers and various other station upgrades). The purpose of this project is to replace aging technology and extend the life of the HVDC station by 20 years. Two years will be needed to procure all necessary equipment, and the installation of the new equipment will require 8 weeks of station outage (4 weeks/circuit). The estimated cost of this project is \$20,000,000.

- There are planned installations in the 2009/12 timeframe of additional 345 kV breakers at Norton, Eel River and Belledune. The installation of these breakers will increase the reliability of the bulk 345 kV power system.
- A new 21.6 MVAR capacitor bank is to be installed on the Grand Lake 69 kV bus in 2010/11 in order to provide back-up voltage support to that area. During peak conditions, an outage of the Grand Lake 138/69 kV tie transformer causes the 69 kV voltage in the area to dip below the acceptable level of 0.9 per unit. The addition of a new capacitor bank would help relieve the voltage problem caused by the loss of this transformer.
- A 345/230 kV, 450 MVA, transformer will be required at Newcastle terminal for system security and backup of the contingency loss of the Bathurst 345/138 kV transformer. The timing of this project is dependent on the load growth rate in the Bathurst and Newcastle areas, and it is projected to become necessary within the 2010 to 2014 time period.
- A new 138 kV transmission line from Salisbury to Memramcook is planned in the 2007/13 timeframe to relieve loading on Line 1156 and Line 1157. Consultation with Customer Services on substation location, route planning and design, and environmental requirements will take many years to complete. Therefore, a 6-year completion date is expected.
- A transformer replacement at Tinker is being considered in the 2008/13 timeframe by WPS Canada Generation, Inc. (WPS) in order to alleviate congestion issues within Northern Maine. The current 138/69 kV transformer, built in 1966, has a nameplate rating of 50 MVA. The planned upgrade would see this rating double to 100 MVA. The exact timing of this potential upgrade is still uncertain as the project is currently being assessed. Its implementation is dependent on a joint study involving NBSO, WPS, and the Northern Maine Independent System Administrator (NMISA).
- It is planned to build a new 345 kV transmission line from Coleson Cove to Salisbury in the 2012/15 timeframe. The objective of this project is to provide backup for the loss of 345 kV line 3004 and line 3013. It is anticipated that this backup will be vital since this 345 kV transmission network section interconnects between large load and high generation areas.

### Regional Studies

- The new 345 kV interconnection between New Brunswick and New England is currently under construction with a targeted in-service date of December 1, 2007. Studies involving this project that are to be completed in 2007/08 include:
  - Determination of the import/export transfer capabilities between New Brunswick and New England.

- A comprehensive area transmission review of the New Brunswick Bulk Power System.
- Revision of all operating procedures concerning the NBSO/ISO-NE interface.
- The following are possible generation expansion projects that NBSO is considering in its studies of greater electricity exports:
  - Wind development in the Maritimes Area (500 to 1000 MW)
  - Second nuclear facility at Point Lepreau (700 to 1000 MW)
  - Second generator at Belledune (500 MW)
  - Liquified natural gas co-generation in Saint John (500 to 750 MW)
  - 2<sup>nd</sup> Refinery co-generation in Saint John (200 MW)
  - Lower Churchill Project import from Quebec and export to New England (740 MW)
  - Lower Churchill Project interconnection at Salisbury, NB and export to New England (740 MW)
- NBSO is participating in an ISO New England (ISO-NE) scenario analysis initiative in order to consider the future supply needs of the New England area, and to consider all of the potential supply options available in order to meet those needs greater imports from New Brunswick. It is anticipated that Phase I of the study will be completed by June 2007. Phase I will identify and analyze alternative resource scenarios, along with the implications for cost, reliability, and the environment.
- On February 9, 2007 the Governor of Maine and the Premier of New Brunswick announced that they had sign a Memorandum of Understanding (MOU) to explore and set forth actions enhancing cross-border cooperation on electrical interconnections. This agreement directs Maine and New Brunswick to explore expansions of generation capacity, including renewables, and transmission opportunities. NBSO will be participating in these undertakings, and it is anticipated that complete detailed assessments of all tasks will be presented to the respective governments in a final report no later than January 1, 2008.
- In early 2007, Central Maine Power (CMP) and Maine Public Service (MPS) commissioned a study to analyse the Northern Maine transmission system and develop alternative transmission interconnections to the MEPCO and New England transmission systems to improve MPS system reliability without adversely affecting the New Brunswick – Maine transmission interface transfer capability. This study will examine the goal of connecting Northern Maine to the New England market, as Northern Maine is presently interconnected only with the New Brunswick transmission system. NBSO is participating in this study, and it is anticipated that it will be completed during the summer of 2007.

- As part of its participation in various studies, NBSO is undertaking scenario analysis in order to determine the most efficient expansion of the New Brunswick transmission system in order to accommodate increased exports to neighbouring markets. It is anticipated that NBSO will complete this study during the summer of 2007.

## 11.0 REFERENCES

[1] *2004 Maritimes Area Triennial Review of Resource Adequacy*, Report approved by NPCC Reliability Coordinating Council March 9, 2005.

[2] *Basic Criteria for Design and Operation of Interconnected Power Systems*, Northeast Power Coordinating Council Document A-2, May 6, 2004

## **APPENDIX A**

### **SYSTEM DESIGN CRITERIA**

#### **INTRODUCTION**

The interconnected New Brunswick system is divided into several classifications, each of which is governed by different design criteria.

These classifications are as follows:

- Bulk Power System (BPS) Transmission
- Transmission
- Subtransmission
- Transformation

To provide the reader a better opportunity to understand the criteria and their application a set of definitions are also provided.

#### **DEFINITIONS**

1. Bulk Power System (BPS) Transmission

According to NPCC Criteria Document A-07 (revised Feb 6, 2006), the BPS transmission is "...transmission facilities on which faults or disturbances can have a significant adverse impact outside of the local area. In this context, local areas are determined by the Council members." By this definition, the New Brunswick BPS transmission encompasses most of the 345 kV transmission system with some dependence on the 230 kV and 138 kV transmission grids. The 345 kV transmission system rings the province. The 230 kV transmission system extends from Keswick to Salisbury, Keswick to Newcastle and extends to Bathurst and Eel River.

2. Transmission

Transmission is defined to be that part of the system, which serves mainly to interconnect generation with subtransmission at major load centres.

This definition encompasses the BPS Transmission; however, the lesser importance of some transmission relative to the BPS Transmission permits a relaxation of the design criteria from that required for the BPS. This definition then governs most of the 138 kV development plus certain 69 kV transmission.

3. Subtransmission

Subtransmission is defined to be that part of the system, which primarily serves as a source for transformation to the distribution level. This type of system is primarily characterised by radial feeds although looped subtransmission exists.

4. Normal System

Normal system conditions which are defined to include all of the following:

- a) Any load condition - this includes the full range of annually forecasted loads.
- b) All transmission facilities in service - no line or transformer maintenance.
- c) Economically scheduled and dispatched generation allowing for planned generator maintenance outages - non-firm generation not included as economically dispatched generation.
- c) All system voltages within 0.95 and 1.05% of nominal.
- e) All system elements within thermally limited ratings.

5. A System Element

A system element is defined to be any one generator, transmission line, transformer or transformer feeder.

6. Prime Time Clearance

Prime time clearance is defined to be the time to clear an in-zone fault. Actual clearance times for bulk transmission are in the 4 to 6 cycles (67 to 100 milliseconds) range for both three-phase and line-to-ground faults.

7. Back-up Clearance

Back-up clearance is defined to be the time to clear an out-of-zone fault. Actual clearance times are in the 15 to 18 cycles (250 to 300 milliseconds) range for both three-phase and line-to-ground faults for bulk transmission.

## 8. Breaker Back-up

Breaker back up is defined to be protection against local breaker failure to trip for any reason. Breaker back up will be applied to all BPS Transmission and most of the Transmission system.

## **BULK POWER SYSTEM (BPS) TRANSMISSION**

Prime time clearances are in the range of 4 to 6 cycles (67 to 100 milliseconds) for both three-phase and line-to-ground faults.

Back-up clearance times are in the range of 15 to 18 cycles (250 to 300 milliseconds) for both three-phase and line-to-ground faults. Times of 20 to 30 cycles (333 to 500 milliseconds) will be permitted under certain instances.

The Design Criteria are:

1. From normal systems conditions, the BPS Transmission shall be able to withstand the loss of any one-system element following a three-phase fault cleared in prime time.
2. From normal systems conditions, the BPS Transmission shall be able to withstand the loss of any one system element following a line-to-ground fault cleared in delayed time.
3. From normal system conditions following loss of any one-system element, all system elements shall be within their thermally limited ratings.
4. From normal system conditions, for the loss of any one system element, as a general guideline no BPS Transmission system voltage shall be less than 90% following a steady state settling out of the system nor shall any bus experience a voltage change from pre-fault to post-fault condition greater than 10%.
5. As far as possible, provision should be made to ensure that no fault is left permanently on the system in case of failure of a primary protective device.

## **TRANSMISSION SYSTEM**

Prime time clearances are in the range of 6 to 9 cycles (100 to 150 milliseconds) for both three-phase and line-to-ground faults.

Back-up clearances are in the range of 20 to 30 cycles (333 to 500 milliseconds) for both three-phase and line-to-ground faults.

The Design Criteria are:

1. From normal systems conditions, the Transmission system shall be able to withstand the loss of any one-system element following a three-phase fault cleared in prime time.

2. From normal systems conditions, the Transmission system shall be able to withstand the loss of any one system element following a line-to-ground fault cleared in delayed time.
3. From normal system conditions following loss of any one-system element, all system elements shall be within their thermally limited ratings.
4. From normal system conditions, for the loss of any one system element, as a general guideline no Transmission system voltage shall be less than 90% following a steady state settling out of the system nor shall any bus experience a voltage change from pre-fault to post-fault condition greater than 10%.
5. As far as possible, provision should be made to ensure that no fault is left permanently on the system in case of failure of a primary protective device.

### **SUBTRANSMISSION SYSTEM**

The Design Criteria are:

1. Subtransmission system loading shall be within the thermally limited ratings.
2. The subtransmission system voltages shall not be less than 95% or greater than 105% of nominal.
3. From normal system conditions, for the loss of any one subtransmission system element which is part of a section of the system which remains collected, no transmission system bus voltage shall be less than 92.5% following a steady state settling out of the system nor shall any bus experience a voltage change from pre-fault to post-fault condition greater than 10%.
4. As far as possible provision, should be made to ensure that no fault is left permanently on the system.

The application of the above criteria does not guarantee a continuity of supply for any single contingency. In the case of a line, a lengthy outage is considered to be a very remote possibility. Time to repair is considered adequate for restoration of service. However, in the case of transformation, an outage is generally a prolonged one. The use of an available mobile transformer for a short-term replacement or the installation of a spare transformer and interconnections with adjacent substations at the distribution level, are considered in decisions concerning the guaranteeing, after outage, of an alternate supply.

## TRANSFORMATION

### Design Criterion

Reinforcement is required in all cases when for single contingency there will result either, thermal damage to equipment in attempting to continue to supply the load or, inability to meet the daily load requirements in whole or in part after due consideration is given to the following:

1. The capacity of the underlying interconnections with another supply points) when applicable.
2. Out-of-merit running of generation when applicable.
3. Loading of remaining station(s) transformer(s) to their (or their associated equipment) thermally limited rating as per Note 4. (This is in conjunction with 1 and 2 above as applicable).
4. Largest available suitable mobile transformer loaded to its nameplate rating. (This is in conjunction with 1 and 2 above as applicable).

### Notes:

1. Reinforcement may be the economic choice even if 1, 2 and 3 or 4 result in satisfaction of the load supply criterion because "expected" out-of-merit costs may significantly exceed the cost of capital advancement.
2. The BPS Transmission system may require additional transformation in certain instances. Although the above 1, 2 and 3 may result in satisfaction of this particular criterion, any other of several possible contingencies (transmission lines, generators or transformers) will result in an "expectation" of either frequent or prolonged outages to a widespread part of the system.
3. The result of application of this criterion may not be installation of additional transformation.
4. Generally in accordance with universally accepted methods and particularly with reference to NEMA Publication No. TR98-1964 "Guide for Loading Oil Immersed Power Transformers with 65 C Average Winding Rise" and USASI Publication C57-92, 1962 "Guide for Loading Oil Immersed Distribution and Power Transformers with 65 C Average Winding Temperature Rise", it is NB Power practice to permit the loading of transformers to exceed the nominal or nameplate value such that thermal limits calculated in accordance with the above references are not regularly exceeded.

In special circumstances, such as single contingency situations where some means of reducing the overload exists, a thermal rating based on a loss of life of 2 1/2% may be applied, in accordance with the above and engineering judgement. The loss of life permitted is measured over the time required to reduce the loading on the transformers. This may be done by switching low voltage circuits or relieving load by use of a mobile transformer.

When no means of reducing the overload exists, a 0% loss of life is used.