
Newfoundland & Labrador

BOARD OF COMMISSIONERS OF PUBLIC UTILITIES

REFERENCE TO THE BOARD

**REVIEW OF TWO GENERATION
EXPANSION OPTIONS FOR THE
LEAST-COST SUPPLY OF POWER TO
ISLAND INTERCONNECTED CUSTOMERS
FOR THE PERIOD 2011 – 2067**

REPORT TO GOVERNMENT

MARCH 30, 2012

BEFORE:

**Andy Wells
Chair & Chief Executive Officer**

**Darlene Whalen, P.Eng.
Vice-Chair**

**Dwanda Newman, LL.B.
Commissioner**

**James Oxford
Commissioner**



NEWFOUNDLAND AND LABRADOR
BOARD OF COMMISSIONERS OF PUBLIC UTILITIES

120 Torbay Road, P.O. Box 21040, St. John's, Newfoundland and Labrador
Canada, A1A 5B2

2012 03 30

The Honourable Jerome Kennedy, Q.C.
Minister of Natural Resources
Government of Newfoundland and Labrador
7th Floor, Natural Resources Building
50 Elizabeth Avenue
St. John's, NL
A1B 4J6

Dear Minister:

On June 17, 2011 Government issued a reference directing the Board to review and report on whether the development of the Muskrat Falls generation facility and the Labrador-Island Link transmission line is the least-cost option for the supply of power to Island Interconnected customers over the period of 2011-2067, as compared to the isolated Island development scenario, with both options outlined in the Terms of Reference.

We are pleased to advise that the Board has completed its review and is now submitting its report.

Respectfully submitted,

Andy Wells
Chair and Chief Executive Officer

Darlene Whalen, P. Eng.
Vice-Chair

Dwanda Newman, LL.B.
Commissioner

James Oxford
Commissioner

EXECUTIVE SUMMARY

The Reference

On June 17, 2011 Government issued a reference to the Board of Commissioners of Public Utilities (the “Board”), pursuant to section 5 of the *Electrical Power Control Act*, directing the Board to review and report on whether the Muskrat Falls generation facility and the Labrador-Island Link transmission line represents the least-cost option for the supply of power to Island Interconnected customers over the period of 2011-2067 as compared to the isolated Island development scenario (the “Reference Question”).

In answering the Reference Question the Board was directed to consider and evaluate factors it considers relevant, including Hydro’s and Nalcor’s forecasts and assumptions for the Island load, system planning assumptions, and the processes for developing and comparing the estimated costs for the supply of power to Island Interconnected customers. The Board was directed to assume that any power from the Muskrat Falls generation facility which is in excess of the needs of the Province is not monetized or utilized, and therefore to not include consideration of the options and decisions respecting the monetization of the excess power from the Muskrat Falls generation facility, including the Maritime Link project.

The two options to be compared were set out in the Terms of Reference as the Muskrat Falls generation facility and the Labrador-Island Link transmission line (the “Interconnected Option”), and an isolated Island development scenario (the “Isolated Island Option”). Consideration of matters such as other supply options and the potential impact on rates for Island customers was not part of the Board’s review.

Thomas Johnson, LL.B., was appointed by Government as the Consumer Advocate.

This report sets out the Board’s response to the Reference Question and reflects the information provided by Nalcor, the findings of the Board’s expert consultants, input from presenters and other persons who participated in the review, and the final submissions by Nalcor and the Consumer Advocate.

Review Process

The Board engaged the services of Manitoba Hydro International (“MHI”) as its expert consultant to assist with the review. MHI’s two-volume report was released on February 1, 2012.

A significant amount of documentation was filed by Nalcor during the review, including public and confidential exhibits. In addition Nalcor filed responses to 605 information requests.

The Board set aside two weeks commencing February 13, 2012 for presentations by Nalcor, MHI and other interested parties. A number of written comments and presentations were also received during the process. All review documentation, including transcripts, was posted to the Board’s website, and the daily proceedings were webcast.

The Board's report on the Reference Question was initially required to be provided to the Minister of Natural Resources by December 30, 2011. This date was later extended to March 31, 2012 as a result of delays in receipt of critical documentation from Nalcor. This significantly impacted the Board's process and ability to answer the Reference Question as key procedural steps had to be changed or eliminated in order to meet the March 31, 2012 deadline.

The information provided to the Board by Nalcor was generally the information available as of Nalcor's Decision Gate 2 in November 2010. This information was considered to be at a concept study or feasibility level and was used by Nalcor in selecting a development scenario to proceed to detailed design. Because Nalcor did not provide information on the detailed engineering and financial analysis completed after Decision Gate 2, the Board's review was limited to the project components, costs and information as of November 2010.

MHI's Report and Findings

MHI's mandate included a review of the work completed by Nalcor and its consultants on the two supply options set out in the Terms of Reference. MHI assembled a team of specialists in the required areas of expertise to review the technical feasibility and cumulative present worth ("CPW") analysis for the Interconnected and Isolated Island Options.

MHI determined that the studies, work and analysis completed by Nalcor and its consultants as of Decision Gate 2 had been generally completed in accordance with best utility practices with certain exceptions:

- The domestic forecasting process is inherently biased toward under predicting energy consumption. Best utility practice would incorporate end-use modeling techniques for the domestic forecast which is not currently being done.
- Nalcor did not complete comprehensive probabilistic reliability studies of the two options to compare the relative reliability of each.
- System integration studies for the Interconnected Option were not completed at Decision Gate 2 as required by good utility practice.
- Nalcor currently does not comply with North American Electric Reliability Corporation (NERC) standards which have been adopted by the majority of utilities in Canada.
- Nalcor's selected design criteria for the Labrador-Island HVdc overland transmission line was not in accordance with industry standards and best utility practice in Canada.

MHI also noted that the potential for variability in the Industrial load forecast was high and could materially impact the CPW analysis.

MHI concluded that, when considered together with the underlying assumptions and inputs provided by Nalcor, the Interconnected Option represents the least-cost option of the two alternatives reviewed. MHI noted, however, that the risks and uncertainties associated with the key inputs are magnified by the project's scope and the length of the analysis period, and changes in key inputs and assumptions can impact the results of the analysis and shift the preference for the least-cost option.

Board's Review and Conclusions

Nalcor submits that the Interconnected Option is the least-cost option based on its Decision Gate 2 analysis and the information available in November 2010. Decision Gate 2 is a concept study or feasibility level stage of the project planning process which provides for changes in project scope and costs as detailed design progresses. The degree of project definition associated with Nalcor's Decision Gate 2 analysis is 5% to 10% for the Interconnected Option and even less so for the Isolated Island Option. This high level, conceptual understanding of the project components is associated with a range of accuracy in the capital cost estimates of +50% to -30%. MHI found that Nalcor's estimates of component costs for both options were generally within this accuracy range except that certain estimates in relation to the Labrador-Island Link transmission line were found to be at the low end of the range. As well, the gaps identified by MHI in Nalcor's analysis as set out above have the potential to significantly impact the project definition and costs for the Interconnected Option.

As required by the Terms of Reference the Board reviewed the load forecast used by Nalcor and questions whether this forecast should be relied on in answering the Reference Question. This load forecast is approximately two years old and was not updated during the review. In addition MHI noted several issues in relation to the load forecast as set out above. While the forecast shows a gradual increase in load, it does not demonstrate an immediate need for the significant amount of new generation contemplated in the Interconnected Option. Assuming no monetization of excess power, the potential supply associated with the Interconnected Option is much greater than the forecast load. The preference for the Interconnected Option would appear to be the result of forecasted fuel savings associated with the closing of the Holyrood Thermal Generating Station.

The risks of capital cost overruns and the uncertainties around load and fuel forecasts for a planning period of over 50 years were concerns during the review. The sensitivity analyses show that the CPW results are significantly affected by changes to the assumptions for fuel prices, load and capital costs. For example, each of the following scenarios would effectively eliminate the CPW preference for the Interconnected Option: i) increasing the capital costs of the Interconnected Option by 50%; or ii) decreasing load by 880 GWh with a 10% increase in capital costs; or iii) reducing the fuel price forecast by 44%.

Nalcor advised that work has been ongoing since Decision Gate 2 and that, by June 2012, it will have an updated load forecast, a CPW analysis with updated inputs including fuel forecasts, and better defined capital costs. Updated information in relation to this ongoing work was not made available to the Board during the review. According to Nalcor the degree of project definition at Decision Gate 3 could be as high as 40% and the range of accuracy of the capital cost estimates could be as narrow as $\pm 10\%$.

In conclusion, the information which was made available during the review was considerably less detailed and comprehensive than the information that Nalcor has today and will have at Decision Gate 3. As Nalcor explained, there can be significant changes as a project proceeds through the planning process and, further, that proceeding through Decision Gate 2 does not ensure that the project will be sanctioned. Nalcor decided in November 2010 at Decision Gate 2 to move to the next phase in the planning process and commence detailed design. The Board

was not asked to determine whether this decision was correct. Rather, the Board was asked to determine whether the Interconnected Option represents the least-cost option for the supply of power to Island Interconnected customers. The Board does not believe that it is possible to make a least-cost determination based on a concept study or feasibility level of information generally from November 2010 which was intended only to ground Nalcor's decision to move to the next phase of the analysis, especially given that so much additional work has already been done to define the project and costs and to further eliminate uncertainties.

The Board concludes that the information provided by Nalcor in the review is not detailed, complete or current enough to determine whether the Interconnected Option represents the least-cost option for the supply of power to Island Interconnected customers over the period of 2011-2067, as compared to the Isolated Island Option.

Other Considerations

There were gaps in Nalcor's information and analysis at Decision Gate 2, including: i) ac integration studies were not done; ii) probabilistic reliability studies to compare the two options were not done; iii) there is uncertainty with respect to adherence to NERC standards, and iv) the design return period for the HVdc overland transmission line is not in accordance with accepted standards and best practice. Nalcor has advised that it is completing the ac integration studies and assessing the implications of NERC compliance for Decision Gate 3. Nalcor does not plan to incorporate comprehensive probabilistic reliability assessments into its decision-making process as is done by other Canadian utilities for major projects. Of particular concern to the Board is the fact that Nalcor does not accept the recommendation of MHI with respect to transmission line design criteria.

Apart from the possible impact on project definition and costs these gaps relate to power system reliability and raise serious concerns in relation to Nalcor's assessment of the impact of the interconnection of the Muskrat Falls generation facility to the Island Interconnected system. Any outage on the system caused by the loss of the HVdc bipole line could significantly impact Hydro's Utility and Industrial customers and lead to additional costs for the system and customers, in addition to the possible societal and economic impacts associated with an extended outage. These deficiencies should be addressed by Nalcor in a meaningful way should the Interconnected Option proceed to project sanction.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

TABLE OF CONTENTS

PART ONE - BACKGROUND

1.0 INTRODUCTION

1.1 Public Utilities Board 1

1.2 Reference to the Board 1

1.3 The Terms of Reference 2

1.4 Consumer Advocate 3

2.0 REVIEW PROCESS

2.1 Manitoba Hydro International Ltd..... 4

2.2 Other Consultants and Support..... 5

2.3 Participants 5

2.4 Public Notices..... 5

2.5 Documentation Filed. 6

2.6 Presentations..... 6

2.7 Comments and Additional Information..... 7

2.8 Access and Transparency 8

3.0 REPORT CONTEXT

3.1 Schedule and Extension..... 9

3.2 Report Context and Structure 12

PART TWO – THE REFERENCE QUESTION

4.0 THE TWO OPTIONS REVIEWED

4.1 The Interconnected Option 14

4.1.1 Muskrat Falls Generating Facility and Labrador ac Transmission..... 14

4.1.2 Labrador-Island Link Transmission Line and Island ac System Additions..... 14

4.1.3 Small Hydroelectric and Thermal Resource Additions 15

4.1.4 Timeline 16

4.2 The Isolated Island Option	16
4.2.1 Holyrood Thermal Generating Station.....	16
4.2.2 Small Hydroelectric and Wind Resource Additions	17
4.2.3 Combined Cycle Combustion Turbines and Combustion Turbine Additions	17
4.2.4 Timeline	18
5.0 REVIEW SCOPE AND INFORMATION	
5.1 Review Scope	19
5.1.1 Other Supply Options	19
5.1.2 Upper Churchill	21
5.1.3 Maritime Link	24
5.1.4 Holyrood Thermal Generating Station Pollution Control Upgrades	25
5.1.5 Board Comments	26
5.2 Information	27
5.2.1 Nalcor’s Decision Gate Process.....	27
5.2.2 Available Information.....	27
5.2.3 Board Comments	29
6.0 LOAD FORECAST AND SYSTEM CAPABILITY	
6.1 Utility Load Forecast.....	31
6.2 Industrial Load Forecast.....	34
6.3 System Capability.....	36
6.4 Board Comments	39
7.0 COST COMPARISION ANALYSIS	
7.1 Cumulative Present Worth Methodology	42
7.2 Strategist Inputs.....	43
7.2.1 Load Forecast.....	44
7.2.2 Fuel Price Forecasts	44
7.2.2.1 Fuel Price Forecasting Methodology	44
7.2.2.2 Board Comments	48

7.2.3	Capital Cost Estimates	49
7.2.3.1	Project Definition and Estimate Accuracy.....	49
7.2.3.2	Capital Cost Estimating Methodology.....	51
7.2.3.3	Interconnected Option-Capital Costs.....	52
7.2.3.4	Isolated Island Option-Capital Costs	55
7.2.3.5	Submissions and Comments	57
7.2.3.6	Board Comments	58
7.2.4	Other Inputs	58
7.2.4.1	Purchase Power Agreement and Cost of Service.....	59
7.2.4.2	Operating Costs.....	60
7.2.4.3	HVdc System Losses	61
7.2.4.4	Service Life Retirements.....	61
7.2.4.5	Insurance.....	62
7.2.4.6	Fuel Inventory.....	62
7.2.4.7	Board Comments	62
7.3	Cumulative Present Worth Analysis	63
7.3.1	Methodology.....	63
7.3.2	Submissions and Comments	64
7.3.3	Board Comments	65
7.4	Sensitivity Analysis and Risk Mitigation.....	66
7.4.1	Sensitivity and Risk Analysis	66
7.4.2	Risk Mitigation	72
7.4.3	Board Comments	74
8.0	NALCOR’S ONGOING WORK	75
9.0	CONCLUSIONS ON THE REFERENCE QUESTION	78
PART THREE – OTHER CONSIDERATIONS		
10.0	ADDITIONAL ISSUES RAISED BY MHI	
10.1	Labrador-Island HVdc Transmission Line Design Criteria	81
10.2	AC Integration Studies	88
10.3	Reliability Assessment	92
10.4	Adherence to NERC Standards	98
10.5	Board Comments.....	99
LIST OF APPENDICES.....		101

PART ONE - BACKGROUND

1.0 INTRODUCTION

1.1 Public Utilities Board

The Board of Commissioners of Public Utilities (the “Board”) is an independent administrative tribunal constituted under the *Public Utilities Act*, RSNL 1990, c. P-47. The Board is responsible for, among other things, the regulation of and general supervision of public utilities in the Province and approves utility rates and capital spending. In carrying out its responsibilities the Board is required to implement the power policy set out in the *Electrical Power Control Act, 1994*, SNL 1994, c. E-5.1 (the “EPCA”).

The Board does not regulate Nalcor Energy (“Nalcor”) which is exempt from the provisions of the *Public Utilities Act*, and the authority of the Board under s. 17(2) of the *Energy Corporation Act*, SNL 2007 c. E-11.01. Newfoundland and Labrador Hydro (“Hydro”) is a subsidiary of Nalcor and, as a public utility, is regulated by the Board under the *Public Utilities Act*.

1.2 Reference to the Board

The Board may be directed by the Government of Newfoundland and Labrador to consider another matter relating to power in the Province, in accordance with section 5 of the *EPCA* which states:

“5. (1) The Lieutenant-Governor in Council may refer to the public utilities board

- (a) existing or proposed rates or a class of rates applicable between producers, retailers and customers;*
- (b) matters affecting or related to rates charged by producers to retailers and customers;*
- (c) the principles used by or appropriate for use by producers in determining rates for the supply of power to retailers and customers; or*
- (d) another matter relating to power,*

and the public utilities board shall hold a public hearing at which it shall investigate and examine the matters referred to it and report on the matters to the minister within the time specified by the Lieutenant-Governor in Council in the reference.

(2) A reference under this section may be general or particular in terms and may specify criteria, factors and procedures to guide the public utilities board in making its investigation, examination and report.”

On June 17, 2011 Government issued a reference directing the Board to review and report on whether the development of the Muskrat Falls generation facility and the Labrador-Island Link transmission line is the least-cost option for the supply of power to the Island interconnected

system over the period of 2011-2067, as compared to the isolated Island development scenario, with both options to be outlined further in a submission to the Board by Nalcor.

1.3 The Terms of Reference

The particulars of the referral to the Board were set out in the Terms of Reference and Reference Question issued by Government as follows:

In the Energy Plan, 2007, Government committed to the development of the Lower Churchill hydro resource. It has been determined that the least-cost option for the supply of power to the Island interconnected system over the period of 2011-2067 is the development of the Muskrat Falls generation facility and the Labrador-Island Link transmission line, as outlined in Schedule "A" attached hereto (the "Projects"), as compared to the isolated Island development scenario, as outlined in Schedule "B" attached hereto (the "Isolated Island Option"), both of which shall be outlined further in a submission made by Nalcor Energy ("Nalcor") to the Board of Commissioners of Public Utilities (the "Board"). It is contemplated that Newfoundland and Labrador Hydro ("NLH") would enter into a long-term power purchase agreement and transmission services agreement with Nalcor, or its subsidiaries, the costs of which would be included in NLH's regulated cost of service with the full cost of the Projects being recovered from NLH's Island interconnected system customers (the "Island Interconnected Customers").

Pursuant to section 5 of the Electrical Power Control Act, 1994 (the "EPCA"), Government hereby refers the following matter to the Board:

The Reference Question

The Board shall review and report to Government on whether the Projects represent the least-cost option for the supply of power to Island Interconnected Customers over the period of 2011-2067, as compared to the Isolated Island Option, this being the "Reference Question".

In answering the Reference Question, the Board:

- shall consider and evaluate factors it considers relevant including NLH's and Nalcor's forecasts and assumptions for the Island load, system planning assumptions, and the processes for developing and comparing the estimated costs for the supply of power to Island Interconnected Customers; and*
- shall assume that any power from the Projects which is in excess of the needs of the Province is not monetized or utilized, and therefore the Board shall not include consideration of the options and decisions respecting the monetization of the excess power from the Muskrat Falls generation facility, including the Maritime Link project.*

Where Nalcor or NLH determine that any information to be given to the Board for this review is commercially sensitive as defined in the Energy Corporation Act, it shall advise the Board, and the Board and its experts and consultants may use such information for this review but shall not release such information to any party.

For the purposes of this review, a consumer advocate shall be appointed pursuant to section 117 of the Public Utilities Act.

Any costs of the Board in respect of this review, including the costs of the consumer advocate, shall be paid by Nalcor.

The Board's report shall be provided to the Minister of Natural Resources by December 30, 2011. The Minister shall make this report public.

On December 12, 2011 Government extended the date for the filing of the Board's report on the Reference Question to March 31, 2012.

The Terms of Reference, with Schedules A and B, are attached as Appendix "A".

1.4 Consumer Advocate

In accordance with the Terms of Reference, on June 17, 2011 Government announced that Thomas Johnson, LL.B., had been appointed as the Consumer Advocate to represent consumers during the review. The Press Release stated:

"The Consumer Advocate will play an invaluable role in supporting an independent and transparent review, and we look forward to Mr. Johnson's participation," said Minister Skinner. We have made a commitment to be open, transparent and accountable to the people of the province, and want to ensure they are engaged, informed and confident in the decision to develop the Lower Churchill."

The Consumer Advocate stated his mandate was:¹

"...to represent domestic and general service customers during the review and to critically review the Nalcor Submission, and any further submissions and reports relating to the Reference Question and to attend any public hearing and make representations to the Board on behalf of ratepayers in respect of the Reference Question."

The Consumer Advocate participated throughout the review by gathering public input, requesting information from Nalcor, participating in the presentations and filing a written submission. The Consumer Advocate retained the engineering and consulting firm of Knight Piésold Consulting, an independent international consulting company specializing in power supply developments, to assist with his mandate for this review.

¹ Consumer Advocate's Submission, pg. 2

2.0 REVIEW PROCESS

Following receipt of the Terms of Reference the Board determined that the procedures and processes would be similar to those followed in the Insurance Review completed in 2004-2005, which was conducted pursuant to a direction from Government under the *Insurance Companies Act*, RSNL 1990, c. I-10. In that review the Board adopted an approach which was more streamlined and less formal than its normal quasi-judicial procedures. This approach allowed the full participation of interested persons and timely completion of the review while still respecting the fundamental principles of accessibility, openness and transparency. The Board found that the approach in the Insurance Review worked well and allowed the Board to review and report on the many technical and complex issues that were within the scope of that review.

2.1 Manitoba Hydro International Ltd.

Immediately upon receipt of the Terms of Reference the Board issued a request for proposals (“RFP”) by invitation for expert consulting services to review the information provided by Nalcor, to undertake independent analysis as required, and to provide a report on the results of its review. Manitoba Hydro International Ltd. (“MHI”) was selected as the Board’s independent expert following this RFP process and was engaged by the Board as of July 4, 2011. The RFP and MHI’s proposal were posted on the Board’s website.

MHI is a wholly-owned subsidiary of Manitoba Hydro, one of the largest and oldest electric power utilities in Canada. MHI provides consulting services to power utilities, governments and private sector clients worldwide and has provided utility infrastructure management, consulting and training services in over seventy countries. MHI assembled a team of technical and financial experts to undertake the required reviews and analyses. The team members included experts in the design and operation of hydroelectric plants and transmission systems, load forecasting, utility resource planning, the design and operation of thermal plants, power system reliability, submarine cables, system integration and planning studies, wind power and financial analysis.

The scope of the work MHI was requested to undertake was determined by the Terms of Reference. MHI’s mandate was to review the two supply options identified in the Terms of Reference and undertake the required technical and financial analysis to assist with the Reference Question as to which of the two defined options is the least-cost for the supply of power to Island Interconnected customers over the period 2011-2067.

MHI reviewed documentation provided by Nalcor during the review and met with Nalcor staff and consultants to clarify points arising during the review of available documentation. Information was also obtained and reviewed through formal requests for information and MHI undertook its own analysis, as required, of various matters.

MHI submitted a two-volume report to the Board outlining the work completed and its findings, which was posted on the Board’s website on February 1, 2012. MHI also made a presentation and answered questions from Nalcor and the Consumer Advocate during the review.

2.2 Other Consultants and Support

The Board also engaged Fred Martin, P. Eng., to assist in the capacity of technical advisor in addition to the Board's engineering consultant Sam Banfield, P. Eng. The Board's experienced regulatory and administrative staff also provided valuable support throughout this review.

The Board would like to thank MHI, its advisors and Board staff for their dedication and commitment to ensuring the timely completion of this review.

2.3 Participants

Nalcor was represented initially in the review by Geoffrey Young, LL.B. In November, Thomas O'Reilly, Q.C., and Denis Fleming, JD, commenced acting on behalf of Nalcor.

The Consumer Advocate participated throughout the review, with Randall Earle, Q.C., assisting.

Maureen Greene, Q.C., acted as Board Counsel.

2.4 Public Notices

On June 17, 2011 the Board issued a media release to advise that it had received the Terms of Reference and would provide further information as it became available. On July 26, 2011 a second media release advised that MHI had been retained as the Board's independent expert to assist with the review, that the information gathering phase of the review was underway, and that all information related to the review would be posted as it became available on the Board's website. This release indicated that it was expected that MHI's report would be filed in September and that the public consultation phase of the review would start in October.

On October 26, 2011 the Board advised through a media release that it was still awaiting receipt of Nalcor's Submission as well as responses to information requests. The Board stated that it had written Government to advise it would require an extension of the date for filing its report and that it was not possible at that time to set a schedule.

On February 1, 2012 the Board issued a media release and a Public Notice advising that MHI's report was available and that the schedule for the completion of the review had been established. The notice giving details on the review process, including the schedule of activities and information on how to participate, was published in the two major newspapers in the Province beginning on February 1, 2012.

An Information Bulletin was issued on February 9, 2012 relating to, among other things, the schedule of presentations. On February 28, 2012 a second Information Bulletin was issued relating to the process and date for filing comments and additional information.

2.5 Documentation Filed

A significant volume of documentation was filed during the review. Nalcor filed 118 public exhibits and a number of confidential exhibits. The Terms of Reference provided that information deemed by Nalcor or Hydro to be commercially sensitive as defined in the *Energy Corporation Act* would be available to the Board and its consultants but could not be released to anyone else. The confidential exhibits were listed on the Board's website and redacted versions of some were made available to the Consumer Advocate and the public.

Nalcor made an initial presentation to Board staff, MHI and the Consumer Advocate on July 18, 2011 which was intended to, among other things, provide an overview of the Muskrat Falls Project. Nalcor filed the submission required by the Terms of Reference on November 10, 2011.

Requests for information were filed throughout the review by the Board, MHI and the Consumer Advocate. Nalcor filed responses to a total of 605 requests for information; 131 from MHI, 196 from the Board and 278 from the Consumer Advocate. It should be noted that many of the requests for information filed by the Consumer Advocate were questions asked on behalf of other interested persons. MHI responded to 20 requests for information from the Consumer Advocate.

2.6 Presentations

The Board scheduled two weeks, commencing February 13, 2012, for presentations by Nalcor, MHI and other interested parties. On February 13, 2012 Nalcor gave an overview of both options, the work it had completed on both, and its position that the Muskrat Falls generation facility and the Labrador-Island Link transmission line is the least-cost option to supply power to Island Interconnected customers over the period 2011-2067. The formal presentation was made by Ed Martin, President and Chief Executive Officer of Nalcor, and Gilbert Bennett, P.Eng., Vice-President, Lower Churchill Project.

Immediately following this presentation a panel of six Nalcor representatives, composed of the following, responded to questions from the Consumer Advocate, Board Counsel and the Commissioners:

Gilbert Bennett, P.Eng., Vice-President, Lower Churchill Project;
Paul Harrington, Project Director, Lower Churchill Project;
Jason Kean, P.Eng., MBA, PMP, Deputy Project Manager, Lower Churchill Project;
Paul Humphries, P.Eng., Manager System Planning, Hydro;
Steve Goudie, B.Sc., B.A., Manager, Economic Analysis, Nalcor; and
Paul Stratton, B.Sc., B.A., Senior Market Analyst, Hydro.

MHI gave a presentation starting on February 15, 2012, providing an overview of the work it had undertaken for the review and its key findings and conclusions, and responding to questions from Nalcor, the Consumer Advocate, Board Counsel and the Commissioners. The MHI panel was composed of:

Paul Wilson, P.Eng., Project Director for the review and Managing Director of MHI;
Allen Snyder, P.Eng., MBA, Project Manager/Team Lead for the review; and
Mack Kast, CA, Financial Project Manager for the review.

A number of individuals made presentations to the Board during the week of February 20, 2012 as follows:

February 20	Cabot Martin Ron Penney and David Vardy Tracy Waltzthoni Fred Winsor, on behalf of the Sierra Club of Canada John Carter
February 21	Danny Dumaresque Robert Cadigan, President & CEO, Newfoundland & Labrador Oil & Gas Industries Association (NOIA) Vince Carey Winston Adams and Troy Templeman Yvonne Jones, M.H.A. Gordon Ralph
February 23	Jack Swinimer Philip Raphals, on behalf of Grand Riverkeeper Labrador Inc., by video conference

Supplemental filings were received from Ron Penney and David Vardy, Winston Adams and Cabot Martin.

All presentations were transcribed and are available on the Board's website.

2.7 Comments and Additional Information

The feedback form available on the Board's website was a convenient way for persons to provide comments. In addition the Board accepted letters of comment and other forms of additional information until February 29, 2012.

Twenty-eight letters of comment and additional information were received and are listed in Appendix "B". The comments and additional information form part of the public record of the review and were made available on the Board's website.

2.8 Access and Transparency

The Board recognizes that the matters raised in this review are of fundamental importance to the Province and of great significance for the Island Interconnected customers. As such, one of the Board's primary objectives in this review was to ensure public access and transparency to allow interested persons to become as informed as possible on the issues in the review. All information which is not confidential, including correspondence, requests for information and responses, exhibits, transcripts of the presentations, comments, additional information and final submissions, was posted on the Board's website.

The Board, for the first time, webcast the proceedings to ensure that interested members of the public would have the opportunity to hear the information provided. The webcast was both live and archived, which permitted people to watch at their convenience. The number of people observing the presentations through the webcast varied from a high of 963 people on February 14, 2012 to a low of 510 people on February 23, 2012, with an average of 622 people a day.

The presentations were open to the public and, because of the importance of the matter and the apparent level of interest, minor renovations were done to the Board's hearing room facilities before the start of the presentations to increase the number of people permitted in the space. Video conferencing was made available for presenters who could not attend the Board's proceedings.

The Board thanks all presenters and those who participated throughout the review.

3.0 REPORT CONTEXT

3.1 Schedule and Extension

The initial schedule for the review provided for the retention of the Board's expert by late June/early July, receipt of the necessary information from Nalcor in the same time frame, filing of Nalcor's submission in late July, the report from the Board's expert in mid-September, the report from the Consumer Advocate's expert and others in early October, a technical conference in mid-to-late October, followed by public consultations in late October/early November with the Board's report by December 30, 2011.

The receipt of all relevant information from Nalcor in a timely way was an essential first step in the process. This was discussed at a meeting with Nalcor representatives on June 17, 2011 and communicated in a letter to Nalcor on June 17, 2011, the day the Government released the Terms of Reference. This letter stated:

"The independent engineering consultants will provide a report on the Project and the Isolated Island Option which shall be made public. This independent engineering report will be an essential element of the public hearing process required by section 5 of the Electrical Power Control Act and must be completed before any public consultations can begin. It is therefore critical that all relevant information, including all technical reports and studies on the various components of the Project and the Isolated Island Option be provided by Nalcor as soon as possible to allow this engineering review to proceed in a timely way."

This letter set out a list of the information and reports that Nalcor should provide by June 30, 2011.

Difficulties were encountered from the beginning with the receipt of timely and complete information from Nalcor. While certain information was filed by Nalcor by early July, it was limited and incomplete, which led to a meeting with Nalcor representatives on July 8, 2011 and letters to Nalcor from the Board on July 12 and 21, 2011. Deficiencies in the information provided, which did not meet the filing requirements outlined in the Board's letter of June 17, 2011, were identified. The letter dated July 21, 2011 from the Board stated:

"The Government has directed that the Board report on its review by December 30, 2011. We reiterate that it is critical that all information requested by the Board and its consultants be provided as soon as possible. The Board is concerned that delays in the provision of information may jeopardize this deadline."

The concerns related to the availability of the required information continued. On September 14, 2011 the Board again wrote to Nalcor and stated:

"This letter is to formally advise that the Board is concerned about the schedule for the Review given the level of information that has been filed to date. In particular, Nalcor has not yet filed its Submission as required by the Terms of Reference. Nalcor's Submission would properly have been filed at the beginning of the Review given that the Terms of Reference specifically states that the two options to be reviewed by the Board would be further outlined in Nalcor's Submission. Initially Nalcor advised the Board that it would file the Submission by the end of July. On August 2, 2011 Nalcor advised that the Submission would not be filed until mid to late August. On August 26, 2011 Nalcor advised that the date for the filing of its Submission was under review. It

has now been three months since the start of the review and Nalcor has not yet filed its Submission and has not advised as to when it will be filed. In addition, there are a significant number of outstanding and incomplete answers to requests for information.

Given the uncertainty surrounding the dates for receipt of the information from Nalcor required for the Review, the Board requested a meeting on September 12, 2011 to fully discuss the implications of the status of the documentation for the schedule. Fixing the dates for the filing of Nalcor's Submission and responses to requests for information is critical for the Board to be able to re-assess the schedule for the Review and whether it will be possible for the Board to conduct public consultations and to file a report with Government by the December 30, 2011 deadline as required by the Terms of Reference."

The Board requested that Nalcor advise by September 16, 2011 as to the date that its submission and responses to outstanding requests for information would be available for review by the Board and its consultants. No reply to this letter was received from Nalcor for more than five weeks. In its reply on October 20, 2011 Nalcor advised that its submission would be filed by November 10, 2011, some three and a half months from the time it had originally indicated it would be filed.

On September 22, 2011 the Board advised the Minister of Natural Resources that the Board would not be able to complete its report by December 30, 2011 as stated in the Terms of Reference. This letter stated:

"It is now clear that the Board cannot meet the December 30, 2011 date for the completion of its report as required by the Terms of Reference. When the Terms of Reference was issued it was evident that completing a full review by the end of the year was an ambitious timeframe which would require significant organization and dedicated resources. While the Board has from the beginning worked toward this date and was initially well positioned to do so, it is now clear that it is not possible to complete the review by year end.

The Board is not formally requesting an extension at this time because we cannot provide a realistic alternate date until we have a better idea as to when Nalcor will answer the outstanding information requests and file the Submission contemplated in the Terms of Reference further outlining the projects. The Board and its experts, Manitoba Hydro International Ltd., have now done everything possible in the absence of further information from Nalcor. Once this information is received the Board will formally request that Government extend the time for the filing of the Board's report, likely to sometime in the spring."

Throughout this time the Board and MHI continued to review the information that was made available and issued information requests. The gathering of information was a challenge and the answers to requests for information were often incomplete, requiring further requests for information to clarify answers. The Exhibits were often disjointed and out of context so it was difficult to identify important information and make linkages. Information was provided in a piecemeal way on various elements which made it difficult to gain an understanding of each option.

The way Nalcor dealt with confidential documentation was also a challenge in the review. Initially Nalcor filed significant documentation as confidential without screening as to whether it was indeed commercially sensitive or could be released publicly. Sixty-seven (67) Exhibits were filed as confidential of which 53 were later released to the public, either fully or in an abridged

manner, with the majority being released to the public after November 1, 2011. Fourteen (14) Exhibits remained fully confidential. Seventeen (17) confidential requests for information were asked in relation to confidential exhibits.

The expected comprehensive reports outlining the options being reviewed, including the individual components of these options, estimated costs and project schedules, identified risks, financial analysis and Nalcor's position on the Reference Question, were received with Nalcor's formal Submission on November 10, 2011. Critical information was provided with or even after Nalcor's Submission. Exhibit 106, a key document on reliability, an area of concern identified by MHI, was provided on November 10, 2011. The confidential capital cost estimate reports for the Muskrat Falls generating facility and the HVdc transmission line, along with the Project Control Schedule, were not provided until November 24, 2011. In addition, 115 responses to information were filed by Nalcor from November 14-25, 2011 and 16 Exhibits were filed from November 7-24, 2011. This information had to be reviewed by the Board and MHI which led to further requests for information on December 16, 2011. Responses to these requests were filed by Nalcor from January 5-16, 2012. In relation to the ac integration studies, Nalcor had initially advised that these studies would be done by November, 2011² and on January 5, 2012 Nalcor advised that the studies were anticipated to be completed by the end of March, 2012.³

On December 12, 2011 the Minister of Natural Resources wrote the Board advising that it was imperative that Government receive the Board's report by March 31, 2012. On December 14, 2011 the Board wrote the Consumer Advocate seeking his input before the Board made a formal request for an extension. The Consumer Advocate stated that a date for completion of the review earlier than June 30, 2012 would not be achievable having regard to the complexity and importance of the matter at hand and the need for not only a due process but due deliberation.⁴

On December 16, 2011 the Board wrote the Minister to formally request an extension to June 30, 2012. This letter stated:

"The reason this extension is necessary is Nalcor's failure to provide the required information in a timely fashion. This review began in June but as of late November Nalcor was still filing significant new information. Between November 10 and November 24, 2011 Nalcor filed its submission as required by the Terms of Reference, a detailed study in relation to reliability, responses to 115 requests for information and 12 additional exhibits. This new information is now being reviewed and assessed and additional requests for information will be issued so that Manitoba Hydro International Ltd. ("MHI") can finalize its report and we can begin the public consultation process.

Given Government's desire to have this review completed in March we have reconsidered the work that remains to be done to see if there are opportunities to make up for the time lost as a result of the late filings by Nalcor. Unfortunately, I must advise that it is not possible for this review to be completed any earlier than the end of June 2012. The full and fair participation of the Consumer Advocate as well as the public hearing required by section 5 of the Electrical Power Control Act, 1994, SNL 1994, c. E-5.1 will dictate the schedule until late spring and it is only then that the Board can begin to write its report."

² MHI-Nalcor-39

³ PUB-Nalcor-143

⁴ Consumer Advocate, Letter to the Board, Dec. 15, 2011

The letter further stated:

“As you note in your letter, this matter is of fundamental importance to the Province. Given the magnitude of the capital costs, the complex technical nature of the information to be considered, and the significance of the matter for the Island Interconnected electrical system and the Province in general, the Board must ensure a full and comprehensive review with full opportunity to the Consumer Advocate and other interested persons to participate.”

On December 23, 2011 the Minister wrote the Board to reiterate Government’s position that the March 31 deadline was achievable. On January 6, 2012 the Board wrote the Minister to advise that the March 31, 2012 completion date directed by Government would not permit the Board to proceed as originally planned. A revised process and schedule was outlined which included presentations by Nalcor and MHI in mid-February followed immediately by public presentations with written submissions and comments by the end of February. The Board advised that other planned activities, including information requests on the MHI report, the filing of technical evidence by other parties, and the planned technical conference could not proceed and the planned public consultation phase would be curtailed. The Board also indicated that it expected that a number of issues would remain outstanding at the conclusion of the review given the shortened timeframe.

3.2 Report Context and Structure

The delay in providing information and the manner in which it was provided by Nalcor, including its approach to commercially sensitive information, impacted the review process and this report. The Board’s report was delayed by three months and the costs will be significantly higher than otherwise would have been the case. More significant from the Board’s perspective is the impact on the Board’s ability to answer the Reference Question. As noted several key procedural steps were eliminated to accommodate the shortened schedule. The Board believes that the originally planned technical review period with requests for information and conference would have provided an opportunity to further investigate the significant technical and financial issues that were raised during the review. This exchange would have permitted the filing of additional information to address the issues that were identified. The Board notes that Nalcor provided new information in its Final Submission and in revisions to an Exhibit filed on March 9, 2012. This information could not be reviewed and was not considered by the Board.

The Board notes that MHI also identified challenges related to the information provided by Nalcor.⁵ These challenges had a significant impact on the schedule and the cost of completing their work. MHI pointed out that the receipt of information spanned several months when it had been anticipated that all information would be available by early July 2011, that Nalcor’s responses to requests for information from MHI took from 5 to 119 days to receive with an average of 22 days, that responses to requests for information from the Board, also necessary for MHI to review, took from 6 to 113 days with an average of 42 days, that a number of documents were just not available from Nalcor, and that Nalcor’s Submission originally scheduled for July was not received until November 10, 2011. MHI stated that these factors made a “comprehensive analysis difficult and time consuming” and made release of its report by September 15, 2011, as originally anticipated, impossible.

⁵ MHI Report, Transmittal Letter, Jan. 31, 2012

MHI's report was a key component of the review. MHI was engaged to review the information provided by Nalcor on the two options set out in the Terms of Reference, the cumulative present worth analysis completed for both, and to do its own analysis as required to enable it to report its opinion as to whether the work performed by Nalcor and its consultants was performed with the degree of skill, care and diligence required by professional practices and standards for this type of work.⁶

MHI based its report on the information provided by Nalcor and on Nalcor's assumptions and inputs. In its report MHI stated that its review and conclusions are based on information, generally as of November 2010, including project components and cost estimates for both options. This was the information which was used by Nalcor in its decision to move to detailed design on the Muskrat Falls generation facility and the Labrador-Island Link transmission line. MHI's review did not include:

- other supply options for the Island Interconnected system, such as natural gas;
- any consideration of the technical feasibility of the Maritime Link;
- any consideration of sales from the Muskrat Falls project outside the Province;
- the impact on customers' electricity rates of either of the two options studied; and
- electricity requirements in Labrador.

MHI also did not review information on project definition or costs arising from the detailed engineering phase that commenced in November 2010, as it was not available.

After MHI's report was filed the Board held a hearing and received further information and submissions from Nalcor, the Consumer Advocate and other interested persons. While MHI's review was limited to the information and inputs provided by Nalcor as of November 2010, the Board must consider the Reference Question taking into account all the relevant issues.

The Board's report is divided into three parts. Part One as set out above describes the reference to the Board and the process undertaken to complete the review. Part Two addresses the specific information related to the Reference Question, including a description of the two options, a review of the load forecast, an analysis of the costs of the two options, and the Board's findings in relation to the Reference Question. This part incorporates the information provided by Nalcor, MHI's findings and the submissions and comments provided by various individuals and organizations, including the Consumer Advocate. Finally, in Part Three, the Board highlights several other considerations that were raised during the review.

This report only addresses issues which were raised during the review. Non-controversial aspects of Nalcor's submissions and proposals are not addressed. The Board notes that the majority of the work undertaken by Nalcor as of November 2010 was found by MHI to be reasonable and consistent with good utility practice with certain significant exceptions which are discussed in this report.

⁶ Section 3.2 of the Contract with MHI

PART TWO – THE REFERENCE QUESTION

4.0 THE TWO OPTIONS REVIEWED

4.1 The Interconnected Option

The Muskrat Falls generating facility and the Labrador-Island Link transmission line (the “Interconnected Option”) comprises the following major components:

- Muskrat Falls generating facility
- Labrador ac transmission
- Labrador-Island Link transmission line
 - Converter stations at Muskrat Falls and Soldiers Pond
 - Strait of Belle Isle cable crossing
 - HVdc overland transmission line
- Island ac system additions
- Small hydroelectric and thermal resource additions

These project components are described below.

4.1.1 Muskrat Falls Generating Facility and Labrador ac Transmission

The proposed Muskrat Falls development will comprise conventional structures including a surface powerhouse, north and south concrete dams and a gated spillway located between the north dam and powerhouse. These structures and a naturally occurring rock knoll and clay spur will provide closure of the river. No other dams or dykes are required to create the small run-of-river reservoir which will operate over a range of 0.5 meters.

The powerhouse will contain four 206 MW Kaplan turbine-generator units with a total installed capacity of 824 MW. This concrete structure will integrate the intake, powerhouse and draft tube facilities. Spillway facilities will include a gate controlled structure and a free overflow spillway on the crest of the north dam.

Recently completed energy studies have concluded that the Muskrat Falls plant would have annual average and firm energy outputs of approximately 4.9 TWh and 4.5 TWh, respectively. The resultant plant capacity factor of 68% is consistent with similar run-of-river hydroelectric projects. The Muskrat Falls generating facility will be connected to the Churchill Falls Generating Station by two 345 kVac transmission lines. An extension to the Churchill Falls Terminal Station and the new Muskrat Falls Terminal Station will provide for the line terminations.

4.1.2 Labrador-Island Link Transmission Line and Island ac System Additions

The proposed HVdc system is rated at 900 MW with converter stations at Muskrat Falls and Soldiers Pond. The interconnecting bipole transmission line would comprise steel structures with a single conductor per pole and have a nominal voltage rating of ± 320 kV. Each pole

would have a 100% overload capacity for 10 minutes and a 50% overload capacity for continuous operation. Overland transmission from the Muskrat Falls Converter Station to a transition station at the Strait of Belle Isle would be approximately 380 km long.

The Strait of Belle Isle Cable Crossing would consist of three mass impregnated submarine cables each 36 km in length connecting the transition station in Labrador to its counterpart on the Island. Switching equipment at both transition sites would permit the removal of a faulted cable with the remaining two cables capable of delivering full rated capacity. The three cables would be installed in separate horizontally drilled conduits extending out from both shores of the Strait such that they would emerge in the Strait at a water depth of approximately 80 meters. Nalcor's analysis concluded that this means of protection would prevent damage from rafting ice and reduce the risk of iceberg contact with a cable to a 1 in a 1000 year event. Damage from fishing activities, dropped anchors and the like would be mitigated by covering the cables on the seabed with rock berms.

From the transition site in Newfoundland, the HVdc overland transmission line would cover another 688 km to the Soldiers Pond Converter Station. Both converter stations would be connected to shoreline pond electrodes by a wood pole distribution type electrode line.

Additions and upgrades to the Island ac system would include the installation of three 300 MVAR high inertia synchronous condensers at the Soldiers Pond Converter Station. Several 230 kV and 138 kV breakers would require replacement because of increased fault levels. In addition, Units 1 and 2 at the Holyrood Thermal Generating Station would be converted to synchronous condenser operation. Unit 3 is already capable of this type of operation. These units would remain in standby status available for generation until 2021 and thereafter would be operated in synchronous condenser mode only.

4.1.3 Small Hydroelectric and Thermal Resource Additions

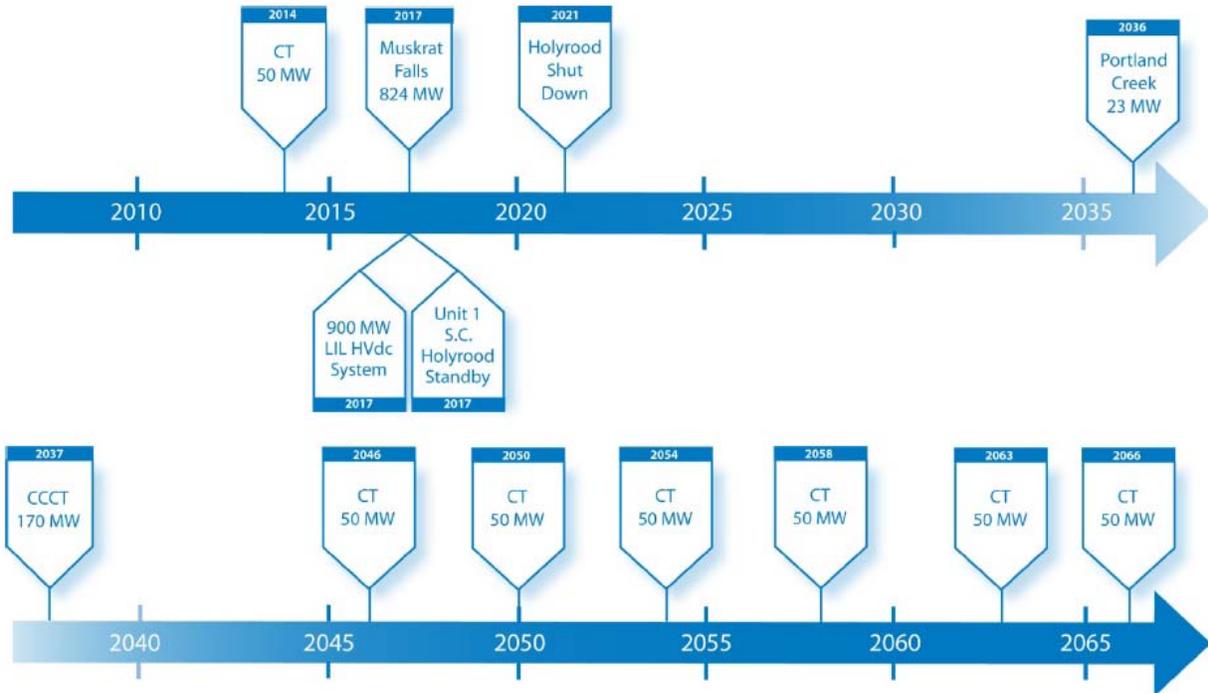
With the commissioning of the Muskrat Falls generating facility and the Labrador-Island Link transmission line in 2017 additional generation resources are not required on the Island until 2036. Over the period covered by the generation expansion plan, 2010-2067, the following resource additions are planned:

- 2014 – One combustion turbine (CT) – 50 MW
- 2036 – Portland Creek Hydroelectric Project – 23 MW
- 2037 – One combined cycle combustion turbine (CCCT) – 170 MW
- 2046 – 2066 – Six combustion turbines (CT) – 50 MW each

In 2067 the capacity mix for the Interconnected Option is 65% hydroelectric and 35% thermal. There will be no wind generation as the existing wind farms are retired in 2028 and not replaced.

4.1.4 Timeline

A timeline of the Interconnected Option as outlined in Nalcor’s Submission was prepared by MHI as set out below.⁷



4.2 **The Isolated Island Option**

The Isolated Island Option is primarily thermal based supplemented with the addition of small hydroelectric developments and one new wind farm. Major components are as follows:

- Holyrood Thermal Generating Station
- Small hydroelectric and wind resource additions
- Combined cycle combustion turbine (CCCT) and combustion turbine (CT) additions

These project components are described below.

4.2.1 Holyrood Thermal Generating Station

A cornerstone of the Isolated Island Option is the continued operation of the 500 MW Holyrood Thermal Generating Station. Units 1 and 2 were commissioned in 1970 and 1971 respectively while Unit 3 entered service in 1977. Three significant cost aspects of this option which relate to the Holyrood Thermal Generating Station are:

⁷ MHI Report, Vol. 1, pg. 28

- major life extension work to keep the plant operating to the 2033-2036 timeframe;
- the addition of emissions control systems; and
- replacement of the plant in 2033 (Units 1 and 2) and 2036 (Unit 3) with three 170 MW CCCTs.

4.2.2 Small Hydroelectric and Wind Resource Additions

The Isolated Island Option provides for the development of three small hydroelectric projects as follows:

- 2015 – Island Pond – 36 MW
- 2018 – Portland Creek – 23 MW
- 2020 – Round Pond – 18 MW

The Isolated Island Option includes the addition of a 25 MW wind farm in 2014 which is the only new wind farm proposed for either option. In addition all wind farms are replaced at 20 years of service. A study conducted by Nalcor in 2004 recommended that a limit of 80 MW be established for non-dispatchable energy on the Island grid. With the two existing wind farms totalling 54 MW, the proposed new 25 MW unit would exhaust that limit.

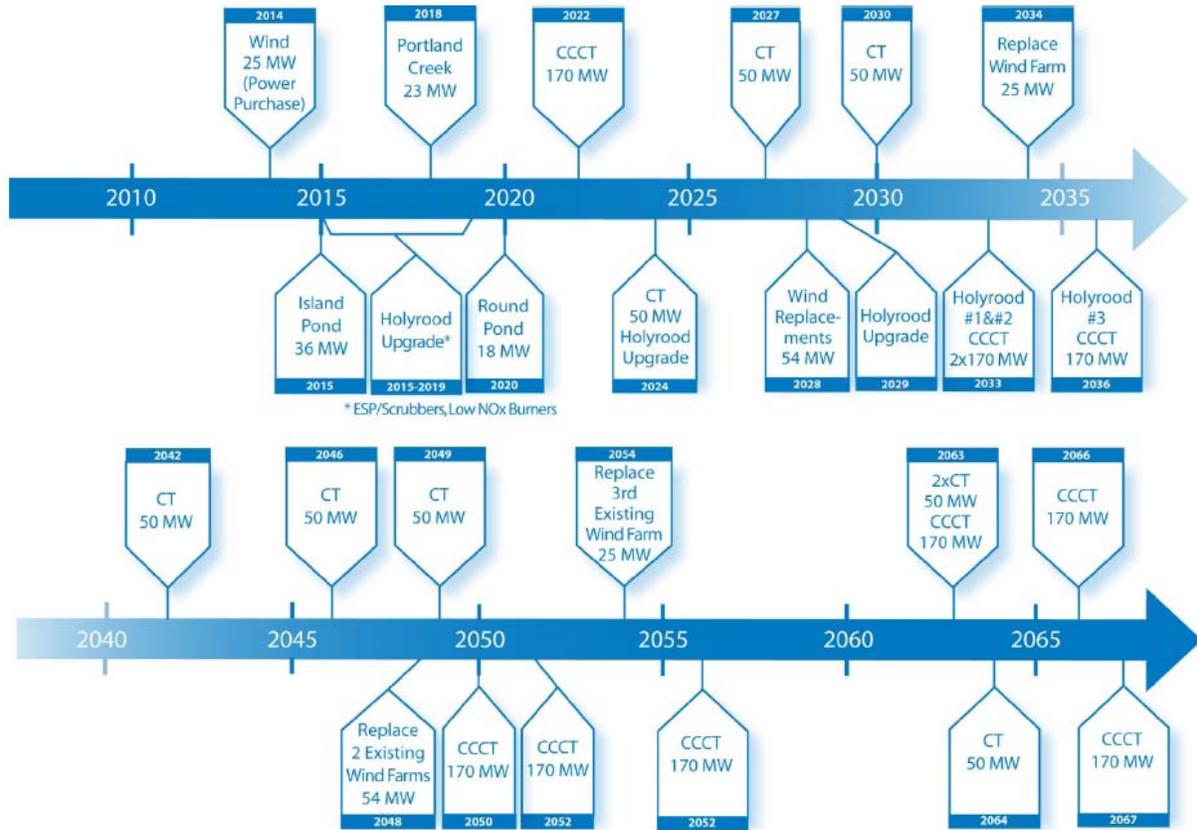
4.2.3 Combined Cycle Combustion Turbines and Combustion Turbine Additions

Thermal resource additions included in the Isolated Island Option comprise seven 170 MW CCCTs added from 2022-2067 and nine 50 MW CTs added from 2024-2064, for a total of 1640 MW. This includes the replacement of existing CTs at Hardwoods and Stephenville.

The capacity mix for the Isolated Island Option in 2067 is 62% thermal, 36% hydroelectric and 2% wind.

4.2.4 Timeline

A timeline of the Isolated Island Option as outlined in Nalcor’s Submission was prepared by MHI as set out below.⁸



⁸ MHI Report, Vol. 1, pg. 29

5.0 REVIEW SCOPE AND INFORMATION

The language of Government's direction to the Board focused the review on two specific options and the information provided by Nalcor, being generally what was available in November of 2010, further circumscribed the extent of the Board's review.

5.1 Review Scope

The Terms of Reference and the Reference Question were very specific, requiring the Board to review and report to Government in relation to the two supply options identified. Since the Terms of Reference provide the only source of authority to the Board in relation to Nalcor, the scope of the review excluded many issues that were raised by interested persons.

5.1.1 Other Supply Options

The two supply options reviewed are detailed in the Terms of Reference with the timing, size and type of the capacity additions and specific retirements set out. Because the two options the Board was directed to compare were so specific, other supply options for the Island Interconnected system could not be considered as part of the review.

Although not part of the review, Nalcor presented a high-level summary of supply options that were considered and screened out.⁹ The options eliminated were nuclear, natural gas, liquefied natural gas, coal, biomass, solar, wave and tidal, deferred Churchill Falls power, recall power from Churchill Falls, the Gull Island development, and purchases of electricity from others. Nalcor stated:¹⁰

“During the Board’s public hearings there were several presentations challenging Nalcor’s analysis of generation options, particularly domestic natural gas, liquefied natural gas (LNG), Churchill Falls power in 2041, wind generation, and conservation and demand management. These generation options did not pass initial screening as they were deemed to be not viable to meet the growing demand...”

In relation to the scope of the review the Consumer Advocate concluded:¹¹

“The examination of other island supply options, consideration of the export market via the Maritime Link, the technical feasibility of the Maritime Link, electricity requirements in Labrador as well as impact on island rates of each of the options were not included in the review by the Terms of Reference.”

Ron Penney and David Vardy stated that the Terms of Reference are too narrow and should be expanded to allow the consideration of other options.¹²

⁹ Nalcor Submission, Nov. 10, 2011; Vol. 1, pg. 103

¹⁰ Nalcor's Final Submission, pgs. 14-15

¹¹ Consumer Advocate's Submission, pg. 2

¹² Transcript, Feb. 20, 2012, pg. 36/21-24; Ron Penney and David Vardy, Supplemental Filing, Feb. 29, 2012, pg. 4

Yvonne Jones, M.H.A. said:¹³

(Ms. Jones): This is the fatal flaw in the review process for this project. Once the decision was made to build a smaller dam at Muskrat Falls combined with 1000s of kilometres of transmission to Nova Scotia, all other alternatives were eliminated from the discussion.

Lorraine Michael, M.H.A. wrote a letter to the Board commenting that the limitations on the scope of the hearings would not allow the outlining of many concerns. She referenced the need for an independent and thorough investigation of all alternative energy sources with informed analysis of the viability of developing wind, natural gas, and other energy sources.

Philip Raphals, on behalf of Grand Riverkeeper Labrador Inc., raised the matter of the wind power component of the Isolated Island Option and stated:¹⁴

(Mr. Raphals): Given all this, I can't help think that had the government asked you to compare the Interconnected scenario to Isolated Island scenarios, plural, rather than comparing it to the Isolated Island scenario, singular, the substantial resources devoted to this exercise would have been better spent. But I understand that is not your mandate.

Fred Windsor, Chair with the Atlantic Canada Chapter of the Sierra Club of Canada, argued that other models of energy production such as wind and small scale energy production generally should be considered.

In a written comment to the Board Dr. Stephen Bruneau concludes that Grand Banks gas is likely the cheapest source of long-term (30 years) dispatchable energy for island electricity generation. He noted that the source cited by Nalcor to support the "commercial unavailability" of natural gas was a 2001 report for the purpose of assessing the development of natural gas resources and transportation and sale in the North American energy grid. He argues that the question of whether natural gas can be purchased for domestic use only has not been answered. He noted that all Grand Banks production platforms use natural gas for power generation and that in 2010 the use of natural gas as a fuel for electrical generation and heating was greater for Hibernia alone than the total oil-fired energy used at Holyrood for 2010.

JM in his comprehensive written submission said that it is unclear why a review of other options and the screening process was excluded from the Terms of Reference. JM disagreed with Nalcor's screening assessment with respect to natural gas and noted that the lack of proven economics for natural gas as established by the 2001 report was the reason expressed for not including it as an option. He concluded that gas represents a very robust solution, proven on a world wide basis and is an alternative that should have been considered.

Other presenters also commented on the limited scope of the review or the potential for other supply options such as natural gas, additional wind and Upper Churchill power.

¹³ Transcript, Feb. 21, 2012 pgs. 73/25; 74/1-6

¹⁴ Transcript, Feb. 23, 2012, pg. 19/8-15

5.1.2 Upper Churchill

The availability of Upper Churchill power as a supply option for the Island was identified during the review process as an issue. Several presentations and comments questioned why Upper Churchill power was not considered by Nalcor as a viable supply option for the Island Interconnected system. Questions were also raised on the amount of recall power under the Upper Churchill power contract that could be available for the Island's requirements.

The power contract dated May 12, 1969 provides for the sale to Hydro Quebec of all the power and energy from the Upper Churchill except a block of 300 MW sold to Nalcor, generally referred to as the recall power, and a block of 225 MW which is used by Twin Falls Power Corporation to supply the Iron Ore Company of Canada and Wabush Mines. The power contract expires in 2041.

Nalcor screened out Upper Churchill power as an option but did include it in the Interconnected Option commencing in 2057, starting at 20 GWh in 2057 and increasing to approximately 500 GWh by 2067. The price assumed is the Upper Churchill power contract price paid by Hydro Quebec.¹⁵

Nalcor stated that it had considered a supply option that included continuation of the Holyrood Thermal Generating Station, additional thermal generation as required to get to 2041 and then a transmission interconnection to access Upper Churchill power in 2041. This option did not advance beyond Phase 1 screening for the following reasons:¹⁶

- “1. *There is inherent uncertainty around guaranteeing the availability of supply from Churchill Falls in 2041 because it is difficult to determine the environmental and policy frameworks that will be in place 30+ years out. There are other issues surrounding the CF asset with respect to Hydro Quebec, as Nalcor is not the sole shareholder of the Churchill Falls operation.*
2. *There is also significant risk associated with maintaining reliable supply through continued life extension measures for Holyrood generating station through to 2041. At that time, the first two units at Holyrood will be 70 years old.*
3. *Deferral of the interconnection would result in significantly higher rates for island consumers between now and 2041 and does not provide rate stability to island customers as rates are tied to highly volatile fossil fuel prices for the first 30+ years of the study period along with escalating maintenance costs for Holyrood and an increasing likelihood that replacement of the plant will be required prior to 2041.*
4. *Island customers will remain dependent on fossil fuel generation for the first 30+ years of the study resulting in continued and increasing GHG emissions. Given the Government of Canada's decision to introduce GHG emissions regulation for coal fired generating stations, Nalcor's ability to refurbish Holyrood without conforming to GHG emissions regulation is doubtful, and replacement of the plant may be required between now and 2041.*

¹⁵ MHI-Nalcor-49.2(d); MHI-Nalcor-99; PUB-Nalcor-92 Rev. 1

¹⁶ Nalcor Submission, Nov. 10, 2012, Vol. 1, pgs. 92/10-25; 93/1-10; MHI-Nalcor-3

5. *Each of the screening criteria above has significant risk and uncertainty that are not present in either the Isolated or Interconnected Island alternatives.*

The prospect of requiring substantial investment to Holyrood to extend its life beyond that contemplated in the Isolated Scenario, or the real possibility of requiring replacement of Holyrood and then retiring it in 2041, increases the probability that this option will be substantially more expensive than projected.”

Nalcor stated that deferral of construction of the Interconnected Option results in economic disadvantages through the lost value of monetization of the energy and lost economic and employment opportunities.¹⁷

With respect to the recall power Nalcor’s position is that it meets the needs of its customers in Labrador from the recall block of 300 MW. In 2010 38% of the energy available under the 300 MW recall was sold in Labrador with the unused balance being sold in short term export markets. In the winter period 220 MW on average is used to meet demand in Labrador. There is insufficient capacity and energy available to meet the Island’s requirements from the balance remaining in the recall block.¹⁸

During questioning of Nalcor’s panel Gilbert Bennett also explained Nalcor’s position on why accessing Upper Churchill power in 2041 is uneconomical.¹⁹

(Mr. Bennett): So there are a couple of considerations here. First of all, from an economic perspective, I guess, if we look at waiting until 2041, the Holyrood facility would continue in service for another 30 years approximately from today, we would have to install scrubbers and precipitators on that facility, we would still continue with our thermal expansion plan until 2041. So in looking at the economics, the outcome of our analysis was that there would be a substantial premium from an economic perspective to maintaining an isolated scenario until 2041, and then interconnecting at that point in time.

Nalcor performed sensitivities to determine the impact of continuing with the Holyrood Thermal Generating Station to 2041 and then accessing Upper Churchill power. This analysis showed a continued preference for the Interconnected Option of \$1.2 billion.²⁰ An additional sensitivity analysis, with the pollution control upgrades removed from the Isolated Island Option, continuing the Holyrood Thermal Generating Station to 2041 and then accessing Upper Churchill power at the existing contract price of \$2/MWh or 0.2 cents/kwh showed a continued preference for the Interconnected Option of \$51 million.²¹

MHI did not state any opinion on the availability of Upper Churchill power as a significant supply option as its report did not consider any of the supply options eliminated. MHI also did not express any opinion about the use of Upper Churchill power in the Interconnected Option in

¹⁷ Nalcor Submission, Nov. 10, 2011, Vol. 1, pg. 93/13-21

¹⁸ Nalcor Submission, Nov. 10, 2011, Vol. 1, pg. 94

¹⁹ Transcript, Feb. 14, 2012, pg. 41/3-17

²⁰ Nalcor Submission, Nov. 10, 2011, Vol. 1, Table 29, pg. 126; MHI-Nalcor-3

²¹ PUB-Nalcor-55

the period 2057-2067 or use of the recall power. MHI did point out that there is risk in relying on the Holyrood Thermal Generating Station to remain operational until 2041.²²

A number of presenters and comments suggested that Upper Churchill power, and not Muskrat Falls, should be the future source of supply for the Island. In their presentation Ron Penney and David Vardy addressed the use of Upper Churchill power for the Island load requirements. They stated:²³

(Mr. Vardy): The least uncertain event for the energy future of this province is that the Churchill Falls contract expires in 2041; we even know the exact day of expiry. The Winter Availability Contract also expires in 2041, as does the Shareholders Agreement between CF(L)Co and Hydro-Quebec. The reservoir, dam, turbines, and related facilities are in place with no construction required. Under the interconnected plan, Nalcor does include Churchill Falls power starting in 2057, yet we are told that 2041, some 16 years earlier in time is too uncertain to consider Churchill Falls as an option.

The only uncertain element about Churchill Falls is whether the current litigation in the Quebec Court that challenges the contract might result in access to the power sooner than 2041. If this materializes, then the Province might well be advised to maintain its flexibility to benefit from such an outcome by holding off its decision to commission the Muskrat Falls project.

Danny Dumaresque stated that Upper Churchill power should be utilized starting in 2041 or earlier depending on the outcome of legal challenges.²⁴

Vince Carey said:²⁵

(Mr. Carey): The Holyrood generating facility will see its end, but it's a vital source of energy that could see us through until we enter negotiations for a new deal on the Upper Churchill. Will we need a new transmission line from Labrador in the future; without a doubt we will, but that will be our only cost if we link to the Upper Churchill and not Muskrat Falls. The usually expensive contracts for civil work, dams, spillways, control gates, transmission lines, purchasing and assembling of generators, transformers, turbines and the staffing of the life of the plant, does make this venture questionable at this point in time when we have all this existing on the Upper Churchill, if we have the patience to wait and use our generating facilities wisely.

He also suggested small ventures or some wise choices should be considered to get to the point of being able to access Upper Churchill power.²⁶

Yvonne Jones, M.H.A., also referred to accessing Upper Churchill power in 2041 and said:²⁷

(Ms. Jones): So what we have to do is bridge the power needs between now and 2041, and our goal should be to achieve that as cheaply as possible in order to ensure that we always have access to the lowest possible cost power.

²² MHI Report, Vol. 1, pg. 13

²³ Transcript, Feb. 20, 2012, pg. 60/3-25

²⁴ Transcript, Feb. 21, 2012, pgs. 5-9

²⁵ Transcript, Feb. 21, 2012, pg. 31/4-21

²⁶ Transcript, Feb. 21, 2012, pg. 35/8-9

²⁷ Transcript, Feb. 21, 2012, pg. 69/2-7

Dr. James Feehan raised the possibility of access to Upper Churchill power earlier than 2041 if legal challenges are successful. MC and JM commented on the need to consider Upper Churchill power as a source of supply commencing in 2041.

5.1.3 Maritime Link

Another issue in relation to the scope of the review set out in the Terms of Reference relates to the Maritime Link. The Board was directed in the Terms of Reference to assume that any power in the Interconnected Option in excess of the needs of the Province is not monetized or utilized and further to not include consideration of the options and decisions respecting the monetization of the excess power from the Muskrat Falls generation facility, including the Maritime Link project. This restriction requires that the review proceed on the basis that there will be no Maritime Link.

While the Maritime Link is not included in this review Nalcor stated that it is sometimes referenced as there are “*joint management practices being contemplated that also encompass the Maritime Link.*”²⁸ Throughout the review the Maritime Link was referenced in relation to the potential revenues²⁹ and potential impacts on reliability.³⁰ In response to a question during Nalcor’s presentation Gilbert Bennett stated that the availability of import capacity from the Maritime Provinces is a significant source of generation for the island.³¹

Nalcor’s responses to requests for information concerning the Maritime Link suggest that Nalcor views the Maritime Link as having positive impacts in terms of revenue and reliability but that it is not critical to the analysis and that Nalcor would proceed without the Maritime Link.³² At times Nalcor did not answer questions in relation to the Maritime Link, stating that neither the Terms of Reference nor Reference Question address matters related to the Maritime Link or Emera.³³ Gilbert Bennett specifically stated:³⁴

(Mr. Bennett): The analysis that we’ve used for DG2 is not—does not indicate that Emera and the conclusion of those agreements is a prerequisite to selecting Muskrat Falls or the Labrador-Island link as a preferred alternative.

The Consumer Advocate stated:³⁵

“The Consumer Advocate notes that the Terms of Reference for the review does not contemplate an examination of the Maritime Link. For purposes of this review, we assume that the Maritime Link will not exist.”

²⁸ Nalcor Submission, Nov. 10, 2011, Vol. 2, pg. 9

²⁹ Nalcor Submission, Nov. 10, 2011, Executive Summary, pg. 5

³⁰ Nalcor Submission, Nov. 10, 2011, Vol. 1, pgs. 130-132; Final Submission pg. 51; Exhibit 106

³¹ Transcript, Feb. 14, 2012, pg. 191/2-5; Feb. 13, 2012, pg. 75/25; pg. 76/1-6; pg. 82/21-25

³² MHI-Nalcor-24; PUB-Nalcor-13; PUB-Nalcor-33; PUB-Nalcor-34; PUB-Nalcor-59; PUB-Nalcor-75; PUB-Nalcor-83

³³ CA/KPL-Nalcor-153; CA/KPL-Nalcor-155; CA/KPL-Nalcor-162; CA/KPL-Nalcor-262

³⁴ Transcript, Feb. 14, 2012, pg. 72/5-10; Feb. 13, 2012, pg. 179/ 1-23

³⁵ Consumer Advocate, Final Submission, pg. 48

The Consumer Advocate noted that Nalcor stated that the addition of the Maritime Link further enhances system reliability but that it will proceed with the Interconnected Option without the Maritime Link.

In a written comment JM stated that it is unclear why the Maritime Link has been excluded from the economic analysis presented. In addition he noted that Nalcor has not answered questions concerning the Emera deal and potential power exports and that, since the Maritime Link has such a fundamental impact on the economics, it should be reviewed properly.

5.1.4 Holyrood Thermal Generating Station Pollution Control Upgrades

The Isolated Island Option includes the installation in 2015 of pollution abatement equipment including electrostatic precipitators, scrubbers and low NO_x burners, with a total in-service capital cost of \$602 million.³⁶ Nalcor said that the pollution abatement equipment is required to meet the commitments of Government's 2007 Energy Plan.³⁷

MHI noted that the Holyrood Thermal Generating Station currently meets the ground level concentration requirements based on monitoring results at several test locations. As well, since the plant currently burns 0.7% sulphur fuel, SO_x emissions are well below the annual limit of 25,000 tonnes. According to MHI Nalcor has been considering low NO_x burners for many years on the assumption that regulatory requirements would mandate the replacement of the present burners.³⁸ There is no regulatory requirement for low NO_x burners at the present time. The Holyrood Thermal Generating Station is currently operating in full compliance with its operating certificate. The proposed pollution control upgrades will not address GHG emissions.³⁹

Ron Penney and David Vardy argued that the pollution control equipment should be removed from the cumulative present worth analysis of the Isolated Island Option. They noted that Hydro has been successful in abating SO_x and particulate emissions by using 0.7% sulphur fuel and that the 2007 Energy Plan was issued prior to the closure of the Abitibi mill in Grand Falls.

Dr. James Feehan also commented that the capital expenditures on pollution abatement do not appear to be justified with the move to lower sulphur content fuel. He suggested that pollution abatement could be further improved upon by moving from the current 0.7% sulphur content fuel to 0.3% sulphur content fuel.

Presenters Tracy Walzthoni and Jack Swinimer both reside in Holyrood and provided information in respect of the impacts of the pollution from the Holyrood Thermal Generating Station.

³⁶ Nalcor Submission, Nov. 10, 2011, Vol. 1, pg. 67

³⁷ Nalcor's Final Submission, pg. 17

³⁸ MHI Report, Vol. 2, pg. 171

³⁹ Transcript, Feb. 13, 2012, pg. 41/16-18

5.1.4 Board Comments

The Board notes that the potential for other supply options was one of the more controversial issues during the review. There seems to be a strong and widely held belief that supply options such as natural gas, additional wind or Upper Churchill power could be viable options. However, the Terms of Reference did not include consideration of the eliminated supply options. While Nalcor did provide information on the options eliminated, this information was summary and not technical in nature and was not examined during the review. MHI did not review other supply options. Requests for information were not asked by the Board or MHI to gather more details in relation to the other options. The notice issued by the Board on February 1, 2012 advised that the review was limited to the two options and would not address other alternatives. There is insufficient information on the record to allow a real consideration of whether any of these options are viable alternatives for the Island Interconnected system.

Consistent with the Terms of Reference alternatives which incorporate Upper Churchill power were also not considered during the review. However Upper Churchill power was raised by several presenters and in several comments during the review and seems to be of great interest to many people. The Board notes that, based on the information provided in the review, the fuel costs and life extension concerns in relation to the continued operation of the Holyrood Thermal Generating Station until 2041 raise questions as to whether accessing Upper Churchill power would be a realistic option.

The exclusion of the Maritime Link was a notable limitation throughout the review, both in terms of evaluating the costs of each option and in terms of assessing the technical aspects of the project. MHI did not review the technical feasibility of the Maritime Link or the sale of excess Muskrat Falls energy outside the Province. Nalcor seemed to struggle with answering questions and providing information which did not include the Maritime Link but ultimately confirmed that it would proceed with the Interconnected Option without the Maritime Link. Since the Terms of Reference direct that the Maritime Link not be considered, the information which Nalcor placed on the record in relation to the Maritime Link cannot be considered. This, as will be discussed later, is significant in terms of the issues of excess power and the reliability of the Interconnected Option.

The installation of pollution abatement equipment at the Holyrood Thermal Generating Station is a part of the Isolated Island Option as set out in the Terms of Reference and, for purposes of the review, the cumulative present worth of the Isolated Island Option must be taken to include this cost. Although there were questions as to whether such equipment is necessary to address environmental concerns, the Board will not comment on this issue.

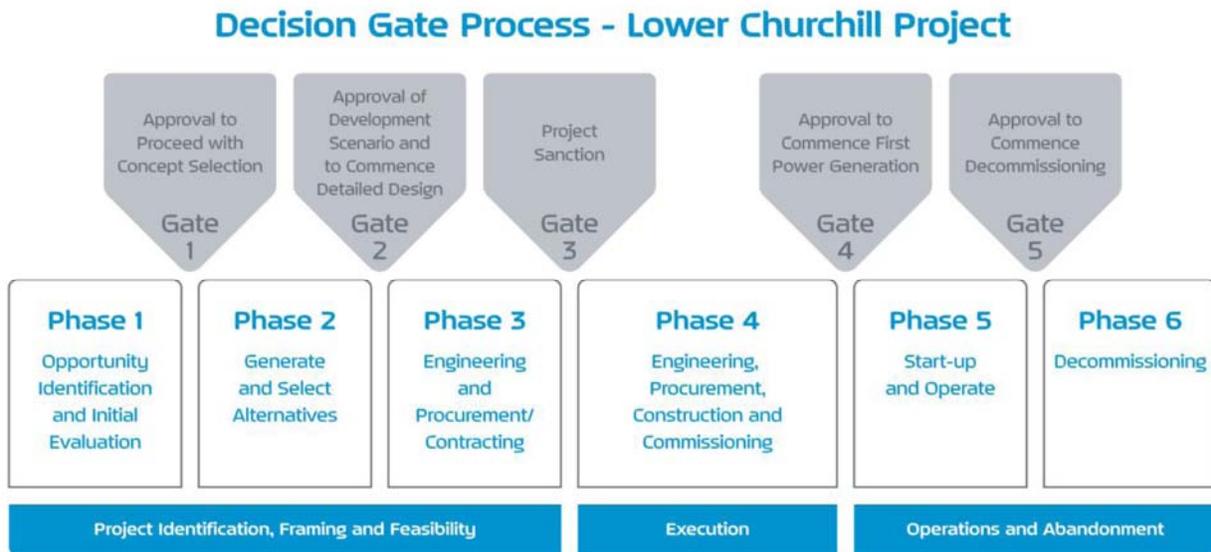
5.2 Information

5.2.1 Nalcor’s Decision Gate Process

Nalcor is using a staged or decision gate process. This process is used to facilitate decision making and to assess the readiness of the project to move from one phase to the next with each phase generally more capital intensive than the previous one.⁴⁰ There are five decision gates within this process:⁴¹

- Decision Gate 1 – Approval to proceed with concept selection
- Decision Gate 2 – Approval of development scenario and to commence detailed design
- Decision Gate 3 – Project Sanction
- Decision Gate 4 – Approval to commence first power generation
- Decision Gate 5 – Approval to commence decommissioning

The decision gate process is illustrated below:⁴²



Nalcor advises that it passed Decision Gate 2 in November 2010 and the analysis and information provided in the review was as of this date.⁴³

5.2.2 Available Information

The inputs in Nalcor’s analysis were completed prior to Decision Gate 2 on November 16, 2010. Some of the information underlying this analysis was prepared months in advance of the November 2010 decision date. While Nalcor did provide limited information completed after November 2010, it only related to the project definition and capital cost estimates used at

⁴⁰ Transcript, Feb. 13, 2012, pgs. 50-51

⁴¹ Nalcor Submission, Nov. 10, 2011, Vol. 2, pgs. 34-38

⁴² Nalcor Submission, Nov. 10, 2011, Vol. 2, pg. 35

⁴³ Nalcor Submission, Nov. 10, 2011, Vol. 2, pg. 6; Transcript, Feb. 13, 2012, pgs. 68/12-20; 103/23-25; 104/2-18

Decision Gate 2 in November 2010. A list of the major inputs used in Nalcor's Decision Gate 2 analysis filed in the review, including the date of preparation and any subsequent updates, is set out below.⁴⁴

1. Load Forecast, May 2010 (Exhibits 1 & 27)
 - No update was provided during the review.
2. Fuel Price Forecast, January 2010 (Exhibit 4)
 - Two updates were provided:
 - (i) May 2011 (MHI-Nalcor-126) and
 - (ii) October 2011 (MHI-Nalcor-127).
3. Capital Cost Estimate, August 2010 (Exhibit 5; PUB-Nalcor-39 Rev. 1)
 - No update was provided during the review.
4. Escalation Rates, January 2010 (Exhibit 3; MHI-Nalcor-31)
 - No update was provided during the review.
5. Power Purchase Expense (Exhibit 36; MHI-Nalcor-49.2)
 - The Muskrat Falls Power Purchase Expense calculation used capital cost estimates that were as of August 2010, operating costs, and an internal rate of return plus escalation. No update was provided during the review.
6. Service Life/Retirements, undated for date originally prepared but was dated July 5, 2011, which is the date prepared for Submission to Board. (Exhibit 7)
 - No update was provided during the review.
7. Operating and Maintenance Costs, Muskrat Falls, undated, and Isolated Island, dated February 2010 (Exhibit 8)
 - No update was provided during the review.
8. Heat Rates, undated (Exhibit 9, Rev. 1)
 - No update was provided during the review.
9. Generation Capacity and Energy Capability, July 2010 (Exhibit 16)
 - No update was provided during the review.

There were also other inputs used in the Decision Gate 2 analysis such as forced outage rates, hourly load shape, and asset maintenance scheduling which were not updated during the review.

Nalcor advised that it has been working intensely since Decision Gate 2 but virtually no updated information was provided during the review. Paul Harrington stated that information after Decision Gate 2 could not be made available as work was still ongoing by multiple disciplines and all of the information was still coming together.⁴⁵ Nalcor has stated that all inputs to the

⁴⁴ Nalcor Submission, Nov. 10, 2011, Vol. 1, pgs. 35-47

⁴⁵ PUB-Nalcor-41; MHI-Nalcor-96; Transcript, Feb. 13, 2012, pg. 104/1-18

cumulative present worth analysis will be updated prior to Decision Gate 3 and after the completion of the review by the Board.⁴⁶

5.2.3 Board Comments

The Board notes that the Reference Question requires that the Board review and report on whether the Interconnected Option represents the least-cost option for the supply of power. The Reference Question did not state that the Board was to review and report on Nalcor's Decision Gate 2 determination and the information available at that time.

⁴⁶ Transcript, Feb. 14, 2012, pg. 73/1-14

6.0 LOAD FORECAST AND SYSTEM CAPABILITY

Load forecasting is an important component of a utility's system planning process as it identifies the anticipated electricity needs for the future. Nalcor explained the significance of the load forecast as follows:⁴⁷

“Information concerning the province’s future annual energy and peak demand requirements is required to determine the timing and plant design of future generation sources. Electricity demand changes over time, reflecting the overall growth or decline in a region’s economic activity. In addition, market factors relating to available fuel choices and pricing have an impact on electricity demand, as well as changes in technology and energy efficiency. The purpose of load forecasting at NLH is to project electricity demand and energy requirements through future periods to ensure sufficient generation resources are available to reliably meet consumers’ requirements. The long-term load forecast aims to minimize the operational risks between inadequate capacity and the financial risks of excessive electricity resource capability, and the economic burdens placed on all consumers in either circumstance.”

The energy and peak demands for the Island Interconnected system are comprised of the industrial load and the utility load, which includes both the domestic and the general service load. Nalcor explained that the industrial load is developed with direct input from the customers whereas the island's utility energy and peak demand requirements are forecast for 20 years using an econometric based model.⁴⁸ This model quantifies, using econometric techniques, the relationships between changes in electricity use and various economic measures across a historical period, typically from the late 1960s, which are then used to forecast expected demand levels in the future for certain economic conditions. The key load forecast inputs from the 20-year macroeconomic forecast for the provincial economy from the Department of Finance include projections of GDP, personal income levels, new housing units and population.

The generation expansion plan and economic analysis filed in this review are based on Hydro's 2010 Planning Load Forecast, which covers the period 2010-2029.⁴⁹ To allow evaluation of the alternatives this 20-year forecast was extended beyond 2029 for an additional 38 years, to 2067, to coincide with the anticipated service life of the Labrador-Island Link transmission line.

Nalcor forecasts the compound annual load growth rate over the 2009-2029 period for the Island Interconnected system to be 1.3%, based on a forecast growth rate of 1.2% for Island Utility and 1.9% for Island Industrial.⁵⁰ The compound annual load growth rate for the Island Interconnected system over the period 2010-2067 is forecast to be 0.8%.⁵¹

MHI completed a detailed analysis of Nalcor's load forecasting practices and methodologies and found that the load forecasting process is conducted with due diligence, skill and care and meets acceptable utility practices with the exception that end-use modeling techniques for domestic loads are not currently employed.

⁴⁷ Nalcor Submission, Nov. 10, 2011, Vol. 1, pg. 12

⁴⁸ Nalcor Submission, Nov. 10, 2011, Vol. 1, pg. 19-21

⁴⁹ Exhibit 27, pgs. 25-27; Transcript, Feb. 13, 2012, pg. 27/7-10

⁵⁰ Nalcor Submission, Nov. 10, 2011, Vol. 1, pg.27

⁵¹ Exhibit 43 (Rev. 1), pg. 62

6.1 Utility Load Forecast

The compound annual growth rate of the island utility load is forecast to be 1.8% over the 2009-2014 period and 1.2% over the period 2009-2029. Nalcor reports that growth in utility load will be lower in the next 20 years than experienced in the previous 20-year period with decelerating growth post-2014.⁵² Nalcor further stated that the preference for electric space heating across residential and commercial customers continues to be an important source of load growth for the utility sector on the island.⁵³

According to MHI best utility practice would incorporate end-use modeling techniques in the forecasting process, so that electricity growth can be quantified for all major domestic end-uses of electricity. MHI stated:⁵⁴

“Although the additional detail required to prepare an end-use forecasting methodology may likely improve forecast accuracy, increased accuracy is not guaranteed because any forecast is dependent on the accuracy of the assumptions on which it is based.”

MHI noted that the domestic sector forecast consistently under predicts future energy needs at a rate of one percent per year. MHI concludes that, although the magnitude of the error is acceptable, the frequency of under predicting energy consumption is a concern. MHI concludes that the domestic forecasting process is inherently biased towards under predicting energy consumption. MHI’s analysis suggests that the load is growing for reasons not identified in the model and/or assumptions driving the model are consistently conservative.⁵⁵ MHI found that the load forecasting process has produced excellent results for the general service sector.

The Consumer Advocate noted that forecasting load over an extended period of time is inherently an uncertain matter:⁵⁶

“Clearly, the longer the load forecast horizon, the more fraught with uncertainty is the load forecast. There are legitimate questions around the aging nature of the population and how that may impact energy demand in future decades of the study period. There is certainly risk that the load forecast and extrapolation for the period beyond 2029 could be too high.”

In relation to the issue of how conservation and demand management is addressed in Nalcor’s load forecast, the Consumer Advocate pointed out that MHI found that the technological change variable was conservative and that a conservation demand management program should not be included in the load forecast, as the energy savings associated with varying levels of conservation and demand management investment should be included as a supply side option.

⁵² Nalcor Submission, Nov. 10, 2011, Vol. 1, pg. 27

⁵³ Nalcor Submission, Nov. 10, 2011, Vol. 1, pg. 24

⁵⁴ MHI Report, Vol. 2, pg. 20

⁵⁵ MHI Report, Vol. 2, pg. 19

⁵⁶ Consumer Advocate’s Submission, pg. 19

The Consumer Advocate noted that the sensitivity analysis conducted by Nalcor shows that, even if actual load growth was only 50% of the Nalcor projections, the Interconnected Option still has a sizable preference.

Nalcor's domestic load forecasts were the subject of much discussion in presentations and comments during the review as summarized below:

- Ron Penney and David Vardy made three observations in relation to the load forecasts, suggesting that the growth of the 24-45 age group in the province cannot continue indefinitely, that it is likely that in the future there will be more senior citizens requiring less space heating, and lastly that there are no provincial demographic projections beyond 2029.⁵⁷ They recommended the adoption of the principles of integrated resource planning which places more weight on demand side management than on least-cost supply planning.⁵⁸
- Philip Raphals suggested that MHI failed to properly take into consideration the impacts on load growth of a properly designed and executed portfolio of conservation and demand management program over the planning period.⁵⁹
- Winston Adams presented information as to the potential significant impact of heat pumps and energy efficiency and the importance of end-use data and research.⁶⁰
- Yvonne Jones, M.H.A., raised several points in relation to Nalcor's demand projections, noting the stable aging population and the ignored potential for conservation.⁶¹
- JM recommended that Nalcor take a regional bottom-up assessment which considers the aging population and movement from rural to urban, that the forecasts for 2029-2067 be based on more than an extrapolation of the period 2025-2029, and that Nalcor provide a high, medium and low model.
- Other commentaries addressed the declining population, the decline in the age group 24 to 45, the increase in the number of the over 65 group, and the potential impacts of the use of heat pumps.

Nalcor argued that the issues raised during the presentations stem from the belief that the forecasts are exaggerated and the Province's population will not require the amount of electricity being projected. Nalcor pointed out that the Department of Finance has extensive forecasting experience and incorporates the relevant factors associated with preparing macro-economic forecasts. According to Nalcor the forecast load growth is primarily associated with an expanded electric heat market share and customer growth that is linked to housing demand and rising income levels and, further, that electricity is expected to remain the principal fuel source for customers' heating requirements on the island.⁶² Gilbert Bennett stated during Nalcor's presentation:⁶³

⁵⁷ Transcript, Feb. 20, 2012, pgs. 53-54

⁵⁸ Transcript, Feb. 20, 2012, pg. 63/15-19

⁵⁹ Transcript, Feb. 23, 2012, pgs. 36/22-25; 37/1

⁶⁰ Transcript, Feb. 21, 2012, pgs. 39-59

⁶¹ Transcript, Feb. 21, 2012, pgs. 76/3-25; 77/1-10

⁶² Nalcor's Final Submission, pg. 13

⁶³ Transcript, Feb. 13, 2012, pgs. 25/12-25; 26/1-2

(Mr. Bennett): Load forecasting is the foundation of all of our generation planning and our generation expansion process, and certainly we look at the processes that are within Newfoundland and Labrador Hydro, those processes have been established for many years and the process of assessing supply and demand for electricity within the province, and then making recommendations to ensure the system can meet that demand. It's a fundamental process that's embedded within our system's planning group. We recognize that there are long lead times for developing new generation and the associated transmission infrastructure that goes with that, so it necessitates that we have a long term planning process.

Mr. Bennett also stated that specific targets for conservation and demand management have not been incorporated into the load forecast and that these programs have not been considered as an alternative to new generation because of the uncertainty of the outcomes.⁶⁴

In relation to the extension of the load forecast beyond the usual 20-year forecast period to 2067 Paul Stratton of Nalcor stated:⁶⁵

(Mr. Stratton): I guess as a load forecaster, I would expect that as time goes out in the load forecast, there is the possibility that there would be more error in that forecast. But the methodology that we have used, as a forecaster, I believe that to be a reasonable forecast over that time.

Nalcor submitted that it conservatively extended the forecast to coincide with the service life of the Labrador-Island Link transmission line by setting the longer-term annual load increments to reflect underlying provincial economic growth after accounting for electric heat market saturation.⁶⁶

Mr. Stratton also addressed the issue of the under prediction of the domestic forecast as raised by MHI:⁶⁷

(Mr. Stratton): Well the one percent error that they've seen over that historical period would reflect both the—any modelling error, that would be in the model, as well as any assumptions that go in to feed that model. I mean, it's also an indication of bias and as a load forecaster, I am very concerned that there would be any bias in the model, but at the same time, I'm less concerned because over that period it's under forecasting and over that time period our models would be continually updated to adjust and to correct for any errors that would occur over that time.

He concluded that the historical under prediction does not necessarily mean that that forecast would under forecast load in the future.⁶⁸

Nalcor stated that it recognizes that load forecasts are subject to error and therefore it evaluated the impacts of material reductions in future load expectation through discrete load sensitivity cases. According to Nalcor these analyses demonstrated that the cumulative present worth preference for the Interconnected Option is robust across a wide range of future load assumptions.⁶⁹

⁶⁴ Transcript, Feb. 13, 2012, pg. 36/17-24

⁶⁵ Transcript, Feb. 14, 2012, pg. 84/17-23

⁶⁶ Nalcor's Final Submission, pg. 12

⁶⁷ Transcript, Feb. 13, 2012, pgs. 221/25; 222/1-12

⁶⁸ Transcript, Feb. 13, 2012, pgs. 222-223

⁶⁹ Nalcor's Final Submission, pg. 13

6.2 Industrial Load Forecast

The compound annual growth in the Island Industrial Customers' load is forecast to be 7.1% in the period 2009-2014 and 1.9% over the 2009-2029 period. Nalcor stated that the Island Industrial load growth in the early years is related to the construction and operation of the Vale nickel processing facility.⁷⁰ Nalcor assumes continued newsprint production at Corner Brook Pulp and Paper, first production at the Vale nickel processing facility in 2013, continued operation of the Come-by Chance refinery and no new unforeseen industrial load on the island.⁷¹

During Nalcor's presentation Paul Stratton explained the approach in relation to the industrial customer load:⁷²

(Mr. Stratton): We request from our industrial customers typically twice a year, what their requirements would be. We assess those requirements against any recent load that they have. If there are variations that we see, significant variations in the history verses where they expect to be, we would communicate that with them, and have probably, you know, discussions with them probably over the phone. And based on those assumptions, we may make minor adjustments to their projections, but otherwise we—they are the keepers of their load, they understand their load, so we typically take, primarily take their loads.

Nalcor confirmed that it does not exercise judgement respecting the long term viability of established industry in the Province and that it did not complete an analysis of international pulp and paper markets though it is aware of some of the challenges facing North American newsprint manufacturers.⁷³ The two recent mill closures were not forecast as the load forecasts for their loads were maintained until definitive notices of the closures were given to the Province.⁷⁴ Nalcor reported that the most recent consultation with Corner Brook Pulp and Paper regarding load requirements was in the spring of 2011.⁷⁵ In relation to the potential for increases in Labrador load Nalcor suggested that there is a potential for additional load in Labrador of up to 500 megawatts for Rio Tinto alone, in addition to others and that this could have a significant impact on the generation expansion plan.⁷⁶

Nalcor argued that the industrial load forecasts are based on direct input from the industrial customers and, given the small industrial customer base, it would not be appropriate to forecast industrial requirements independent of direct input from the industrial customers. Nalcor noted that there is considerable opportunity for industrial load growth in Labrador but there have been no firm commitments so this has not been factored into Nalcor's analysis. Nalcor stated that, since MHI concludes that the assumed continued operation of Corner Brook Pulp and Paper is optimistic and the assumed absence of new industrial load is pessimistic, the current industrial load growth assumptions are reasonable.⁷⁷

⁷⁰ Nalcor Submission, Nov. 10, 2011, Vol. 1, pg. 27

⁷¹ Nalcor Submission, Nov. 10, 2011, Vol. 1, pg. 22

⁷² Transcript, Feb.13, 2012, pg. 223/10-23

⁷³ PUB-Nalcor-136

⁷⁴ Transcript, Feb. 14, 2012, pg. 91/8-11

⁷⁵ PUB-Nalcor-148

⁷⁶ Transcript, Feb. 14, 2012, pgs. 96-103

⁷⁷ Nalcor's Final Submission, pgs. 11-12

MHI found that the preparation of the industrial forecast on a case by case basis with direct input from customers is a reasonable methodology when considering the small number of industrial customers on the island. However, MHI noted that the industrial forecast has performed poorly in the past because of pulp and paper mill closures that were not accounted for in forecasts, even though the industry is facing reductions and increasing low-cost competition. If the pulp and paper mill closures were accurately forecasted, the energy and peak forecasts would have been excellent.⁷⁸ MHI concluded that the load forecast will significantly over predict electricity requirement if the remaining pulp and paper mill closes. MHI also noted that the industrial forecast does not include any new loads for the study period.⁷⁹

The Consumer Advocate concurred with MHI that it is imperative that Nalcor obtain as much understanding as possible regarding the future prospects for the continued operation of its industrial customers and, in addition, contingency plans be developed to address the implications of restrictions in industrial loads.⁸⁰

The Industrial Customers stated⁸¹:

“The current Island Industrial Customers understand that Nalcor’s load forecast assumes no significant additional industrial load during the Review period, after the addition of the anticipated load for the Vale Long Harbour facility. Positing a significant decrease in Island load from the Nalcor forecast reflects what the current Island Industrial Customers expect to be an overly pessimistic view of the Island’s economic prospects over the whole of the Review period, including prospects for continuing and new industrial activity. In saying this, the current Island Industrial Customers acknowledge that there is the possibility of volatility in industrial load requirements over the Review period. However, the current Island Industrial Customers expect, and believe that the Province’s citizens would expect, that the Provincial Government will over the Review period pursue policies that promote the maintenance and expansion of industrial activity on the island, as a vital component of the Provinces economy.”

Ron Penney and David Vardy noted that the industrial load has been overestimated as a result of the closure of two pulp and paper mills and also that the remaining mill has adjusted its operation so that it purchases much less from Hydro.⁸² Yvonne Jones, M.H.A., also raised the issue of the potential industrial demand in Labrador.⁸³

⁷⁸ MHI Report, Vol. 1, pg. 44

⁷⁹ MHI Report, Vol. 1, pg. 45

⁸⁰ Consumer Advocate’s Submission, pg. 22

⁸¹ Island Industrial Customers, Letter of Comment, Feb. 29, 2012, pg. 1

⁸² Transcript, Feb. 20, 2012, pg. 52/9-15

⁸³ Transcript, Feb. 21, 2012, pgs. 77-78

6.3 System Capability

As noted earlier Nalcor stated that a long-term load forecast aims to minimize both operational risks associated with inadequate capacity and financial risks of excessive electrical resource capacity.⁸⁴ According to Nalcor:⁸⁵

“Without new supply capacity by 2015, demand will increase to a point where additional generation is required to maintain an appropriate generation reserve for the forecast peak demand. In the absence of additional supply, NLH’s reserve capacity will fall below the minimum standard that ensures a continuing reliable supply of electricity to meet the island’s demand. As forecasted load continues to grow, the island will also experience an energy deficit by 2021 if additional generation capacity is not added.”

The table below sets out Nalcor’s load forecast and existing capacity and energy for the 20-year forecast period.⁸⁶

Capacity and Energy Balance and Deficits for 2010 PLF (2010-2029)

Year	Island Load Forecast		Existing System		LOLH (hr/year) (limit: 2.8)	Energy Balance (GWh)
	Maximum Demand (MW)	Firm Energy (GWh)	Installed Net Capacity (MW)	Firm Capability (GWh)		
2010	1,519	7,585	1,958	8,953	0.15	1,368
2011	1,538	7,709	1,958	8,953	0.22	1,244
2012	1,571	7,849	1,958	8,953	0.41	1,104
2013	1,601	8,211	1,958	8,953	0.84	742
2014	1,666	8,485	1,958	8,953	2.52	468
2015	1,683	8,606	1,958	8,953	3.41	347
2016	1,695	8,623	1,958	8,953	3.91	330
2017	1,704	8,663	1,958	8,953	4.55	290
2018	1,714	8,732	1,958	8,953	5.38	221
2019	1,729	8,803	1,958	8,953	6.70	150
2020	1,744	8,869	1,958	8,953	8.05	84
2021	1,757	8,965	1,958	8,953	10.14	(12)
2022	1,776	9,062	1,958	8,953	13.05	(109)
2023	1,794	9,169	1,958	8,953	16.75	(216)
2024	1,813	9,232	1,958	8,953	19.94	(279)
2025	1,827	9,290	1,958	8,953	25.76	(337)
2026	1,840	9,372	1,958	8,953	29.92	(419)
2027	1,856	9,461	1,958	8,953	35.57	(508)
2028	1,872	9,543	1,958	8,953	42.35	(590)
2029	1,888	9,623	1,958	8,953	50.71	(670)

Source: NLH, *Generation Planning Issues, July 2010* (Exhibit 16)

⁸⁴ Nalcor Submission, Nov. 10, 2011, Vol. 1, pg. 12

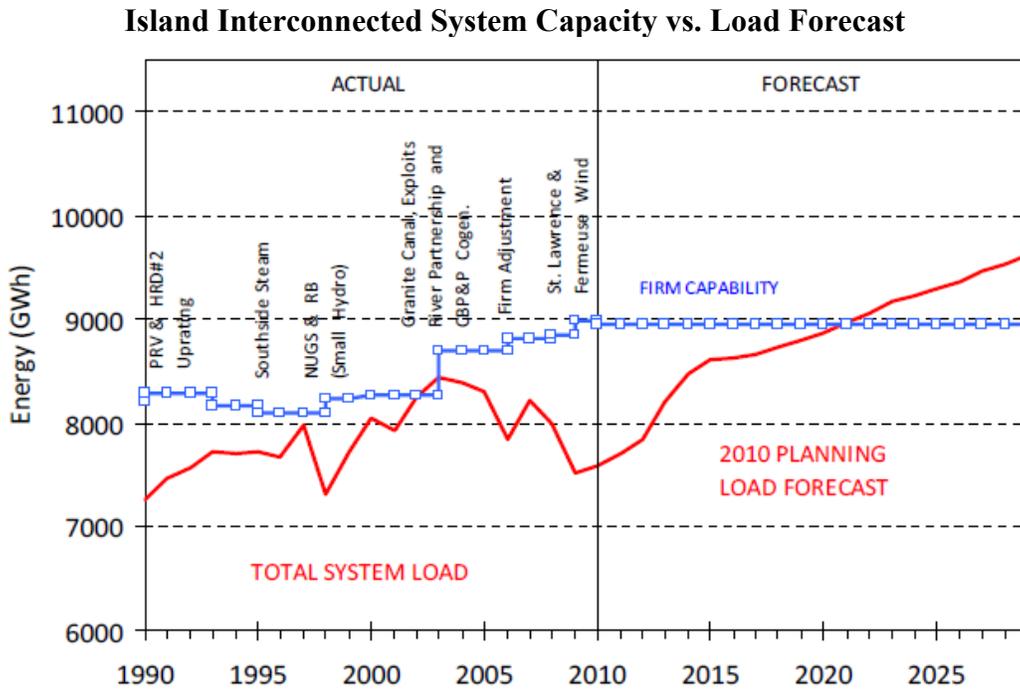
⁸⁵ Nalcor’s Final Submission, pg. 10

⁸⁶ Nalcor Submission, Nov. 10, 2011, Vol. 1, Table 20, pg. 51

Nalcor stated:⁸⁷

“NLH has the responsibility to assess and recommend supply options to meet the province’s growing energy needs. This is a function the company has been performing since its inception in the 1970’s and its predecessors before it.”

The following graph shows the historical and forecast load and the existing system capability for the Island Interconnected system.⁸⁸

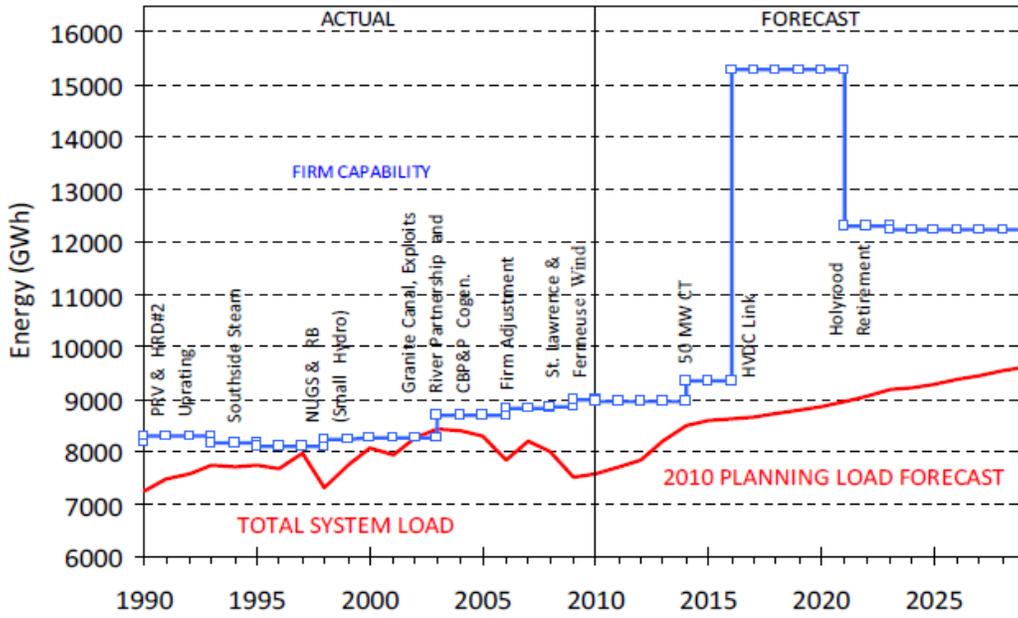


⁸⁷ Nalcor’s Final Submission, pg. 52

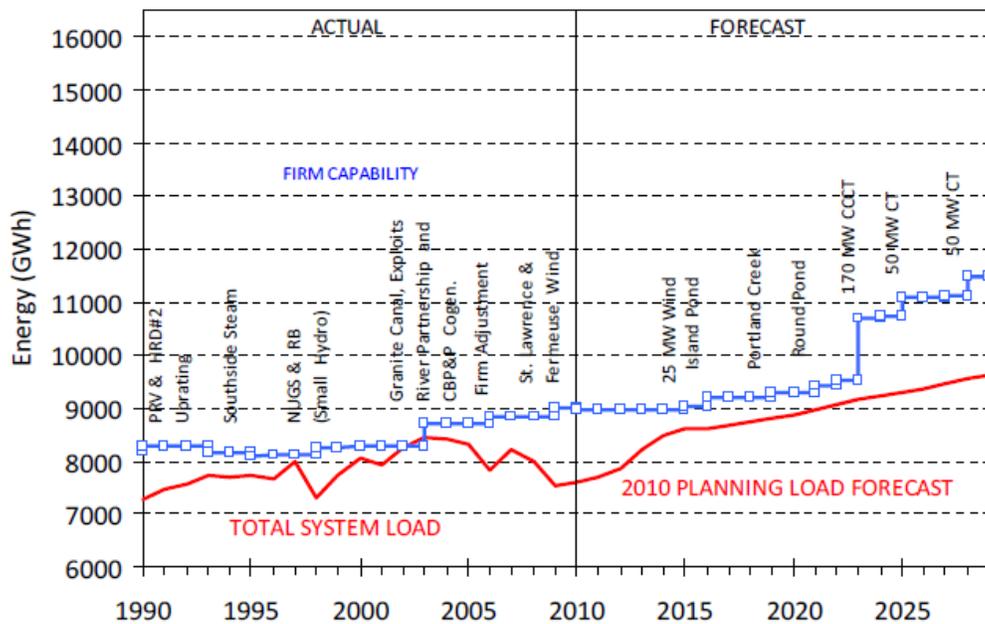
⁸⁸ Exhibit 16, Generation Planning Issues, 2010 July Update, Figure 5-1, pg. 11

Nalcor also provides a graphical comparison of the forecast load to the system capability for both the Interconnected Option and the Isolated Island Option.⁸⁹

Preliminary HVdc Link Expansion Plan vs. Load Forecast



Preliminary Isolated Island Expansion Plan vs. Load Forecast



⁸⁹ Exhibit 16, Generation Planning Issues, 2010 July Update, Figure 7-1; Figure 7-2, pg. 23

Nalcor stated that it has a responsibility to provide least-cost power and that the need for additional power generation to meet demand is clear.⁹⁰ With respect to the concept of taking the incremental approach Nalcor stated:⁹¹

(Mr. Bennett): I guess the question is, buying time for what? I mean, if you go down that road incrementally, I think you will continue to go down that road. And what we're effectively doing by not making a decision is continuing down the isolated path. Doing so will not develop power for industrial development in Labrador. We will have no surplus generation for Muskrat Falls in that scenario. We will have to do with what we have and we will remain isolated. So, I think Mr. Martin has pointed this out on a couple of occasions, doing nothing and not making a decision, effectively is a decision. It puts us on the isolated path.

Ron Penney and David Vardy stated:⁹²

"We question whether the load growth projected really justifies a project of this magnitude when only 40% of the energy will be used on the Island in the early years, while 100% of the costs must be recovered."

They also stated:⁹³

"Furthermore we believe that relatively small projects can assure our near term energy future without a large scale investment in new capacity. Such a hiatus will allow the Province to weigh other options and to open up other avenues to meet our energy needs."

6.4 Board Comments

The Terms of Reference specifically state that the Board shall consider and evaluate forecasts and assumptions for the Island load. The Board notes the particular importance of the load forecast in answering the Reference Question given the period of time involved and the large incremental increase in generation associated with the Interconnected Option. It is therefore imperative that the load forecast be the best available in the circumstances. In this regard the Board has three concerns related to the load forecast: i) the date of the Planning Load Forecast, ii) end-use modeling; and iii) the industrial customer load forecast.

The Board notes that the load forecast used in Nalcor's analysis is the 2010 Planning Load Forecast, which is dated May 2010. This forecast is based on provincial economic forecasts from 2009 and analysis completed in the first part of 2010, which means this forecast is now two years old. While Nalcor provided some information in relation to the continued economic growth in the Province through 2011, it did not explain how this relates to the 2010 Planning Load Forecast.⁹⁴ Nalcor advised during the review that a planning load forecast is normally completed every year. When asked if a load forecast was completed in 2011 Nalcor stated:⁹⁵

⁹⁰ Nalcor Submission, Nov. 10, 2011, Executive Summary, pg. 1

⁹¹ Transcript, Feb. 14, 2012, pg. 233/3-17

⁹² Ron Penney and David Vardy, Supplemental Filing, Feb. 29, 2012, pg. 1

⁹³ Ron Penney and David Vardy, Supplemental Filing, Feb. 29, 2012, pg. 1

⁹⁴ Nalcor Submission, Nov. 10, 2011, Vol. 1, pgs 13-14

⁹⁵ PUB-Nalcor-133

“Nalcor did not complete a long term load forecast and a generation expansion analysis during 2011. With the announcement of the current proceeding before the Board in 2011, Nalcor elected to maintain a consistent body of material through this proceeding. This includes the 2010 PLF, which is the foundation for the generation expansion plan and economic analysis filed in this proceeding.”

During Nalcor’s presentation Paul Stratton reiterated this position.⁹⁶ It appears that the usual annual load forecasting exercise was not carried out in 2011 for no reason other than to ensure that the information available during the review was consistent. This explanation is surprising given that Nalcor expresses the significance of the process as follows:⁹⁷

“NLH normally completes one long-term load forecast analysis annually beginning in the last quarter of each year. The annual development of long-term forecasts ensures, to the extent possible, that the constantly shifting set of inputs and parameters affecting the province’s electricity demand are incorporated into current operating plans and investment intentions.”

This review did not get underway until July 2011 and Nalcor provided very little substantive information until late in the summer and fall of 2011. The 2011 Planning Load Forecast would normally have been prepared in the spring. The decision to break from its established load forecasting process and not prepare a 2011 Planning Load Forecast is a concern and, in the Board’s view, Nalcor’s explanation is inadequate. The most recent load forecasting information would have either served to demonstrate that the 2010 Planning Load Forecast continued to be relevant or that it should not be relied on, critical information in either case.

The second issue in relation to the 2010 Planning Load Forecast is that it was not prepared in accordance with best practice in relation to end-use modeling. While improved accuracy is not guaranteed it is possible that end-use modeling would be of benefit in relation to some of the concerns that were noted during the review related to the domestic load forecast, such as the impact of changing consumption patterns and demographics of the province and the potential impacts of conservation and demand management programs. In particular end-use modeling might assist in addressing the under prediction bias in the current domestic sector forecast. Given that end-use modeling is best practice and the current model appears to have an inherent bias, it seems advisable to adopt end-use modeling before making a determination in relation to a large incremental increase in capacity such as the Interconnected Option.

The last concern in relation to the 2010 Planning Load Forecast relates to the process used for determining the industrial load forecast. The industrial load is about 17%-20% of the total load on the Island Interconnected system and Corner Brook Pulp and Paper accounts for about 50% of the industrial load.⁹⁸ According to Nalcor the industrial load forecast was determined based on information from each industrial customer without the application of any judgement or any independent analysis. Nalcor acknowledged that the closure of the other two paper mills in the province were not forecast. It appears that Nalcor did not take any additional steps outside of the normal load forecasting process to obtain reassurance in relation to the anticipated industrial load. With so few industrial customers, the recent unforecasted closure of other pulp and paper

⁹⁶ Transcript, Feb. 14, 2012, pg. 82/21-25

⁹⁷ Nalcor Submission, Nov. 10, 2011, Vol. 1, pg. 19

⁹⁸ Transcript, Feb. 14, 2012, pgs. 87-89

mills in the province, the current challenges facing Corner Brook Pulp and Paper which is the largest industrial customer, and the potential for significant increases in the Labrador load, one might expect that as part of such a major generation planning exercise the utility would, to the extent possible, be proactive in trying to obtain some reassurance in relation to the industrial customer load. The Board notes the Consumer Advocate's comment that it is considered imperative that Nalcor obtain as much understanding as possible regarding the future prospects for the continued operation of its industrial customers and, in addition, that it develop contingency plans to address the implications of reductions in industrial loads. The Board notes that, without the Corner Brook Pulp and Paper load, there would no energy deficit during the 20-year planning period.⁹⁹

In relation to how the 2010 Planning Load Forecast relates to system capability, the Board refers to the comparison graphs of forecasted load and system capability set out above. The first graph shows the forecast energy shortfall in 2021. The next two graphs show how the two options will meet the forecast load. The Interconnected Option involves a very large incremental increase in generation capability and a significant amount of excess energy and capacity until well beyond the 20-year planning period. This graph highlights the significance of the assumption required by the Terms of Reference that the excess power is not monetized or utilized. As shown in the third graph the Isolated Island Option offers what might be considered a less risky approach more in line with principles of distributed generation, where capacity and energy are added in smaller increments more closely matching the load forecast.

These graphs show that there is not an immediate need for the large incremental supply associated with the Interconnected Option and that Island electricity needs could be met in the short to medium term with available renewable sources on the Island and/or additional thermal generation. It appears that avoidance of fuel costs is a critical factor in this generation planning decision. Nalcor's analysis shows that the Interconnected Option is least-cost primarily as a result of the avoided fuel costs associated with the closure of the Holyrood Thermal Generating Station.

⁹⁹ Transcript, Feb. 15, 2012, pg. 99/16-17

7.0 COST COMPARISON ANALYSIS

7.1 Cumulative Present Worth Methodology

The Terms of Reference direct the Board to review and report on whether the Interconnected Option is the least-cost option for the supply of power to Island Interconnected customers over the period 2011-2067, as compared to the Isolated Island Option. In comparing supply options to determine which is the preferred option, there are several methodologies that can be used including Cumulative Present Worth (CPW), Net Present Value, and Internal Rate of Return. Each uses a discount rate, which usually reflects risk exposure, to recognize the time value of money. CPW focuses on incremental capital expenditures, fuel costs, power purchase costs, and operating expenses as related to the options being considered, and does not consider the future cash in-flows related to revenues. Net Present Value and Internal Rate of Return require an estimate of the revenue stream generated by power tariffs over the forecast period. CPW is generally accepted as a methodology for comparing mutually exclusive alternatives, as long as there is a fixed output or an objective that is common to both alternatives. In this case, the fixed objective is to meet the projected load forecast, assuming the same level of service and reliability targets for each of the two options.

In the preparation of its least-cost generation expansion plan Nalcor used a CPW methodology to evaluate alternative supply options, which it describes as the present value of all incremental utility capital and operating costs incurred to reliably meet a specific load forecast given a prescribed set of reliability criteria. Nalcor explained that:¹⁰⁰

“An alternative long-term supply future that has a lower CPW than another supply alternative will be the preferred investment strategy for the utility where all other constraints, such as access to capital, are satisfied. The selection of an alternative investment path with a lower CPW is consistent with the objective of providing least cost power because an alternative with a lower CPW results in an overall lower regulated revenue requirement from the customers served.”

Once Nalcor determined, based on the load forecast, that additional generation was required to meet system demands the *Ventyx Strategist* computer model was used to analyse and plan the generation requirements of the system and to evaluate those which were deemed acceptable for consideration and costing. Nalcor explained that the CPW was calculated for each alternative to determine the present value of all incremental utility and operating costs to confirm the long term least-cost generation expansion plan. Nalcor stated that a further evaluation was done to ensure transmission reliability was comparable and not compromised by either alternative.¹⁰¹

MHI agreed that Nalcor’s use of *Strategist* and the CPW approach is reasonable to identify the least-cost choice between the two options.¹⁰² MHI commented:¹⁰³

¹⁰⁰ Nalcor Submission, Nov. 10, 2011, Vol. 1, pg. 34

¹⁰¹ Nalcor Submission, Nov. 10, 2011, Executive Summary, pg. 4

¹⁰² MHI Report, Vol. 2, pg. 185

¹⁰³ MHI Report, Vol. 1, pg. 39

“The Strategist tool that Nalcor used for its CPW analyses is sophisticated and will optimize a resource plan based on available resource options, load forecasts, fuel pricing, and capital and operating costs.”

The Consumer Advocate accepted MHI’s findings that Nalcor’s CPW analysis was completed using recognized best practices.¹⁰⁴

There was little comment filed with the Board in relation to the methodology and tools used by Nalcor for its CPW analysis. EC argued that CPW is not the appropriate method for this analysis.

7.2 Strategist Inputs

Nalcor described the *Strategist* computer model that is used in its planning analyses:¹⁰⁵

“Strategist is an integrated strategic planning computer program that allows modeling of the current and future generation system and that performs, among other functions, generation system reliability analysis, production costing simulation and generation expansion planning analysis. Given the current generation system, available resource options, a load forecast and other inputs, as will be described, algorithms within Strategist evaluate all of the various combinations of resources and produce a number of generation expansion plans, including the least cost plan, to supply the load forecast within the context of the power system reliability criteria and other technical limitations.”

The key inputs to the *Strategist* model are:¹⁰⁶

- planning load forecast (PLF);
- time period of study;
- load shape;
- escalation series;
- heavy fuel oil and distillate market prices;
- weighted average cost of capital/discount rate;
- capital cost estimates;
- power purchase agreements (PPAs);
- service life/retirements;
- operating and maintenance costs (O&M);
- thermal heat rates;
- generation capacity and energy - existing and future resources;
- asset maintenance scheduling;
- forced outage rates; and
- generation unit capacities.

¹⁰⁴ Consumer Advocate’s Submission, pg. 14

¹⁰⁵ Nalcor Filing, July 6, 2011, pg. 4

¹⁰⁶ Nalcor Filing, July 6, 2011, pgs. 6-8; Nalcor Submission, Nov. 10, 2011, Vol. 1, pgs. 35-46

7.2.1 Load Forecast

The load forecast is a critical input in the CPW analysis. In addition to the issues discussed in Section 6.0, another issue that was raised in relation to the load forecast was that Nalcor used the same planning load forecast for both options in the CPW analysis.

Initially two load forecasts, one for the Isolated Island Option and one for the Interconnected Option, were prepared based on the different load growth profiles associated with each option.¹⁰⁷ As explained by Nalcor, the load growth profile for the Interconnected Option is affected by the higher initial rates for this option, which results in a lower energy requirement for this period due to lower demand. When Nalcor decided that rates for the Interconnected Option would be no higher than those for the Isolated Island Option it determined that the use of the same load forecast was appropriate. Nalcor explained that if there were material cost and rate differences mitigation strategies would be implemented.¹⁰⁸

MHI acknowledged this policy decision of Nalcor and recognized that:¹⁰⁹

“At this point, the details of this mitigation strategy have not been identified, but the implication for the CPW analysis is that rates will be managed in order to ensure they never exceed what would have been attained using the base load forecast. The Isolated Island load forecast is essentially a proxy for the rate management strategies that will constrain rates to the level that would have otherwise been seen.”

7.2.2 Fuel Price Forecasts

The fuel price forecast is also a critical input in the CPW analysis. Fuel costs make up about 70% of the CPW costs for the Isolated Island Option which, by 2067, involves primarily thermal generation. The fuel price forecast is used to estimate the future costs of production for the Holyrood Thermal Generating Station and for the combustion turbines and combined cycle combustion turbines which are included in the expansion alternatives. The amount of fuel used and the resulting fuel costs are a function of fuel efficiency or “heat rate”, which varies depending on the technology employed and plant efficiency. The heat rate efficiencies are also inputs to *Strategist*.

7.2.2.1 Fuel Price Forecasting Methodology

In the Isolated Island Option the No. 6 fuel used at Holyrood has 0.7% sulphur content until emission control systems are commissioned in 2015, and thereafter 2.2% sulphur content fuel is used. In the Interconnected Option the 0.7% sulphur content No. 6 fuel is used for the entire planning horizon. Diesel fuel is used in combustion turbine and combined cycle combustion turbine plants.

¹⁰⁷ These forecasts were filed with the Board as part of Hydro’s 2010 Capital Budget in the report “Generation Planning Issues 2009 Mid Year” dated July 2009

¹⁰⁸ PUB-Nalcor-87

¹⁰⁹ MHI Report, Vol. 2, pg. 189

Nalcor provided the January 2010 fuel price projections for No. 6 and No. 2 (diesel) fuel which were used in the CPW analysis.¹¹⁰ The forecasts are completed by PIRA Energy Group of New York (PIRA), an energy consulting firm which provides analysis and price forecasting services for world energy prices. Nalcor explained that PIRA is a leading international supplier for energy market analysis and forecasts.¹¹¹

PIRA provided four forecasts of fuel prices: reference, low, high and expected fuel price. The reference price is used by Nalcor in its costing and sensitivity analyses. MHI described the difference between these forecasts and the manner in which they are derived:¹¹²

- The reference price is the price for delivery at a specific location, based on a current ‘reference’ scenario for various world financial and economic drivers.
- The high and low forecasts reflect alternate possible econometric scenarios that would lead to either higher price pressures or lower price pressures, respectively.
- An expected price scenario is calculated as the weighted average price forecast of the reference, low and high cases. The assumed weightings used by PIRA in the expected forecast are 50 percent, 25 percent and 25 percent, which reflect the probability of occurrence for each.¹¹³ The expected price forecast encompasses the uncertainties associated in the other three scenarios into one.

In its CPW analysis Nalcor used the reference forecast price from PIRA, based on PIRA’s November 2009 report. According to Nalcor this forecast represents PIRA’s most likely view of how the energy market events will evolve.¹¹⁴ Nalcor cited the “PIRA Energy SPS Annual Guidebook 2011” as stating that the Reference Case is the one that PIRA puts forward as the most likely basis for decision-making. Nalcor stated that if you use the expected fuel price forecast as opposed to the reference price forecast the CPW preference increases to \$2.6 billion from \$2.2 billion.¹¹⁵ Updated forecasts as of May 2011 and October 2011 were subsequently filed.¹¹⁶

The following table shows the January 2010 PIRA Reference Forecast and the May 2011 update for the period 2010-2025:¹¹⁷

¹¹⁰ Exhibit 4

¹¹¹ Nalcor Submission, July 6, 2011, pg. 6

¹¹² MHI Report, Vol. 2, pgs. 204-205

¹¹³ Transcript, Feb. 14, 2012, pg. 21/11-19

¹¹⁴ MHI-Nalcor-131

¹¹⁵ Transcript, Feb. 14, 2012, pg. 20/21-24

¹¹⁶ MHI-Nalcor-60 Rev. 1; MHI-Nalcor-127; Exhibit 43

¹¹⁷ Nalcor Submission, Nov. 10, 2011, Vol. 1, Table 8, pg. 38

Thermal Fuel Oil Price Forecast Used in *Strategist* CPW Analysis

Year	Reference Forecast at Jan 2010			Reference Forecast at May 2011		
	#6 0.7% (\$Cdn/bbl)	#6 2.2% (\$Cdn/bbl)	Diesel (\$Cdn/l)	#6 0.7% (\$Cdn/bbl)	#6 2.2% (\$Cdn/bbl)	Diesel (\$Cdn/l)
2010	81.30	79.60	0.674			
2011	83.20	80.50	0.700	102.90	95.70	0.908
2012	90.90	88.00	0.760	118.40	113.70	0.990
2013	98.80	95.50	0.815	122.50	119.20	1.025
2014	102.60	99.00	0.850	126.90	123.40	1.060
2015	106.80	103.00	0.905	130.80	127.10	1.100
2016	111.10	107.00	0.945	135.60	131.60	1.140
2017	116.30	111.50	0.990	140.70	136.00	1.180
2018	121.10	115.60	1.030	144.30	139.00	1.210
2019	124.90	118.60	1.065	147.90	141.80	1.240
2020	129.20	120.30	1.100	151.50	142.80	1.275
2021	132.80	123.10	1.155	153.60	144.20	1.315
2022	136.00	125.80	1.195	155.50	145.80	1.350
2023	139.10	128.50	1.235	157.80	147.70	1.385
2024	142.10	131.10	1.275	160.70	150.20	1.425
2025	145.00	133.70	1.315	162.80	152.00	1.460

Notes: (1) Product prices reflect landed values on Avalon Peninsula.
(2) Diesel represents No. 2 distillate gas turbine fuel fob Holyrood.
(3) Post 2025 pricing is forecast at annual inflation of 2%.

Sources: (1) Nalcor Energy/ NLH, *Thermal Fuel Oil Price Forecast: Reference as of January 2010* (Exhibit 4)
(2) Nalcor response to MHI-Nalcor-126

The forecast fuel prices have a compound annual growth rate of 3.5% to 4.5%, depending on the fuel source, for the period 2010 to 2025. Beyond 2025 Nalcor escalated the fuel series at 2% annually in line with general inflation to 2067.¹¹⁸ Nalcor also filed additional fuel price forecasts from the National Energy Board and the US Energy Information Administration, which were both consistent with the PIRA forecast.¹¹⁹ Nalcor pointed out that, in its latest forecasts, PIRA recognizes that shale oil liquids will be an important growing source of non-OPEC crude. However, PIRA stated that shale oil liquids will primarily offset the decline in other non-OPEC fields and will not result in enough global volume to be a “game changer” for the global crude market.¹²⁰

Nalcor explained how it takes into account the difficulty in forecasting fuel prices over the 57-year analysis period.¹²¹

¹¹⁸ Transcript, Feb. 13, 2012, pg. 40/5-19

¹¹⁹ Exhibit CE-69; CA/KPL-Nalcor-53; Nalcor’s Final Submission, pgs. 20-21

¹²⁰ Nalcor’s Final Submission, pg. 21

¹²¹ Transcript, Feb. 14, 2012, pg. 119/1-15

(Mr. Goudie): Well we handle it by going in with a reputable company that produces a comprehensive analysis behind their fuel price projections. We do sensitivity analysis to understand the leverage that alternate price projections to our reference case would have on our base case results. I mean, the uncertainty is prevailing and one of the reasons why we analyse and ultimately recommend an Interconnected Island Option is exactly to get rid of that uncertainty because if that ever comes to roost on the wrong side, electricity will be very unaffordable on the Island of Newfoundland.

Nalcor submitted that the fuel price forecast used in its Decision Gate 2 analysis was well grounded and realistic.¹²²

MHI addressed the issue of uncertainty in fuel price forecasting:¹²³

“The forecasting accuracy for fuel costs will remain a challenge over the duration of the projected review period, which is in excess of 50 years. There are many variables which could come into play over that period that could have a substantial impact on fuel costs, over which Nalcor has no control or influence.”

MHI explained that since it is beyond a reasonable expectation for anyone to predict with accuracy the extent of fuel price escalation beyond 2025, it conducted sensitivity analyses on the potential fluctuation of fuel costs beyond 2025. MHI stated:¹²⁴

“It is clear there is much uncertainty related to the pricing of fuel for thermal-based power generation. Different scenarios can and should be run and compared, but the results related thereto often have a short shelf life. While the prospect of raising the necessary capital to finance and construct the Infeed Option may be daunting, the uncertainty associated with forecasting the price of fuel for thermal generation over the long term might be, and likely is, even more so.”

The Consumer Advocate agreed with MHI that there is uncertainty related to pricing of fuel for thermal power generation:¹²⁵

“If the absence of uncertainty in oil price forecasts was required before advancing with capital spending, one would observe little capital spending. The reality is that corporations have to make investment decisions on the basis of less than certain information and upon assumptions about the future grounded in the best available information.”

In speaking to the challenge of forecasting oil prices Cabot Martin noted that rising shale oil production is already having a significant impact on some crude prices and that private sector investments are now citing long term oil prices at \$80 or \$90 (2010\$ US) per barrel.¹²⁶

¹²² Nalcor’s Final Submission, pg. 20

¹²³ MHI Report, Vol. 1, pg. 85

¹²⁴ MHI Report, Vol. 2, pg. 205

¹²⁵ Consumer Advocate’s Submission, pg. 27

¹²⁶ Cabot Martin Presentation, Feb. 20, 2012, pg. 2; Cabot Martin, Supplemental Filing, Feb. 29, 2012

Ron Penney and David Vardy stated in their presentation:¹²⁷

“The shale gas revolution is raising uncertainty in energy markets and we are well advised to recognize its impact, not only on gas and oil prices, but also on electricity prices throughout North America.”

Philip Raphals provided a retrospective study demonstrating that there have been periods when fuel forecasts were dramatically too high for several years and then too low for several years.

The Minister of Natural Resources filed a report by PIRA on its fuel forecast methodology and assessment of future oil price trends. The report, dated February 28, 2012, stated that the reference case is considered the most likely case, consistent with the most likely assumptions on all of the key inputs and is the price put forward as a most likely basis for decision-making. The report stated that its current assessment includes an assessment of supply from shale oil and explained the principal reason for the increase in the forecast from 2009 to the current view was the increase in uncertainty over supply in the Middle East and North Africa and an increase in demand from its previous forecast.¹²⁸

MA wrote:

*“Perhaps **risk magnification** helps explain why NL Hydro's legislation restricts demand forecasting to 20 years, why the PIRA Energy Group only forecasts oil prices out to 15 years, why the National Energy Board only forecasts oil prices out 25 years, and why the NL government forecasts demographic estimates out to only 20 years.*

*Beyond 20 or 25 years, "risk magnification" is intensified --- and forecasts become not only unreliable --- but **meaningless**.”*

Robert Cadigan of NOIA expressed confidence in the fuel forecasts, pointing out that Nalcor has compared its PIRA forecast to other credible sources that forecast fuel costs, including the National Energy Board and the US Energy Information Administration.¹²⁹

7.2.2.2 Board Comments

The fuel price forecast is the most significant factor in the CPW analysis and is the main factor in the CPW preference for the Interconnected Option. Fuel makes up about 70% of the CPW costs for the Isolated Island Option and, because fuel prices are volatile and difficult to forecast over a long period, there is likely to be a great deal of variability around this input. Nalcor explained that uncertainty in relation to fuel costs is prevailing which is one of the reasons that Nalcor recommends the Interconnected Option with reduced reliance on thermal production. MHI noted that there are many variables that can come into play over a period greater than 50 years. The Consumer Advocate suggested that investment decisions must be made even in the presence of risk. As long as thermal generation is a part of the generation mix the uncertainty associated with fuel price forecasting will be present in the generation planning exercise. The only response

¹²⁷ Ron Penney and David Vardy Presentation, Feb. 20, 2012, pg. 5

¹²⁸ Minister of Natural Resources, Letter of Comment, Feb. 29, 2012

¹²⁹ Transcript, Feb. 21, 2011, pgs. 20/22-25; 21/1-2

to this uncertainty is to ensure that the fuel price forecasts are based on current and credible information and assumptions.

The fuel price forecast used by Nalcor is based on a forecast dated January 2010 from PIRA, a recognized consulting firm that provides analysis and price forecasting for world energy prices. Updated forecasts as of May 2011 and October 2011 confirmed the continued relevance of the January 2010 forecast. PIRA confirmed that the reference price used by Nalcor is the most likely case and further that it is the one that PIRA puts forward as a basis for decision making. The PIRA forecast covers the period 2010 to 2025. Beyond 2025 the fuel forecast price was escalated at 2% annually to 2067, which is about half of the forecast compound annual growth over the period 2010 to 2025. Other forecasts of fuel prices to 2035 from the National Energy Board and the US Energy Information Administration were consistent with Nalcor's forecast.

Based on the information filed it appears that the fuel price forecasts provided are current and based on credible sources. The significant risks associated with forecasts of fuel 57 years into the future must be recognized and monitored. Even with all the best forecasts the Board agrees with MHI that it is beyond a reasonable expectation to predict fuel price escalation beyond 2025.

7.2.3 Capital Cost Estimates

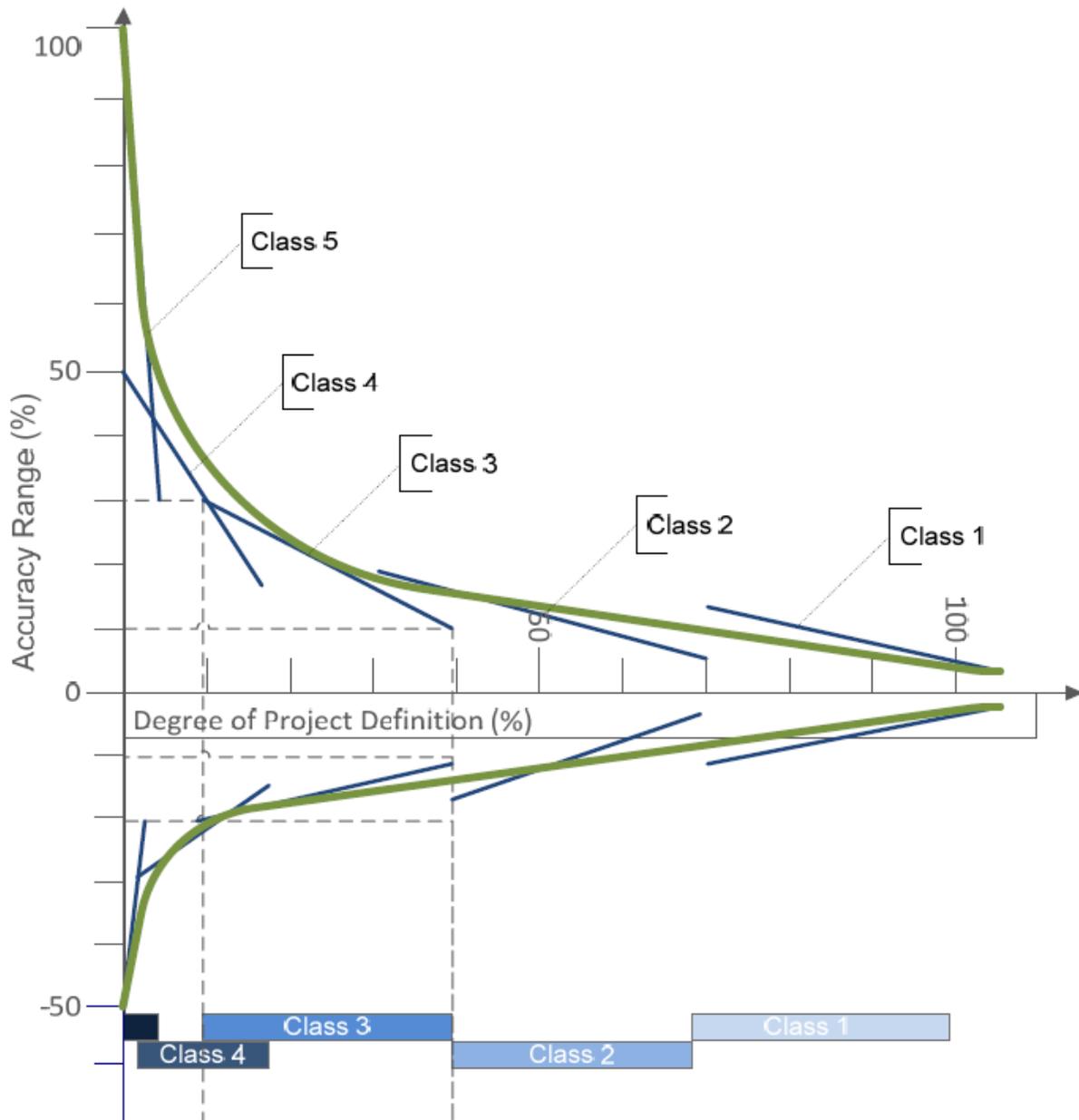
7.2.3.1 Project Definition and Estimate Accuracy

Nalcor has adopted the estimating practices of the Association for the Advancement of Cost Engineering ("AACE") and selected the level of cost estimate maturity required for each of its identified decision gates. The level of accuracy of a capital cost estimate is directly related to the degree of project definition used in the preparation of the cost estimate. Confidence in the cost estimate increases as the project progresses through development due to the increase in the degree of project definition.¹³⁰ This is illustrated in Figure 7 of MHI's Report as shown below:¹³¹

¹³⁰ Transcript, Feb. 13, 2012, pgs. 69-71

¹³¹ MHI Report, Vol. 1, Figure 7, pg. 35

AACE Cost Estimating Accuracy Classes



Nalcor advised that it passed Decision Gate 2 in November 2010 and the analysis and information provided in the review were as of this date. Nalcor determined that the Decision Gate 2 capital cost estimate would be a feasibility level estimate commensurate with an AACE Class 4 estimate.¹³² The degree of project definition associated with Decision Gate 2 and a Class

¹³² Exhibit 31, pg 7

4 estimate is 1% to 15%, which is concept study or feasibility level. The cost estimate associated with this level of project definition has an accuracy range of +50% to -30%.¹³³

Paul Harrington of Nalcor stated that project definition at Decision Gate 2 for the Interconnected Option was up to 5%¹³⁴ while Jason Kean of Nalcor stated the project definition at that point was in the range of 5%-10%.¹³⁵ Mr. Harrington said that the project definition for the Isolated Island Option would be less than 5% at Decision Gate 2.¹³⁶

In relation to the accuracy range Mr. Harrington stated that, in his view, Nalcor's capital cost estimate at Decision Gate 2 was close to the narrow band (+20 to -15%) of the AACE range for a Class 4 estimate. Mr. Harrington said that +50% and -30% are on the extreme edges and that he didn't believe Nalcor would be there.¹³⁷ However, Gilbert Bennett said:¹³⁸

(Mr. Bennett): ...from there, it's fine to say, yes, we think that we have that done, but for Nalcor to say the estimate is within this specific range, it's a very difficult thing to do based on the nature of the process that we're in. So people have pointed out that the extreme edge of the range is -30 to +50 percent. There is a narrow end of the spectrum, as Mr. Harrington just pointed out as well, but other than completing the analysis that we've done, other than reviewing the nature of the work that's been completed, it would be very difficult to say that we think that the estimate is, you know, at this point in time within these specific parameters. That was the point I was trying to make yesterday.

7.2.3.2 Capital Cost Estimating Methodology

In preparing its capital cost estimates for Decision Gate 2 Nalcor developed a process based on AACE principles which provided for the inclusion of three major estimate components for each project element. The three components were: base estimate, contingency and escalation. The base estimate was determined using the project definition that existed at that time. It included bottom-up estimating, using four main inputs of project definition, construction methodology including timelines, price, and performance factors for those components of the project where detailed project definition existed. In addition, for certain components, including portions of the Labrador-Island Link transmission line, factored adjustments were made from previous work completed on different project configurations. The project was broken down into a series of contract packages (e.g. turbine/generator units and dams) and estimates were developed by applying the costs of materials, labour and equipment to the required amount of materials, quantities and equipment. Estimates for equipment were based upon recent quotes while prices for construction consumables were obtained from vendors. The contractors' overhead and profit were included as well as labour rates.¹³⁹

A contingency amount of 15% was selected by Nalcor following a risk analysis performed for Decision Gate 2 which included a review by the Westney Consulting Group (Westney) of

¹³³ Exhibit 31, pg. 6; Exhibit CE-51 Rev 1 (Public), pg. 10; PUB-Nalcor-42

¹³⁴ Transcript, Feb. 13, 2012, pg. 118/1-4

¹³⁵ Transcript, Feb. 14, 2012, pg. 48/21-25

¹³⁶ Transcript, Feb. 14, 2012, pg. 131/5-13

¹³⁷ Transcript, Feb. 14, 2012, pg. 51/16-24

¹³⁸ Transcript, Feb. 14, 2012, pgs. 53/23-25; 54/1-13

¹³⁹ Exhibit 31, pgs. 7-8

available cost and schedule estimates.¹⁴⁰ Westney recommended a contingency of 16% but Nalcor decided that 15% would be appropriate as, in its view, there had been progression of the project definition since Westney's recommendation.¹⁴¹ Westney had also recommended the creation of a strategic reserve for the Decision Gate 2 cost estimate. The amount of this reserve was set out in a confidential exhibit reviewed by the Board and MHI. This recommendation was not accepted by Nalcor as in its view there had been a reduction in the key risks identified by Westney since its recommendation as a result of factors such as the commitment by the Federal Government for a loan guarantee and the selection of a conventional technology for the HVdc transmission line. Nalcor stated that it would reconsider the need for a strategic reserve amount at Decision Gate 3.¹⁴²

The third component of the capital cost estimate is escalation. Escalation was used to bring cost estimates from past engineering studies to January 2010 dollars and to bring 2010 dollar estimates forward to the time when the actual costs would be incurred. Escalation factors were calculated using detailed Producer Price Index projections as provided primarily by Global Insight, a forecasting service used by Nalcor, to extrapolate the 2010 dollar estimate to commissioning date values.¹⁴³

MHI reviewed the capital cost estimating process followed by Nalcor and concluded that Nalcor's process is very similar to that used by Manitoba Hydro and is a utility best practice.¹⁴⁴ MHI also confirmed the degree of project definition and accuracy ranges associated with an AACE Class 4 estimate as set out above.¹⁴⁵

The detailed costing for each supply option was provided to the Board and MHI on a confidential basis. A general discussion of the components of the capital cost estimates for the Interconnected Option and the Isolated Island Option are set out in the following sections.

7.2.3.3 Interconnected Option-Capital Costs

For the two major components of the Interconnected Option, the Muskrat Falls generating facility and the Labrador-Island Link transmission line, Nalcor prepared detailed cost estimates using basic inputs to the work breakdown structure, including crew sizes, wages, productivity rates, fuel, consumables and construction fleet costs. Major equipment estimates were based on supplier budget quotations or knowledge gained from similar previous projects. Owner and engineering, procurement and construction management contractor costs were also estimated and added to arrive at a total base cost estimate of \$2,206 million for the Muskrat Falls generating facility and \$1,616 million for the Labrador-Island Link transmission line. To each base estimate Nalcor applied a 15% contingency allowance of \$328 million and \$236 million respectively.¹⁴⁶

¹⁴⁰ Exhibit CE-52, pg. 1

¹⁴¹ Nalcor Submission, Nov. 10, 2011, Vol. 2, pg. 81

¹⁴² Nalcor Submission, Nov. 10, 2011, Vol. 2, pg. 82

¹⁴³ MHI-Nalcor-50; MHI Report, Vol. 2, pg. 195

¹⁴⁴ MHI Report, Vol. 1, pg. 36

¹⁴⁵ MHI Report, Vol. 1, pgs. 34-35; Transcript, Feb. 15, 2012, pg. 112

¹⁴⁶ Nalcor Submission, Nov. 10, 2011, Vol. 2, pg. 71

To determine appropriate escalation factors and the cumulative escalation to be applied to each of the project elements Nalcor used the physical components of the project, the project schedule and producer price indices. The estimated cumulative escalation for the Muskrat Falls generating facility and the Labrador-Island Link transmission line was \$335 million and \$208 million, respectively.¹⁴⁷

Total estimated costs for the Muskrat Falls generating facility, including two 345 kV ac transmission lines to Churchill Falls and associated terminal stations, is \$2,869 million (2010\$). Total estimated cost for the Labrador-Island Link transmission line including ac system upgrades on the Island, is \$2,060 million (2010\$). Both estimates are inclusive of contingency and escalation but exclude interest during construction.

MHI's review of the Muskrat Falls generating facility estimate was not performed as a separate detailed independent cost estimate. Rather, MHI examined Nalcor's cost estimating methodology and several of the major inputs to Nalcor's analysis and compared them with those of similar projects.¹⁴⁸ MHI examined key documents related to the development of the project cost estimates and also held meetings with Nalcor staff to discuss various aspects of the development.¹⁴⁹ Having reviewed Nalcor's cost estimating methodology, construction labour rates, construction materials and equipment, permanent equipment packages and owner's engineering and management costs for the Muskrat Falls generating facility, MHI concluded that the overall cost estimate methodology is appropriate for a major construction project and would allow for a reliable estimate provided that the inputs to the analysis are meaningful.¹⁵⁰

MHI considered the cost estimate at Decision Gate 2 to be within the accuracy range of an AACE Class 4 estimate (+50% to -30%).¹⁵¹ MHI concluded for the Muskrat Falls generating facility that:¹⁵²

“The cost estimate was prepared using an appropriate methodology that was applied in a comprehensive manner with relevant input data and assumptions. The scope of work identified for the estimate is in keeping with utility best practices. The resulting cost estimate appears to be consistent with the nature of the works proposed for construction, local conditions, and construction market conditions. The Base Cost Estimate for the works appears to be reasonable and should fairly represent the costs to be included in the Infeed Option. The approach adopted for the project cost contingencies and escalation is also reasonable.”

¹⁴⁷ Nalcor Submission, Nov.10, 2011, Vol. 2, pg. 71

¹⁴⁸ MHI Report, Vol. 2, pg. 92

¹⁴⁹ Confidential Exhibits: CE-51 – Overview of Decision Gate 2 Capital Cost and Schedule Estimate; CE-65 – Gate 2 Capital Cost Estimate Report – Muskrat Falls Generating Facility; and CE-67 – Project Control Schedule.

¹⁵⁰ MHI Report, Vol. 2, pg. 93

¹⁵¹ MHI Report, Vol. 2, pg. 97

¹⁵² MHI Report, Vol. 2, pg. 97

MHI further stated with respect to the absence of a strategic reserve amount for the Muskrat Falls generating facility:¹⁵³

“Note however, that the project cost estimate (sum of Base Estimate, plus contingency, plus escalation allowance) does not include any provision for changes to elements such as the project scope, or unexpected events such as strikes, abnormal weather, etc. A financial contingency would normally be established to allow for such factors in creating the project budget.”

MHI’s review of the Labrador-Island Link transmission line was separated into three components: HVdc converter stations and electrodes; HVdc overland transmission line; and the Strait of Belle Isle submarine cable crossing. MHI reviewed Nalcor’s key documents and other available information related to the Labrador-Island Link transmission line capital cost estimate of \$2,060 million (2010\$).¹⁵⁴

To review the Strait of Belle Isle submarine cable crossing MHI engaged CESI, an international consulting firm with significant experience and expertise in submarine cable projects. CESI prepared an estimate for the marine crossing cable system for comparison to Nalcor’s estimate. Factors considered in the estimate prepared included cable manufacturing, installation and protection. MHI found that the marine crossing estimate prepared by Nalcor at Decision Gate 2 was within the range of an AACE Class 4 cost estimate.¹⁵⁵

For the HVdc converter stations, electrodes and Island ac system upgrades including synchronous condensers, MHI used industry benchmarks and information from similar projects to evaluate Nalcor’s estimate. MHI concluded that the estimates for the HVdc converter stations, electrodes, including electrode lines, and synchronous condensers were within the range of an AACE Class 4 estimate. However the estimates for the synchronous condensers were at the low end of the range.¹⁵⁶

For the HVdc overland transmission line MHI concluded that, while the capital cost estimate falls inside the typical range of capital construction estimates for this type and length of transmission line, Nalcor’s estimate appears to be at the low end of the range.¹⁵⁷ MHI based this conclusion on utilizing industry benchmark costs as a comparison.

MHI also noted that certain documentation related to the Labrador-Island Link transmission line was not available for its review, including the HVdc converter station single line diagrams, performance requirements for the converter stations, a system risk analysis for operations, and design details for the overland transmission line such as tower design, tower loading conditions, route selection and risk analysis for the line.¹⁵⁸

¹⁵³ MHI Report, Vol. 2, pg. 96

¹⁵⁴ Confidential Exhibits: CE-51 – Overview of Decision Gate 2 Capital Cost Estimate; CE-66 – Gate 2 Capital Cost Estimate Report – Island Link; and CE-67 – Project Control Schedule

¹⁵⁵ MHI Report, Vol. 1, pg. 12

¹⁵⁶ MHI Report, Vol. 1, pg. 11

¹⁵⁷ MHI Report, Vol. 2, pg. 120

¹⁵⁸ MHI Report, Vol. 1, pgs. 59-63; Vol. 2, pgs. 110, 112, 116

The Interconnected Option also includes the development of Portland Creek and the installation of combustion turbines and combined cycle combustion turbines. Nalcor's cost estimate for the Portland Creek hydroelectric development of \$90 million (2010\$), was based on Exhibit 5c, a 2007 feasibility study with appropriate escalation factors applied.¹⁵⁹ MHI reviewed the capital cost estimates for all three small hydroelectric projects including Portland Creek, and found that the level of engineering and investigations were consistent with a feasibility level study.¹⁶⁰

Nalcor's estimate for the 50 MW combustion turbines was based on a high level budget quotation provided by a manufacturer. To this, Nalcor added further costs to cover site preparation, fuel storage facilities, grid interconnections, engineering and project management. The resultant estimate of \$65 million was reviewed by MHI and considered to be reasonable and comparable to industry estimates.¹⁶¹

A benchmark study was used by Nalcor to estimate the capital costs of the 170 MW combined cycle combustion turbines.¹⁶² MHI reviewed the cost estimates prepared by Nalcor for these units and found they compared well with the estimated values determined by MHI.¹⁶³

MHI identified certain gaps and deficiencies in Nalcor's work as of Decision Gate 2 for the Interconnected Option which have the potential to impact capital cost estimates. These gaps relate to the appropriate design for the HVdc overland transmission line, probabilistic reliability studies, system integration studies and compliance with NERC standards. The costs to address these deficiencies were not included in the Decision Gate 2 capital cost estimates for the Interconnected Option reviewed by MHI but, together, they could be significant. As an example, during the review process the additional cost to increase the return period to 1:150 years for the HVdc overland transmission line was said by Nalcor to be \$150 million¹⁶⁴ and, if the return period used is 1:500 years, the additional cost is \$225-250 million.¹⁶⁵ Until these gaps are addressed by Nalcor it is not possible to identify the potential further additional costs which must be included in a revised capital cost estimate for the Interconnected Option. These issues are discussed more fully in Part Three-Section 10 of this report.

7.2.3.4 Isolated Island Option-Capital Costs

The Isolated Island Option provides for the continued operation of the Holyrood Thermal Generating Station to the mid-2030s. Total capital costs included in the CPW analysis for the Isolated Island Option for life extension capital projects in relation to the Holyrood Thermal Generating Station amount to \$230 million between 2016 and 2029.¹⁶⁶ Nalcor indicated that these estimates were based on comparisons with similar plants in the region.¹⁶⁷ MHI concluded

¹⁵⁹ MHI Report, Vol. 2, pg. 153

¹⁶⁰ MHI Report, Vol. 2, pg. 158

¹⁶¹ MHI Report, Vol. 2, pg. 167

¹⁶² Exhibit CE-46 Rev. 2 (Public)

¹⁶³ MHI Report, Vol. 2, pg. 168

¹⁶⁴ PUB-Nalcor-15; Transcript, Feb. 13, 2012, pg. 170/3-9

¹⁶⁵ Transcript, Feb. 14, 2012, pg. 3/1-9

¹⁶⁶ Transcript, Feb. 13, 2012, pg. 41/23-25

¹⁶⁷ MHI Report, Vol. 2, pg. 166

that although these estimates were not based on detailed engineering assessments, they are conservative and representative of similar plants.¹⁶⁸

The Isolated Island Option includes the installation of emission control systems at the Holyrood Thermal Generating Station. Nalcor determined that this would entail the installation of electrostatic precipitators, flue gas desulphurization units and low NO_x burners. Nalcor's cost estimate for this equipment of \$602 million is primarily based on a detailed report by an external consultant completed in 2008.¹⁶⁹ This estimate was reviewed by MHI and found to be in line with industry norms and reasonable to carry in the CPW analysis.¹⁷⁰

The Isolated Island Option includes replacement of Units 1 and 2 at the Holyrood Thermal Generating Station in 2033 and Unit 3 in 2036 with three 170 MW combined cycle combustion turbines. Nalcor used a 2001 engineering study with appropriate escalation factors to determine the costs to be carried in the cumulative present worth analysis.¹⁷¹ MHI prepared comparison estimates and found that the values used for Decision Gate 2 are reasonable based on present utility plant retirements.¹⁷² The generation expansion plan for the Isolated Island Option also includes the installation of seven additional 170 MW combined cycle combustion turbines and nine 50 MW combustion turbines. As noted previously, MHI found that the cost estimates for the combustion turbines and combined cycle combustion turbines were reasonable.

The Isolated Island Option also includes the development of small hydroelectric sites at Island Pond (36 MW), Round Pond (18 MW) and Portland Creek (23 MW). As noted earlier, Nalcor's cost estimate for the Portland Creek development is \$90 million (2010\$). Nalcor's estimates for Island Pond and Round Pond, at \$166 million (2010\$) and \$142 million (2010\$) respectively, were derived using escalated costs from previous feasibility level studies. MHI found that the capital cost estimates for all three small hydroelectric plants were consistent with a feasibility level study and resolution of uncertainties would likely increase the costs.

This option also includes the installation of a new 25 MW wind farm in 2014 and replacement of all wind farms following 20 years of service. Nalcor's capital costs for the wind farms are based on the 2007 Ontario Power Authority Integrated System Plan as per Exhibit 25. MHI found that the resulting capital costs for these projects used by Nalcor in their analysis, ranging from \$58 million to \$63 million (2010\$), was appropriate.¹⁷³

MHI noted that the capital cost estimates for the Isolated Island Option were less detailed than for the Interconnected Option.¹⁷⁴

¹⁶⁸ MHI Report, Vol. 1, pg. 13

¹⁶⁹ Exhibit 5L(i); Exhibit 5

¹⁷⁰ MHI Report, Vol. 1, pg. 79; Vol. 2, pgs. 171-172

¹⁷¹ MHI Report, Vol. 2, pg. 173

¹⁷² MHI Report, Vol. 2, pgs. 178-179

¹⁷³ MHI Report, Vol. 1, pg. 14

¹⁷⁴ MHI Report, Vol. 1, pg. 36

7.2.3.5 Submissions and Comments

The Consumer Advocate noted that MHI based its findings relative to project components and costs as of Decision Gate 2 and stated:¹⁷⁵

“Likewise, of course, the Consumer Advocate can only comment on project components and costs as of DG2, the time at which approval was given to the Muskrat Falls-Labrador Island Link development scenario and to proceed with commencement of detailed design.”

The Consumer Advocate stated in relation to the capital costs for both Options:¹⁷⁶

“Pursuant to the Terms of Reference for the review, the Board and its advisors had access to Nalcor’s confidential information as regards project costing and schedule that was deemed by Nalcor pursuant to the terms of the Energy Corporation Act to be commercially sensitive and/or proprietary in nature. Such confidential information was not released to the Consumer Advocate or his advisors. Accordingly, the Consumer Advocate and his advisors were not able to undertake a detailed review of Nalcor’s capital cost estimates in the fashion permitted of the Board and its advisors. This limitation practically means that the Consumer Advocate must rely upon the Board’s and its advisors’ analyses of Nalcor’s detailed cost estimates as at DG2. The Consumer Advocate is satisfied that MHI’s methodology and approach to its review of Nalcor’s cost estimates as outlined in its report are reasonable for the purposes of this review.”

The Consumer Advocate further stated that he accepts MHI’s findings that the inputs, including the capital cost inputs, were generally found to be appropriate.¹⁷⁷

Concerns about the potential for increases in capital costs from Nalcor’s estimates were expressed by a number of presenters. Ron Penney and David Vardy pointed out that the capital cost information was more than a year out of date and had the potential for overruns of 50%.¹⁷⁸ They stated that the Board should have more definitive capital cost estimates than the Class 4 estimates provided by Nalcor and that the Board should be given access to Nalcor’s Class 3 estimates.

Cabot Martin also raised this issue in both his presentation and supplemental comments. He stated that Nalcor had to defer answering many questions at the hearing until Decision Gate 3 work was completed and that there was a high probability of large cost adjustments between Decision Gate 2 and Decision Gate 3. He recommended the Board should adjourn until it received the updated Decision Gate 3 information.¹⁷⁹

Yvonne Jones, M.H.A., and a joint submission from Dennis Browne, Edward Hearn and Richard Cashin raised concerns in relation to capital cost overruns. Others raised the issue of the inclusion of the Holyrood pollution control equipment costs in the Isolated Island Option.

¹⁷⁵ Consumer Advocate’s Submission, pg. 33

¹⁷⁶ Consumer Advocate’s Submission, pgs. 33-34

¹⁷⁷ Consumer Advocate’s Submission, pg. 42

¹⁷⁸ Transcript, Feb. 20, 2012, pg. 51/15-18

¹⁷⁹ Transcript, Feb. 20, 2012, pg. 14/22-25; 15/1-4; Cabot Martin, Supplemental Filing, Feb. 29, 2012

7.2.3.6 Board Comments

The capital cost estimates provided by Nalcor in this review are reflective of a concept study or feasibility level estimate with a degree of project definition of approximately 5%. The level of project definition for the Interconnected Option is between 5% and 10% and for the Isolated Island Option less than 5%. With this degree of project definition Nalcor said that the capital cost estimates may be as much as 50% higher than forecast. A cost increase within this range would result in total CPW for the Interconnected Option in the order of \$8,616 million.¹⁸⁰

Aside from the level of project definition and range of accuracy there are a number of other uncertainties in relation to the capital costs of both options which, taken together, could significantly affect the CPW analysis. In particular the Board notes that there are several issues which could place upward pressure on the capital cost estimates in relation to the Interconnected Option:

- MHI found that the estimates in relation to the synchronous condensers and the HVdc overland transmission, which are approximately half of the costs estimated for the Labrador-Island Link transmission line, are at the low end of the range.
- Additional costs in relation to increasing the design return period of the HVdc overland transmission line would increase the estimated capital costs between \$150 million and \$250 million, depending on the design return period chosen.
- Additional costs could be expected with the completion of the system integration studies and if probabilistic adequacy studies were undertaken and NERC standards are observed. Based on the information provided it is not possible to quantify any impacts on capital costs that may be associated with these issues.
- The recommended strategic reserve was not included in the cost estimates.
- The possible additional costs of compliance with the conditions of environmental release cannot be quantified at this time.

The Board also notes project schedule delays can impact costs and it seems there may be a delay in the schedule for the Interconnected Option. The schedule provided with Nalcor's Submission had contemplated obtaining environmental assessment release for the generation project in the third quarter of 2011, and commencing certain site work immediately thereafter.¹⁸¹ However, the environmental release did not occur until March 2012, some six months behind schedule.

7.2.4 Other Inputs

Aside from the major inputs of load forecasts, fuel price forecasts and capital costs there are a number of other important inputs to the CPW analysis. MHI reviewed these inputs in detail and found that the inputs used by Nalcor were generally appropriate.¹⁸² The Consumer Advocate

¹⁸⁰ PUB-Nalcor-118

¹⁸¹ Nalcor Submission, Nov. 10, 2011, Vol. 2, pg. 89

¹⁸² MHI Report, Vol. 2, pg. 208; Vol. 1, pg. 88

accepted MHI's findings.¹⁸³ There was little comment or issue in reference to most of the inputs during the review except as discussed below.

7.2.4.1 Power Purchase Agreement and Cost of Service

In general Nalcor has used a cost of service (COS) approach to determine the CPW of incremental capital and operating costs incurred in the development of each option. Nalcor has, however, used a Power Purchase Agreement (PPA) approach in relation to the costs for the Muskrat Falls generating facility in the Interconnected Option. The PPA distributes the costs of the Muskrat Falls generating facility over a 50-year period, the anticipated life of the asset, in a per-unit charge for energy sold to Hydro by Nalcor. This rate is expected to be uniform throughout the future period, adjusted only for escalation.

In using the PPA approach Nalcor assumed that Hydro would sign a take-or-pay contract with Nalcor for the forecast energy purchases from the Muskrat Falls generating facility. To calculate the PPA prices it was assumed that all of the firm output generated by Muskrat Falls would be sold, that the internal rate of return would be 11.0%, and that equity financing would be 100%. Since Hydro purchases are expected to be 40% of Muskrat Falls' firm energy in 2017, the use of this arrangement is forecast to allow Hydro an internal rate of return of 8.4%. Nalcor explained that the take-or-pay contract would mean that, regardless of the amount of energy that Hydro needs, it would still have to pay the contracted revenue.¹⁸⁴

Nalcor stated that it:¹⁸⁵

"...recommends the PPA approach, with a proposed constant dollar base price of approximately \$76 per megawatt hour (MWh) in 2010\$ for Muskrat Falls power and escalation at two percent annually as providing the best scenario for electricity consumers.

In addition to providing consumers with manageable rates for Muskrat Fall's power in the early years of operations, this pricing approach avoids intergenerational inequity by ensuring that all existing and future consumers will pay the same price in constant or real 2010\$ over the life of the project."

In the alternative Nalcor calculates the price of the COS model, with an internal rate of return of 8.4%, to be \$214/MWh in year one declining each year thereafter as the Island sales base grows and the return on rate base declines.¹⁸⁶ Nalcor explained that it does not intend to sell Muskrat Falls power for \$214/MWh and instead it will sell it to Hydro at \$76/MWh (2010\$) which in year one will be \$87/MWh.¹⁸⁷ Nalcor stated that:¹⁸⁸

"...in its PPA pricing approach equity income is not forgone in the early years but rather it is lower than it otherwise would be if a traditional rate base cost of service pricing model was followed for pricing. While both the cost of service and PPA are cost based approaches for price determination, the pattern of fixed cost recovery is different."

¹⁸³ Consumer Advocate's Submission, pg. 14

¹⁸⁴ Transcript, Feb. 14, 2012, pg. 213/21-24

¹⁸⁵ Nalcor's Final Submission, pg. 27

¹⁸⁶ PUB-Nalcor-46

¹⁸⁷ CA/KPL-Nalcor-127

¹⁸⁸ CA/KPL-Nalcor-236

According to Nalcor, whether the price in relation to the Muskrat Falls generating facility is based on a COS approach or a PPA, the CPW result for the Interconnected Option will be the same.¹⁸⁹ Nalcor stated that beyond 2067, pricing will be a policy decision for the Government at that time.¹⁹⁰

During MHI's presentation Mr. Kast stated:¹⁹¹

(Mr. Kast): My final comment in this area relates to the take or pay aspect of the PPA rate. The PPA rate is proposed to be fixed at the time of the signing of the PPA contract between Nalcor and Newfoundland Hydro based on, as I understand it, the then-current Newfoundland Hydro planning load forecast. The PPA contract will be a take or pay contract for a 50-year term. The minimum revenues from Newfoundland Hydro to Nalcor for any given year, as I understand, will be fixed by contract at that time of signing. On the other hand, if the volumes exceed those in the contract, the unit rate will be, for example, the \$75.82 per megawatt hour, of course, escalated."

MHI tested the use of a full COS approach for the Muskrat Falls generating facility costs. It found that the CPW cost of using a PPA approach was approximately \$70 million more than the cost of using the COS approach.¹⁹²

In a supplemental filing Ron Penney and David Vardy commented:¹⁹³

"The rates emerging from the interconnected option, based on PPA pricing, should not be compared with the rates estimated for the isolated Island option, which are based on traditional cost of service pricing. Particular care should be taken to inform the public that the projected rates, upon interconnection, are heavily influenced by a switching away from cost of service regulation in favour of PPA pricing, which brings lower rates in the early years which are intended to be offset in later years. The rates which ratepayers are required to pay in the early years do not cover the full costs. Another way of saying this is that ratepayers are subsidized in the early years or else that they pay only part of the actual cost and incur a liability for the shortfall. The Board needs to prepare a financial analysis which allows the rates to be compared with the same financial structure and the same cost of service pricing."

7.2.4.2 Operating Costs

The operating costs for new generation facilities are estimated by Nalcor based on experience for similar types of facilities where possible. Nalcor stated that:¹⁹⁴

"Non-fuel O&M costs for the resource projects are derived from feasibility studies and Hydro's extensive operating experience. These O&M costs are comprised of fixed expenditures related to asset maintenance and variable costs driven by production output."

¹⁸⁹ PUB-Nalcor-177

¹⁹⁰ Nalcor's Final Submission, pg. 29

¹⁹¹ Transcript, Feb. 15, 2012, pg. 156/4-19

¹⁹² MHI Report, Vol. 2, pg. 186; Vol. 1, pg. 84

¹⁹³ Ron Penney and David Vardy, Supplemental Filing, Feb. 29, 2012, pg. 3

¹⁹⁴ Nalcor Filing, July 6, 2011, pg. 8

Nalcor provided the operating costs for each option.¹⁹⁵ The operating costs are valued in 2010 base dollars and an escalation factor was applied for future operating and maintenance costs.

Although MHI could not verify the operating costs for the Interconnected Option it did note that Nalcor incorporated in the CPW analysis a constant annual operating cost from 2017 to 2025, and costs of vegetation management programs after that period. Fixed costs for periodic cable surveys for the Strait of Belle Isle crossing approximately every five years were also included. However, since MHI did not find any provision for capital maintenance of the converter transformers, it assumed costs of \$5 million for each of 14 converter transformers, distributed over years 20-30, leaving the Labrador-Island Link transmission line assets fully depreciated in 2067. The result was an increase in the CPW for the Interconnected Option from \$6,652 million to \$6,672 million. MHI found the difference, when discounted in the CPW calculation, is not material.

7.2.4.3 HVdc System Losses

Nalcor assumed HVdc system losses to be 5%. During Nalcor's presentation Paul Humphries addressed this issue:¹⁹⁶

(Mr. Humphries): ...if the losses were higher than were anticipated in the analysis, you are actually getting less energy from the line. So that has to be made up from another source...At periods when the link is operating at full capacity, the losses will be higher, but on an average, they will be closer to the 5 percent range than they are to the 10 percent overall average loss, based on the anticipated loadings of that line.

In relation to the likelihood that the transmission losses could be as high as 10% Mr. Humphries stated:¹⁹⁷

(Mr. Humphries): Close to 10 percent, yes, that could be if the line is at full peak load, but we have to realize that the line will not - when we look at Muskrat Falls, Muskrat Falls is an 824 megawatt facility with approximately 60 percent capacity factor. It is not possible for Muskrat Falls to load that line at 824 megawatts 24 hours a day, 365 days a year.

MHI believes that the transmission losses could be higher than 5% given information provided by Nalcor. MHI noted that an incremental increase of 5% to system losses may result in the addition of \$150 million to the CPW costs for the Interconnected Option.¹⁹⁸

7.2.4.4 Service Life Retirements

MHI reviewed the asset lives used by Nalcor, which are typical in the industry, and has determined that the assigned service lives are reasonable.¹⁹⁹ MHI noted that the typical process for comparing alternatives requires that all options have the same lifespan. In this case the timeline for the analysis matches the Labrador-Island Link transmission line and approximates

¹⁹⁵ MHI-Nalcor-1 (R1); Exhibit 99

¹⁹⁶ Transcript, Feb. 14, 2012, pg. 24/1-5/11-16

¹⁹⁷ Transcript, Feb. 14, 2012, pg. 26/17-24

¹⁹⁸ MHI Report, Vol. 2, pg. 206

¹⁹⁹ MHI Report, Vol. 2, pg. 198

that of the Muskrat Falls generating facility, and there are some assets whose full life-cycle benefits are not completely captured. The impact on the Interconnected Option is minimal, but for the Isolated Island Option there is a larger proportion of investment projects that are not fully depreciated by 2067. A compensating adjustment for this differential would likely increase the CPW differential between the two options.

7.2.4.5 Insurance

All property, other than transmission and distribution assets which are self-insured, is insured on a replacement-cost basis. According to Nalcor property insurance costs included in the CPW are based on the original in-service cost and, even though the replacement cost of a current capital expenditure would be an escalated amount with a corresponding escalated premium, the CPW assumes that the insurance expense is constant until the plant is retired. According to MHI this difference between fixed premiums and escalated premiums does not have a material effect on the final CPW analysis.

7.2.4.6 Fuel Inventory

MHI found that Nalcor did not include the carrying cost of fuel inventory in the calculation of the CPW of the two options. Its inclusion would affect the costs in the CPW analysis in years where the Holyrood Thermal Generating Station is no longer producing base load (after 2017) and then it would increase the gap between the CPW values of the two options.²⁰⁰ Steve Goudie of Nalcor stated that this cost is not a material cost in evaluating the CPW of the two options.²⁰¹

7.2.4.7 Board Comments

MHI generally found the inputs used by Nalcor in its CPW analysis to be appropriate. MHI did note some issues in relation to HVdc system losses which may impact the CPW analysis by increasing the costs associated with the Interconnected Option by \$150 million. MHI found that the CPW cost of using the power purchase agreement approach was approximately \$70 million.

The Board acknowledges the issues raised by some presenters in relation to the use of the power purchase agreement approach. The Board notes Nalcor's explanation that this approach ensures that the ratepayer is not overly burdened in the early years of such a large project where the full capacity may not initially be used. The Board also notes that the information provided in the review in relation to the power purchase agreement was for purposes of the review only and that the details of the arrangement are yet to be worked out with Hydro. It should be noted that the proposed take-or-pay aspect of this arrangement might pose some risks to Island Interconnected customers if there is a significant variance in load from forecast.

²⁰⁰ MHI Report, Vol. 2, pg. 197

²⁰¹ Transcript, Feb. 14, 2012, pg. 28/12-13

7.3 Cumulative Present Worth Analysis

7.3.1 Methodology

Nalcor explained that:

“Where the cost of one alternative supply future for the grid has a lower CPW than another, the option with the lower CPW will be recommended by Hydro, consistent with the provision of mandated least cost electricity service.”²⁰²

In comparing the two supply options Nalcor determined, using a variety of assumptions, that the CPW of the Isolated Island Option was \$8,810 million while the CPW of the Interconnected Option was \$6,652 million. Nalcor provided the following comparison of the generation expansion alternatives with the CPW per cost component of each of the two options:²⁰³

**Comparison of Generation Expansion Alternatives: CPW by Cost Component
(Present Value 2010\$, millions)**

CPW Component	Isolated Island	Interconnected Island	Difference
Operating and Maintenance	\$634	\$376	(\$258)
Fossil Fuels	\$6,048	\$1,170	(\$4,878)
Existing Power Purchases	\$743	\$676	(\$67)
Muskrat Falls Power Purchases	NA	\$2,682	\$2,682
Depreciation	\$553	\$450	(\$103)
Return On Rate Base	\$831	\$1,297	\$466
Total CPW	\$8,810	\$6,652	(\$2,158)

During Nalcor’s presentation Ed Martin stated:²⁰⁴

(Mr. Martin): Point number two is we’ve done some extensive analysis of the options and we’ve come up with a recommendation that Muskrat Falls and a Labrador-Island link is the best option, it’s the lowest cost option to meet this need over time by a number of 2.2 billion dollars, which is the cumulative present worth difference between the alternatives being considered. So this is not a trivial amount, obviously. There’s a 30 to 35 percent difference between the two options, and over time-as I mentioned, this is a present value number. Over time from a nominal perspective, this number will be even larger. So that’s the basic primary simple fact of the matter is that there’s a need and we have come up with a recommendation for the lowest cost option.

MHI completed a financial review of the cumulative present worth analysis used by Nalcor to select the least cost alternative and made the following key finding:²⁰⁵

“As a result of the investigations based on the material, data, and assumptions provided by Nalcor, MHI finds that the Infeed Option is the least-cost option of the two alternatives reviewed. There are, however, risks associated with the assumptions used for certain key inputs such as load, fuel prices and cost estimates which may impact the CPW analysis for the two options. The risks associated with these inputs are further magnified considering the length of the period (2010-2067) used in the preparation of the CPW analysis.”

²⁰² Nalcor Filing, July 6, 2011, pg. 4

²⁰³ Nalcor Submission, Nov. 10, 2011, Vol. 1, Table 28, pg. 124

²⁰⁴ Transcript, Feb. 13, 2012, pgs. 9/18-25; 10/1-9

²⁰⁵ MHI Report, Vol. 1, pg. 91

MHI explained that it reviewed all Nalcor exhibits and responses to requests for information that related to the calculation of the CPW, and that it assessed the specific details of the methodologies employed, both to evaluate the approach used and to look for possible mechanical or methodological errors.²⁰⁶ Paul Wilson explained how MHI approached the review of this project:²⁰⁷

(Mr. Wilson): For the financial perspective, financial review, we reviewed Nalcor's CPW methodology which has a number of elements in it, including capital and operating expenses. We reviewed the fuel price forecasts. MHI did an assessment on the allowance for funds used during construction as part of those estimates. We looked at the escalation rates, discount rates and the debt to equity component of those projects. We examined the power purchase agreements and we looked at the power purchase agreement, PPA, versus the cost of service methodology approach and their treatment for Muskrat Falls. In order to test the merits of the CPW results, we used a sensitivity analysis to determine what were the critical elements and the sensitivities to the CPW.

MHI determined that Nalcor's CPW analysis was completed using recognized best practices and the cumulative present worth for each option was correct based on the inputs used by Nalcor.²⁰⁸

7.3.2 Submissions and Comments

The Consumer Advocate stated that the assessment as to the cost of each option must be evidence based and that:²⁰⁹

"Consumers will ultimately bear the costs (rate) and service (reliability) risks associated with either of the options that are being presented for assessment. Both options realistically, are costly. Nalcor states that of these two options, the Muskrat Falls-Labrador Island Link Project is the least costly way forward, stating that it has a 2.2 billion (2010\$) dollar cumulative present worth(CPW) preference over the Isolated Island Option over the term of the life of the Muskrat Falls generating and Labrador Island link assets."

The Consumer Advocate agreed that MHI has undertaken an in-depth analysis and stated:²¹⁰

"The Consumer Advocate accepts MHI's determination that Nalcor's cumulative present worth analysis for the two Options was completed using recognized best practices and that the cumulative present worth for each option was correct based on the inputs used by Nalcor."

The Consumer Advocate accepts MHI's determination based upon its technical and financial analysis that the inputs used by Nalcor were generally found to be appropriate."

The Consumer Advocate further stated:²¹¹

"The Consumer Advocate agrees with MHI's finding that the Muskrat Falls Generating Station and the Labrador Island Link HVdc projects represent the least cost option of the two alternatives, when considered together with the underlying assumptions and inputs provided by Nalcor."

²⁰⁶ MHI Report, Vol. 2, pg. 207

²⁰⁷ Transcript, Feb. 15, 2012, pg. 111/5-21

²⁰⁸ MHI Report, Vol. 2, pg. 208,

²⁰⁹ Consumer Advocate's Submission, pg. 5

²¹⁰ Consumer Advocate's Submission, pg. 4

²¹¹ Consumer Advocate's Submission, pgs. 9-10

Several other presenters and submissions commented on the CPW analysis undertaken by Nalcor.

MA suggested that the magnified risks of a 57-year load forecast and the high margin of error of the cost estimates (Decision Gate 2, low quality, Class 4, feasibility level) are both critical factors and should be considered together. He concluded that the two options are in a statistical tie given that the Decision Gate 2 cost estimates are within each other's margin of error and suggests there are insufficient grounds on which the Board can reasonably, rationally and reliably conclude that the Interconnected Option is least-cost.

JM suggested the major advantage offered by the isolated alternative, the incremental outlay of capital expenditures, has not been included in the cumulative present worth analysis. He stated that with the Isolated Island Option we are not spending \$5 billion in 2017 and the Interconnected Option remains available should high oil prices develop.

The Industrial Customers stated:²¹²

"In the view of the current Island Industrial Customers, unduly delaying the choice between the Infeed Option and the Isolated Island Option, and in the interim proceeding with significant 'stop gap capital investments in Island generation capacity, is not the least cost option."

EC concluded that neither of the scenarios allows reasonable economic analysis of the Muskrat decision. He said that CPW is not the best or even a valid way of comparing these projects.

Robert Cadigan of the Newfoundland and Labrador Oil & Gas Industries Association (NOIA) stated that the Interconnected Option is the best alternative and provides the least-cost and most environmentally friendly solution to meet the energy needs of the province.²¹³

7.3.3 Board Comments

Nalcor determined in November of 2010, based on the available information at that time, that the Interconnected Option was the lowest cost option and that this development scenario should be advanced for detailed design and engineering work. MHI also determined based on the November 2010 Decision Gate 2 information provided by Nalcor and using Nalcor's assumptions that the Interconnected Option is the least-cost option, noting risks associated with the key input assumptions are magnified by the length of the period. MHI also found several notable gaps in Nalcor's work at that time which could have a significant impact on the capital cost estimates and therefore the CPW analysis.

The Board agrees with Nalcor and MHI that, using the available information from November 2010 and ignoring the gaps found by MHI, the Interconnected Option could be said to have a lower CPW based on analysis of feasibility level information. The Board does not believe, however, that this conclusion assists in determining whether this option is the least-cost option.

²¹² Island Industrial Customers, Letter of Comment, Feb. 29, 2012, pg. 2

²¹³ Transcript, Feb. 21, 2012, pg. 16/12-16

The CPW is calculated based on a series of inputs. To the extent that an input is incorrect, incomplete or out-of-date the CPW will not be an accurate reflection of the present value of the costs. In particular, certain key inputs have a very significant impact on the CPW analysis. Load is one of the key factors and, as already discussed, the Board has concerns as to Nalcor's load forecast. The fuel price forecast, another critical input, is subject to a great deal of volatility and is very difficult to forecast. The third significant input to the CPW analysis, capital costs, is particularly important in relation to the Interconnected Option. As discussed earlier, there are issues in relation to the degree of project definition and the range of accuracy of the capital cost estimates used in the CPW analysis. There are also notable gaps in Nalcor's information and processes which may impact the CPW analysis. The Board is of the view that the Decision Gate 2 CPW analysis does not form an adequate basis upon which to consider the two supply options as set out in the Terms of Reference, especially given the concerns in relation to Nalcor's load forecast and capital cost estimates.

7.4 Sensitivity Analysis and Risk Mitigation

7.4.1 Sensitivity and Risk Analysis

Nalcor explained that sensitivity analyses, where the key input values are increased or decreased to determine the impact on a reference case, provide useful information concerning the robustness of the analytical results and investment preference.²¹⁴ Nalcor stated that it has undertaken sensitivity analyses to stress test the preferred alternative.²¹⁵ During Nalcor's presentation Gilbert Bennett stated that he thinks it is important to explore the risks of the two expansion plans.²¹⁶ Mr. Bennett explained:²¹⁷

(Mr. Bennett): So, I think that, again, the importance and value of the sensitivity analysis is to give us a basis for further analysis and to highlight and identify the areas where we need to focus attention. That as a predictive tool, their usefulness is limited because we're dealing with our earlier analytical inputs. So, in terms of highlighting areas for focus, they're absolutely valuable. In terms of identifying the areas where we need to do more work and to further advance and define the numbers, they're extremely valuable, but the next step in this process will be to look at the numbers at a later stage, at Decision Gate 3, where you have further clarity on all the input information.

²¹⁴ Nalcor Submission, Nov. 10, 2012, Vol. 1, pgs. 124-125

²¹⁵ Nalcor's Final Submission, pg. 25

²¹⁶ Transcript, Feb. 13, 2012, pg. 46/9-11

²¹⁷ Transcript, Feb. 14, 2012, pg. 10/2-18

A summary of the sensitivity analysis conducted by Nalcor is set out below:²¹⁸

**Summary of CPW Sensitivity Analysis with Respect to Reference Case and Preference
(Present Value 2010\$, millions)**

	Isolated Island	Interconnected Island	Preference for Interconnected island
Reference Case	\$8,810	\$6,652	(\$2,158)
PIRA High World Oil Forecast	\$12,822	\$7,348	(\$5,474)
PIRA Low World Oil Forecast	\$6,221	\$6,100	(\$120)
PIRA May 2011 Update For Reference Oil Price Forecast	\$9,695	\$6,889	(\$2,806)
Moderate Conservation (375 GWh by 2031)	\$8,363	\$6,652	(\$1,711)
Aggressive Conservation (750 GWh by 2031)	\$7,935	\$6,652	(\$1,283)
Loss of 880 GWH 2013 Forward	\$6,625	\$6,217	(\$408)
Low Load Growth (50% of 2010 PLF post Vale)	\$7,308	\$6,618	(\$763)
200 MW Additional Wind (100 MW in 2025 and 100 MW in 2035)	\$8,369	\$6,652	(\$1,717)
MF and LIL Capital Cost +20% & Fuel Costs Reduced by 20%	\$7,600	\$7,217	(\$383)
MF and LIL Capital Cost +25%	\$8,810	\$7,627	(\$1,183)
MF and LIL Capital Cost +50%	\$8,810	\$8,616	(\$194)
Federal Loan Guarantee	\$8,810	\$6,052	(\$2,758)
Holyrood to 2041, then CF at Market Price	\$7,935*	\$6,652	(\$1,283)
Carbon Pricing on Fossil Fuel	\$9,324	\$6,669	(\$2,655)
CF Energy Post 2057 at Market Rates Instead of Cost	\$8,810	\$6,664	(\$2,146)
<ul style="list-style-type: none"> • The deferred CF alternative is not an Isolated Island alternative, however it has been included in this column for comparative purposes against the isolated Island reference case • PIRA High and Low World Oil Prices forecasts as of March 2010 			

Sources: (1) NLH, 2010 Expansion Plan Analysis, 2010 (Exhibit 43 – Rev .1)
 (2) Nalcor response to PUB-Nalcor-54
 (3) Nalcor response to PUB-Nalcor-118
 (4) Nalcor response to MHI-Nalcor-3

²¹⁸ Nalcor Submission, Nov. 10, 2011, Vol. 1, pg. 126, Revision 1, Nov. 30, 2011

Gilbert Bennett concluded that the sensitivity analysis completed by Nalcor indicates a preference for the Interconnected Option over a broad range of conditions and the Interconnected Option can be characterized as a robust alternative.²¹⁹ In relation to the risk related to capital cost Mr. Bennett explained:²²⁰

(Mr. Bennett): I think from my perspective, the sensitivity analysis has demonstrated a sensitivity on capital cost and then I think, you know, from our perspective, the steps to be taken would be to mitigate that exposure. So, you know, it comes back to all of the techniques and approaches that Mr. Harrington and Mr. Kean described yesterday in order to narrow in that range and to mitigate and diminish that sensitivity and that concern.

Nalcor noted that the price volatility of oil poses a significant risk to consumer electricity rates in the Isolated Island Option as fuel costs comprise 70% of the cost for the Isolated Island Option. Nalcor explained:²²¹

“Nalcor recognizes that future oil markets are uncertain. This uncertainty, which has been a cost characteristic of the Isolated Island grid for many years, continues to be the principle driver of electricity prices under the Isolated Island alternative. The probability of a low price future is seen as equally plausible as a high price future. Therefore, the use of a reference forecast from PIRA is reasonable.”

In addition, Nalcor pointed out that there are a number of contingencies not included in the analysis which would enhance the CPW of the Interconnected Option, such as the Federal loan guarantee and possible future carbon pricing on fossil fuels.²²²

MHI explained that, given the magnitude of the project and the length of the analysis period, there are risks and uncertainties associated with the key inputs and assumptions. Any changes in the key inputs and assumptions will affect the financial results, must be assessed for materiality, and can impact the results of the analysis, even to the point of shifting the preference for what is the least cost option.²²³ MHI reviewed the risk analysis components of all reports and studies including the “Technical Note – Strategic Risk Analysis and Mitigation” which was filed by Nalcor on a confidential basis.²²⁴ MHI detailed the risks associated with the assumptions used for certain key inputs such as load, fuel prices and cost estimates which may impact the cumulative present worth analysis for the two options.²²⁵

²¹⁹ Transcript, Feb. 14, 2012, pg. 230/14-25

²²⁰ Transcript, Feb. 14, 2012, pg. 8/14-24

²²¹ Nalcor’s Final Submission, pg. 22

²²² Nalcor’s Final Submission, pg. 26

²²³ MHI Report, Vol. 2, pg. 206

²²⁴ MHI Report, Vol. 1, pg. 36

²²⁵ MHI Report, Vol. 2, pgs. 208-209

MHI reviewed the various sensitivity analyses provided by Nalcor and conducted additional analyses. The following table sets out certain of the sensitivities reviewed:²²⁶

CPW Sensitivity Analysis Summary

	Sensitivity Summary	Isolated Island Option	Infeed Option	Difference
1	Base case	\$8,810	\$6,652	\$2,158
2	Annual load decreased by 880 GWh	\$6,625	\$6,217	\$408
3	Fuel costs: PIRA's low price forecast	\$6,221	\$6,100	\$120
4	Fuel price reduced by 44% from base case	\$6,134	\$6,134	\$0
5	Labrador-Island Link capital cost increased by 25%	\$8,810	\$7,050	\$1,760
6	Muskrat Falls GS capital cost increased by 25%	\$8,810	\$7,229	\$1,581
7	Muskrat Falls GS and Labrador-Island HVdc Link capital cost increase by 25%	\$8,810	\$7,627	\$1,183
8	Labrador-Island HVdc Link and Muskrat Falls capital cost increased by 50%	\$8,810	\$8,616	\$194
9	Scenario with <ul style="list-style-type: none"> • Fuel cost decreased 20% • Annual load growth decreased of 20% • Capital cost increased for Muskrat Falls GS and Labrador-Island HVdc Link by 20% 	\$7,037	\$6,878	\$159
10	Scenario with <ul style="list-style-type: none"> • Annual load decreased by 880 GWh • Muskrat falls GS and Labrador-Island HVdc Link Capital cost increased by 10% 	\$6,625	\$6,598	\$27

Sources:

- Scenarios 1,2,3,4,5,6,7: Response to RFI MHI-Nalcor-41 Revision 1 and EX-43 Rev.1
- Scenario 8: Response to RFI PUB-Nalcor-118
- Scenario 9: Response to RFI PUB-Nalcor-56
- Scenario 10: MHI derived

These sensitivity analyses suggest that fuel costs would have to be 44% lower than forecast, which would be similar to the PIRA low forecast, to reduce the CPW preference to zero, whereas the PIRA high forecast would increase the CPW preference for the Interconnected Option to \$5,474 million. The use of the May 2011 updated forecast in place of the January 2010 forecast (used for Decision Gate 2 analysis) increases the CPW difference to \$2,806 million as compared to \$2,158 million.²²⁷ MHI found that the CPW analysis is not particularly sensitive to the choice of the annual escalation factor applied to the base fuel prices beyond 2025 because the escalation is so far into the future that the discounting minimizes the impact.²²⁸

²²⁶ MHI Report, Vol. 2, pg. 207

²²⁷ MHI Report, Vol. 2, pg. 208; Nalcor's Final Submission, pg. 25; Undertaking # 1

²²⁸ MHI Report, Vol. 2, pg. 204

In addition to assessing the sensitivity of changing a single input MHI completed an analysis of the sensitivity of changes to multiple inputs. During MHI's presentation Mr. Kast talked about combined sensitivities.²²⁹

(Mr. Kast): So up to this point I've only talked about sensitivity impacts from a single focused perspective. We can all appreciate that changing only one variable by holding all others constant is probably not that realistic, so let's take a look at the impact of a couple of examples related to combined sensitivities. The changes to the risk areas acting in unison could have a major impact on shifting the CPW differential. The first example: Assume the fuel cost decreased by 20 percent, the load growth decreases by 20 percent and capital costs for Muskrat Falls and LIL increase by 20 percent, in which case the CPW is essentially reduced to a minimal differential. Well, 100 million differential, but still in favour of the Infeed option.

In Example two, if we have a pulp and paper mill closure and capital costs of Muskrat Falls and LIL increase by 10 percent, the CPW is essentially reduced again to a minimal differential. This table provides a summary of the various sensitivity reviews. The scenarios are illustrated in order of diminishing differential. I spoke to the first nine items, I believe, up to this point and the tenth item that's in this table relates to how much would fuel prices have to decrease for the differential to be zero and the answer is 44 percent in this case.

The Consumer Advocate commented in relation to risk:²³⁰

"No one can predict the future so as to be able to state definitively that one of these options will have a lower cost in the long run than the other. In other words, there is risk involved in making that assessment. There is a risk that forecast oil prices may be either lower or higher than posited by Nalcor and its advisors in their Submission. There is a risk that the Muskrat Falls generation and Labrador Island Link project could be subject to cost overruns which could reduce or eliminate the preference for that option. There is a risk that the assumptions made by Nalcor for load growth over the very long period out to 2067, could be too high, or alternatively, too low thereby either reducing or increasing the preference of the Interconnected Option over the Isolated Island Option. Consumers in the Province therefore have a vital interest in ensuring that the forecasts and various costs assumptions have been developed using sound methodologies applicable to the circumstances. Put simply, consumers need to know that the forecasts and assumptions relied upon by Nalcor are reasonable."

The Consumer Advocate accepted MHI's judgement that Nalcor's inputs were developed in accordance with utility best practices.

JM commented on the risks associated with the inputs in the CPW analysis stating:

"The substantial financial risk of the LCP if the market is not there does not appear to factor into the CPW analysis. The risk of the upfront CAPEX commitment prior to the demand realization should be factored within the CPW. The risk for low demand should not be a sensitivity case, but should be included as a contingency line in the base case CPW analysis."

²²⁹ Transcript, Feb. 15, 2012, pgs. 159/20-24; 160/1-24

²³⁰ Consumer Advocate's Submission, pg. 6

The Industrial Customers stated:²³¹

“The current Island Industrial Customers accept that the postponement of the choice between the Infeed Option and the Island Isolated Option is not likely to significantly reduce, over the mid-and-long terms, the risks raised by the inherent uncertainty of oil price and load forecasts and regarding future greenhouse gas emissions regulation. It appears to the current Island Industrial Customers that the Manitoba Hydro International (MHI) report confirms that when subjected to various sensitivity tests in relation to oil price and load forecasts (and the risk of project cost overruns), the Infeed Option continues to maintain a margin of preference over the Isolated Island Option as least cost generation over the Review period of 2010-2067.”

Dr. James Feehan suggested that the Interconnected Option will reverse the trend of declining provincial debt and may risk the province’s improved credit rating and suggests that the Isolated Island Option offers an opportunity to avoid the risk associated with a single large capital-intensive and irreversible investment.

GP noted concerns in relation to the price and large debt that comes with it, cost overruns, the possibility of decreased consumption with rate increases, the downward pressure on rates elsewhere and the possibility of a combination of other supply alternatives and wonders if the province could find some incremental power cheaper than Muskrat Falls.

EC said that the incremental approach seems to have governmental rather than economic obstacles.

In his presentation Cabot Martin discussed the risks in relation to the two options:²³²

(Mr. Martin): The essence of the risk in the thermal option, you know, it’s been stated that the greatest risk to the Isolated Island case is unstable and possibly rising oil prices, but due to the oil price hedge that I’ve tried to describe in the previous two slides, three slides actually, there should be little, if any, actual oil price risk. If we do have high oil prices, we will also have high oil revenues and a provincial government with an ability to pay direct payments to the citizens who need assistance due to any high oil prices.

Turning to the risk at the Muskrat Falls. First point, I think, just as a point of clarification, I think it is fair to say that the 50 to 30 percent variation that we’ve heard about associated with the class four or DG2 cost projection does not measure the cost risks associated with the Muskrat Falls Project. That spread is merely a reflection of how preliminary the DG2 cost projections are. If a DG3 cost analysis and budget is approved and sanctioned by the province, then the true cost overruns from the sanction budget start to accumulate from that date. I would say that the largest true risk in the Churchill Falls case or the Muskrat Falls case is cost overruns and cost overruns on such large projects typically arise from changes during construction, including design changes, and owner’s inexperience in managing contractors.

Ron Penney and David Vardy stated that, in a project of this magnitude, there is great potential for large cost increases and raised the possibility of sharing the risk through the use of the Lower Churchill Development Corporation, a joint federal/provincial body.²³³ David Vardy stated:²³⁴

²³¹ Island Industrial Customers, Letter of Comment, Feb.29, 2012, pg. 2

²³² Transcript, Feb. 20, 2012, pgs. 5/6-25; 6/1-13

²³³ Transcript, Feb. 20, 2012, pgs. 41/17-19; 42/5-10

²³⁴ Transcript, Feb. 20, 2012, pgs. 45/25; 46/1-25

(Mr. Vardy): The mitigation of risk is a key issue to be addressed in this hearing. There is risk associated with all options, not just one. Some of the risks are controllable; some are not. Some can be anticipated and known; others are unknown. We can never be assured that all risks have been identified and minimized. However, we must attempt to ensure that system planning takes all risk factors into account. We believe that in a project of this magnitude, all available expertise and information should be mobilized. The major risks as we have identified them are as follows; capital cost overruns, volatile oil and gas prices, over-estimation of load growth, under-estimation of load growth from emerging new industrial users of electricity, volatile electricity prices in potential export markets for electricity produced in Newfoundland and Labrador, changes in demography which may impact upon load growth, decline in family formation and new home construction, and changes in the usage of electricity, and finally, physical risks such as storms and icebergs scouring on the Strait of Belle Isle.

Mr. Vardy further stated:²³⁵

(Mr. Vardy): The isolated island alternative contains a series of smaller projects which allow Newfoundland Hydro to move forward and supply power, maintain system reliability, and thereby provide ample time to mitigate the risk associated with Muskrat Falls and to explore other options. The Muskrat Falls Project is of such a scale and nature that once a decision has been made, there is no turning back. We cannot make piecemeal adjustments. The cost of Muskrat Falls is all up front and inescapable.

Our recommendation is that Government take short to medium term energy decisions which will allow sufficient time for the province to complete its due diligence on Muskrat Falls.

Yvonne Jones, M.H.A. raised risks associated with oil price projections and capital costs.²³⁶

Philip Raphals suggested that the real challenge is to find a plan that is optimal, not just based on current assumptions, but that is robust over a broad range of possible futures.²³⁷

7.4.2 Risk Mitigation

During Nalcor's presentation Ed Martin stated in relation to the issue of risk²³⁸:

(Mr. Martin): On the flip side of that, the obvious question is are there risks associated with this decision, and absolutely there are risks associated with this decision, there's no question about that. There's risk associated with any decision naturally.

Nalcor stated that it believes that early risk planning is a key factor in increasing predictability and that it has taken extensive steps to ensure best practice for risk planning. Nalcor stated that it has extensively used risk-informed decision making techniques to facilitate decision quality assurance for all aspects of business case evaluation and project planning. Nalcor engaged the Westney Consulting Group to assist with the implementation of a holistic risk management program and a Risk Resolution Team was formed in 2007 to determine the optimal resolution strategy for the identified risks.²³⁹ The Westney's Risk Resolution methodology has been adopted by Nalcor as the backbone of its risk management process for the Project.²⁴⁰ Nalcor filed a document, "Strategic Risk Management and Mitigation Progress at Decision Gate 2",

²³⁵ Transcript, Feb. 20, 2012, pgs. 47/21-25; 48/1-12

²³⁶ Transcript, Feb. 21, 2012, pgs. 81/1-25; 86/2-21

²³⁷ Transcript, Feb. 23, 2012, pg. 18/5-8

²³⁸ Transcript, Feb. 13, 2012, pg. 20/10-15

²³⁹ Nalcor Submission, Nov. 10, 2011, Vol. 2, pgs. 64-68

²⁴⁰ Nalcor's Final Submission, pg. 35

setting out a detailed evaluation in relation to the risks of the Interconnected Option for the review of the Board and MHI on a confidential basis.²⁴¹

Nalcor explained that:²⁴²

“Nalcor has directed considerable effort over the past five years on activities that have a direct influence on capital predictability and ensure the company’s cost and schedule expectations are realistic and achievable. An extended focus on front-end loading and defining the project during the planning phase (pre-DG3) is also key to addressing potential risks and avoiding cost overruns. The process provides the critical information needed to make decisions towards project sanction (DG3).”

Nalcor noted that its efforts in relation to risk were validated by a review by Independent Project Analysis which found that the project was better prepared than a typical megaproject. According to Nalcor the two options have different risk profiles, with the Isolated Island Option facing risks which are primarily external and impossible to control and the Interconnected Option facing risks which are internal and which Nalcor, through its practices and processes, can manage, mitigate or otherwise control. Nalcor noted that the risk exposure window of the Interconnected Option is approximately six years and has an increased predictive accuracy. Nalcor stated:²⁴³

“There are cost escalation risks inherent in both the Isolated Island and the Interconnected Island alternatives. Unlike the Isolated Island, in the Interconnected alternative, risks are primarily internal and therefore can be managed and mitigated through project management practices and the Decision Gate (DG) process.

Muskrat Falls, while an intensive capital project, is well understood and extensively studied. Nalcor has invested in the best project processes, practices and people to manage and mitigate risks to consumers. By Decision Gate 3, the accuracy of the Project’s cost estimate will be at the narrow range according to the Association for the Advancement of Cost Engineering International (AACEI) standard.”

During Nalcor’s presentation Ed Martin said:

(Mr. Martin): You can never get rid of all the risk, but we can certainly identify, work on it, and have some ability to control and mitigate that risk. If you look at the fuel cost risk, we essentially have no control over that particular risk. It’s a globally driven commodity.²⁴⁴

The specific efforts that Nalcor has taken to mitigate risks for project execution were discussed at length by Ed Martin, Gilbert Bennett and Paul Harrington during Nalcor’s presentation. These include: putting in place an experienced team; the engagement of an experienced international engineering, procurement and construction management contractor; use of proven project execution approaches and practices, the most important being front end loading; and the adoption of proven technologies.²⁴⁵ Jason Kean explained that he believes that labour and labour

²⁴¹ Exhibit CE-52 Rev. 1 (Public)

²⁴² Nalcor’s Final Submission, pg. 34

²⁴³ Nalcor’s Final Submission, pg. 8

²⁴⁴ Transcript, Feb. 13, 2012, pg. 21/17-23

²⁴⁵ Transcript, Feb. 13, 2012, pgs. 54/9-25; 55/1-21

productivity are the most significant aspects in relation to risk. To address this risk Nalcor engaged a consultant in 2008 to develop a productivity action plan.²⁴⁶ Paul Harrington explained that, with respect to labor, Nalcor identified demand at Decision Gate 2 and did a survey of all special project agreements that have been put in place across Canada with a view to adopting a positive and constructive labour agreement strategy, worked with educational and governmental agencies to address the training gap and to avail of the untapped workforce, and worked to ensure a good work site with an attractive camp and decent working rotation.²⁴⁷ In relation to the capital cost risk Paul Harrington described the favorable construction characteristics of Muskrat Falls which results in robust conventional designs for all structures, no underground or diversion tunnels, and the use of conventional proven equipment.²⁴⁸

7.4.3 Board Comments

Risk is a factor in every generation planning decision and, in the current context, it is magnified given the large scale of the contemplated generation addition, the costs and the timeframe involved. It was clear during the review that there is a high level of concern regarding the risks associated with the decision to be made in relation to the two supply options. In particular concerns were expressed about the risks of large capital projects, the potential for significant cost overruns, and the risks associated with forecasting the price of fuel and load over the length of the study period. Nalcor acknowledged these risks and provided considerable information on the steps it has taken to manage these risks. Nalcor was able to demonstrate during the review that it had undertaken a comprehensive assessment of the risks associated with the Interconnected Option and that it is putting the necessary steps and processes in place to mitigate these risks. As expected, Nalcor's risk mitigation strategy is focused on those risks it can manage. For the Interconnected Option these risks are associated primarily with the capital costs, which can be mitigated to some extent by ensuring best practices in project design, execution and management.

Nalcor also carried out sensitivity analyses to identify areas of significant costs and assess impacts. The sensitivity testing demonstrates that there are significant risks in relation to forecasts of load and fuel prices and capital cost estimates. The preference for the Interconnected Option is virtually eliminated if either:

- Fuel costs are 44% lower than forecast (which would be close to the PIRA low forecast);
- Capital cost estimates for the Interconnected Option are 50% higher than estimated, (which is within the accuracy range used by Nalcor for Decision Gate 2); or
- Capital costs are increased by 10% and forecast Island load is reduced by 880 GWh (which is approximately equivalent to the loss of the Corner Brook Pulp and Paper load).

Any combination of these scenarios could shift the decision preference to the Isolated Island Option.

²⁴⁶ Transcript, Feb. 13, 2012, pg. 138/22-25

²⁴⁷ Transcript, Feb. 13, 2012, pgs. 132/5-24; 133/1-5; 15-25; 134/1-25; 135/1-7

²⁴⁸ Transcript, Feb. 13, 2012, pgs. 209-210

8.0 NALCOR'S ONGOING WORK

As discussed earlier in this report, Nalcor has adopted a decision gate process for the planning for the Interconnected Option. The information provided by Nalcor for this Reference, which was reviewed by MHI, was generally as of November 2010 and was used to support its decision to approve a development scenario and to commence detailed design.²⁴⁹ Significant work has been ongoing since then which will result in an updated project definition and capital cost estimate for the Interconnected Option to be used as the basis for decision at project sanction at Decision Gate 3. Nalcor has advised that Decision Gate 3 is now anticipated to occur in June 2012.²⁵⁰

Nalcor has determined that the capital cost estimate for the Interconnected Option at Decision Gate 3 will be commensurate with an AACE Class 3 estimate which has an accuracy range of +30% to -20%²⁵¹ and is associated with a project definition of 10% to 40%.²⁵² Nalcor determined, as discussed earlier, that the project definition for the Interconnected Option at Decision Gate 2 was 5% to 10% and the capital cost estimate at that time was within the AACE Class 4 accuracy range of +50% to -30%.

With respect to Decision Gate 3 Jason Kean of Nalcor stated that the work would provide:²⁵³

“...a level of confidence that we have fully understood the characteristics of the plant, how it will be built and how it can be delivered on time and on budget, and of course, maintain Nalcor’s target safety excellence.”

In its Final Submission Nalcor stated:²⁵⁴

“At DG3, project definition will be well advanced and the project cost estimate will include firm contract costs from suppliers and contractors. This, in combination with the advanced engineering and field work, favourable site conditions and a clear understanding and respect of the risks that remain will enable accurate project outturn cost predictability. The degree of project definition at DG3 will place the accuracy of the capital cost estimate within the AACE Class 3 range, closer to the narrower range of accuracy according to that standard.”

Jason Kean explained that the narrower range of accuracy for an AACE Class 3 cost estimate is $\pm 10\%$.²⁵⁵

Nalcor acknowledged that there could be significant changes in the inputs used at Decision Gate 2 and those at Decision Gate 3.²⁵⁶

²⁴⁹ Nalcor Submission, Nov. 10, 2011, Vol. 2, pg. 35

²⁵⁰ Transcript, Feb. 14, 2012, pg. 60/17-22

²⁵¹ MHI Report, Vol. 1, pg. 34; Transcript, Feb. 14, 2012, pg. 58/3-7

²⁵² Transcript, Feb. 13, 2012, pg. 97/1-8; Exhibit 31, pg. 6

²⁵³ Transcript, Feb. 13, 2012, pg. 99/19-25

²⁵⁴ Nalcor’s Final Submission, pg. 32

²⁵⁵ Transcript, Feb. 14, 2012, pg. 58/3-7

²⁵⁶ Transcript, Feb. 13, 2012, pgs. 106/9-25; 107/22-25; 108/1/10

Nalcor explained how, as part of the Decision Gate 3 process, the engineering, procurement and construction management contract was awarded to SNC-Lavalin which now has 220 people working on the project, while Nalcor has 130.²⁵⁷ Detailed engineering work on all aspects of the Interconnected Option has been ongoing since Decision Gate 2 in November 2010 as has financial, legal and environmental work. Nalcor reported that \$82.8 million was spent from Decision Gate 2 (November, 2010) to December 31, 2011, with a forecast of \$12-15 million per month from January 2012 to Decision Gate 3.²⁵⁸ The total value of all contracts and work packages prepared to date since Decision Gate 2 is in excess of \$900 million.²⁵⁹

Additional items which Nalcor confirmed would have to be updated by June 2012 for Decision Gate 3 include:

- (1) load forecast and generation expansion plan;²⁶⁰
- (2) all inputs for the CPW analysis, including capital costs, interest rates, discount rates and foreign exchange rates;²⁶¹
- (3) risk analysis and mitigation strategies;²⁶²
- (4) fuel forecast;²⁶³ and
- (5) system integration studies.²⁶⁴

Nalcor's position is that all these activities will be complete by June 2012 allowing a Decision Gate 3 decision at that time and that the updated information will be based on a better definition of the project and a higher degree of accuracy in the cost estimate.²⁶⁵ Nalcor stated that finalization of the agreement on the Federal loan guarantee and the agreement with Emera were not necessary pre-requisites for Decision Gate 3 approval.²⁶⁶

In his presentation Cabot Martin pointed out that the information at Decision Gate 2 was only a Class 4 (Feasibility) Level and that Nalcor had to defer answering many questions at the hearing until more accurate Decision Gate 3 studies were done. He went on to say that the Board should adjourn until the Decision Gate 3 information was available.²⁶⁷ In his supplemental filing Mr. Martin again raised this issue and stated there was a high probability of large cost adjustments between Decision Gate 2 and Decision Gate 3 stages due to design and other engineering changes. He re-iterated his recommendation that the Board should adjourn until it received updated Decision Gate 3 information.²⁶⁸

²⁵⁷ Transcript, Feb. 13, 2012, pgs. 54/17-21; 96/14-17

²⁵⁸ PUB-Nalcor-178

²⁵⁹ Undertaking # 7

²⁶⁰ Transcript, Feb. 14, 2012, pg. 72/12-24

²⁶¹ Transcript, Feb. 14, 2012, pg. 73/1-14

²⁶² Transcript, Feb. 14, 2012, pgs. 74/5-25; 75/1-12

²⁶³ Transcript, Feb. 13, 2012, pgs. 107/22-25; 108/1-10

²⁶⁴ PUB-Nalcor-143

²⁶⁵ Transcript, Feb. 14, 2012, pg. 81

²⁶⁶ Transcript, Feb. 14, 2012, pgs. 71-72

²⁶⁷ Transcript, Feb. 20, 2012, pgs. 14/1-25; 15/1-4

²⁶⁸ Cabot Martin, Supplemental Filing, Feb. 29, 2012, pg. 2

Ron Penney and David Vardy also raised this issue and pointed out that the capital cost information reviewed by MHI was more than a year out of date and had the potential for overruns of 50%.²⁶⁹ In their supplemental filing they stated that the Board should have more definitive capital cost estimates than the Class 4 estimates that were provided by Nalcor. They stated that the Board cannot/should not provide recommendations on which is the least-cost option based on Class 4 estimates but should have access to Class 3 estimates.²⁷⁰

The Industrial Customers stated:²⁷¹

“In the view of the current Island Industrial Customers there remains the opportunity, prior to making the decision to sanction (Decision Gate or DG3) the Infeed Option, to address certain areas of concern raised by MHI in its report...

The current Island Industrial Customers, on review of the MHI report and of the transcripts of the presentations to the Board are left with the view that these areas of concern could and should all be further addressed before DG3, in a transparent and accountable manner.”

²⁶⁹ Transcript, Feb. 20, 2012, pg. 51/5-18

²⁷⁰ Ron Penney and David Vardy, Supplemental Filing, Feb. 29, 2012, pg. 1

²⁷¹ Island Industrial Customers, Letter of Comment, Feb. 29, 2012; pgs. 2-3

9.0 CONCLUSIONS ON THE REFERENCE QUESTION

The Board was directed by Government to review and report on whether the Interconnected Option represents the least-cost option for the supply of power to Island Interconnected customers over the period of 2011-2067, as compared to the Isolated Island Option.

Nalcor submits that the Interconnected Option is the least-cost alternative based on its Decision Gate 2 analysis and the information generally available in November 2010. Based on this information MHI confirmed the preference for the Interconnected Option, accepting Nalcor's inputs and assumptions and noting certain gaps and risks. The Decision Gate 2 information provided in the review was a feasibility level of information which was used by Nalcor to select a development scenario to proceed to detailed design. While Nalcor explained that significant design and engineering work for the Interconnected Option has been completed since this time and is ongoing as it progresses towards Decision Gate 3, updated information in relation to this work was not made available to the Board during the review.

The degree of project definition associated with Nalcor's Decision Gate 2 analysis was 5% to 10% for the Interconnected Option and even less so for the Isolated Island Option. This high level, conceptual understanding of the project components is associated with a very wide range of accuracy for the estimated capital costs. Nalcor advised that the estimated capital costs could be 50% higher or 30% lower than the amount included in its Decision Gate 2 analysis. MHI reviewed the estimated component costs included in Nalcor's analysis and found that most were within this accuracy range, although certain estimates in relation to the Labrador-Island Link transmission line were found to be at the low end of the range. This finding reflects the level of uncertainty associated with the feasibility stage of the project planning process, which provides for changes in project scope and costs as detailed design progresses.

MHI also identified several gaps in the information and analysis that should have been part of Nalcor's Decision Gate 2 process, including the failure to complete ac integration studies and comprehensive probabilistic reliability studies, the use of a design return period for the HVdc overland transmission line which is not in accordance with accepted standards and best practice, and uncertainty as to compliance with NERC. MHI also noted a lack of detail in the information provided in relation to the converter stations and the HVdc overland transmission line design. These issues have the potential to significantly impact the project definition and costs for the Interconnected Option.

As required by the Terms of Reference the Board also considered Hydro's and Nalcor's forecast and assumptions for the Island load. The Board questions whether this load forecast should be relied on in answering the Reference Question. The load forecast used by Nalcor is two years old and was not updated during the review. In relation to the domestic load, MHI noted an inherent bias in the model and that best utility practice was not followed in the absence of end-use modeling. In addition there is significant uncertainty in relation to the industrial load forecast, with potential for both new customers and the departure of existing customers.

The load forecast provided by Nalcor shows a gradual increase in load but does not demonstrate an immediate need for the significant amount of new generation contemplated in the Interconnected Option. Assuming no monetization of excess power, as was required by the Terms of Reference, the potential supply associated with the Interconnected Option, is much greater than the forecast load. The preference for the Interconnected Option, which contemplates a significant amount of available excess power, would appear to be the result of forecasted fuel savings associated with the closing of the Holyrood Thermal Generating Station.

The risk of capital cost overruns and the uncertainties around load and fuel forecasts for a planning period of over 50 years were concerns during the review. The Board acknowledges that these risks are an accepted part of any generation planning decision which contemplates the addition of a large new supply. Nalcor and MHI conducted sensitivity analyses which showed that the CPW results are significantly affected by changes in assumptions for fuel prices, load and capital costs. For example, each of the following scenarios would effectively eliminate the CPW preference for the Interconnected Option: i) increasing the capital costs of the Interconnected Option by 50%; or ii) decreasing load by 880 GWh with a 10% increase in capital costs; or iii) reducing the fuel price forecast by 44%. This demonstrates the significance of the issues noted in relation to the capital cost estimates and load forecasts and also highlights the risks associated with forecasting fuel prices over such a long period. The Board notes that one of the ways that these risks can be mitigated is to ensure that the best available information is considered in the generation planning process.

Nalcor advised that it has been working intensely since Decision Gate 2 in November 2010 and expects that, by June 2012, it will have an updated load forecast and generation expansion plan, a completed CPW analysis with updated inputs including fuel forecasts and better defined capital costs, as well as system integration studies. According to Nalcor, at Decision Gate 3 the degree of project definition could be as high as 40% and the accuracy range of the capital cost estimates could be as narrow as $\pm 10\%$. In the Board's view the time to answer a least-cost question is not at Decision Gate 2, but further along in the decision-making process when there is a higher degree of project definition and significantly less variance around the estimated capital costs. As discussed above, it appears there is no urgent need to proceed in advance of a full review of this information, though there may be other factors outside the scope of this review which may influence decision timing.

In conclusion, the information which was made available during the review was considerably less detailed and comprehensive than the information that Nalcor has today and will have at Decision Gate 3. As Nalcor explained, there can be significant changes as a project proceeds through the planning process and, further, that proceeding through Decision Gate 2 does not ensure that the project will be sanctioned. Nalcor decided in November 2010 at Decision Gate 2 to move to the next phase in the planning process and commence detailed design. The Board was not asked to determine whether this decision was correct. Rather, the Board was asked to determine whether the Interconnected Option represents the least-cost option for the supply of power to Island Interconnected customers. The Board does not believe that it is possible to make a least-cost determination on the Interconnected Option based on a feasibility level of information generally from November 2010 which was intended to ground a decision to move to the next phase of the generation planning process, especially given that so much additional work has already been done to better define the project and costs and further eliminate uncertainties.

The information provided by Nalcor in the review is not detailed, complete or current enough to allow the Board to determine whether the Interconnected Option represents the least-cost option for the supply of power to Island Interconnected customers over the period of 2011-2067, as compared to the Isolated Island Option.

PART THREE – OTHER CONSIDERATIONS

10.0 ADDITIONAL ISSUES RAISED BY MHI

10.1 Labrador-Island HVdc Transmission Line Design Criteria

Transmission line reliability-based design criteria is typically defined in terms of a return period load. The return period is a statistical average of occurrence of a climatic event that has a defined intensity (ice and/or wind). It is often described in terms of years, for example, a one in 50-year (1:50) event will occur on average every 50 years.²⁷²

CAN/CSA C22.3 No. 60826:06, Design Criteria of Overhead Transmission Lines, covers a reliability based method for line design and has been approved as a National Standard of Canada. Section A.1.2.5, page 125 of the Standard states in part:²⁷³

“A.1.2.5 Selection of Reliability Levels

Transmission lines are typically designed for different reliability levels (or classes) depending on local conditions, requirements and the line duties within a supply network.

Designers can choose their reliability levels either by calibration with existing lines that have had a long history of satisfactory performance or by optimization methods found in technical literature.

In all cases, lines should at least meet the requirements of a reliability level characterized by a return period of loads of 50 years (level 1). An increase in reliability above this level could be justified for more important lines of the network as indicated by the following guidelines:

It is suggested to use a reliability level characterized by return periods of 150 years for lines above 230 kV. The same is suggested for lines below 230 kV which constitute the principal or perhaps the only source of supply to a particular electric load (level 2).

Finally, it is suggested to use a reliability level characterized by return periods of 500 years for lines, mainly above 230 kV which constitute the principal or perhaps the only source of supply to a particular electric load. Their failure would have serious consequences to the power supply.”

Within a specified return period, e.g. 1:50 years, the actual design loading may vary considerably for various sections of the line. This is dependent on the analysis of meteorological data and subsequent loading determination (ice and/or wind) for each line section. This is particularly relevant for long transmission lines such as the Labrador-Island HVdc overland transmission line.

Based upon the results of its transmission reliability analysis Nalcor selected a 1:50 year return period as the design basis for the Labrador-Island HVdc overland transmission line with or without the Maritime Link.²⁷⁴

²⁷² Nalcor Exhibit 106, pg. 8

²⁷³ MHI Report, Vol. 2, pgs. 118-119

²⁷⁴ Nalcor Submission, Nov. 10, 2011, Vol. 1, pg. 136

MHI found that Nalcor's proposed transmission line design criteria was inadequate and did not comply with industry standards and practices. Its key finding with respect to the transmission line design criteria used by Nalcor is:²⁷⁵

“Nalcor has selected a 1:50 year reliability return period (basis for design loading criteria) for the HVdc transmission line, which is inconsistent with the 1:500-year reliability return period outlined in the International Standard CEI/IEC 60826:2003 with Canadian deviations in CSA Standard CAN/CSA-C22.3 No. 60826:06, for this class of transmission line without an alternate supply. In the case where an alternate supply is available, the 1:150-year reliability return period is acceptable. In this latter scenario, Nalcor should also give consideration to an even higher reliability return period in the remote alpine regions. MHI considers this a major issue and strongly recommends that Nalcor adhere to these criteria for the HVdc transmission line design. The additional cost to build the line to a 1:150 year return period is approximately \$150 million.”

MHI agreed with Nalcor's adoption of the IEC Standard and CSA Code for the transmission line design criteria, particularly in view of the extensive meteorological data related to the HVdc transmission line that has been collected since the 1970's. According to MHI this information is essential when designing with reliability-based methods for new transmission lines. However, MHI did not agree that Nalcor was properly applying the standard. MHI stated:²⁷⁶

“Considering the directions given in the IEC Standard, the voltage level of the Labrador-Island Link HVdc transmission line, the importance of this HVdc transmission line, and the local historical data gathered by Nalcor during the investigation of the Avalon Peninsula upgrade project, at a minimum the ±320kV HVdc line should be designed to a return period of 1:150 years when an alternate supply is available. Nalcor should also give consideration to an even higher reliability level return period in the remote alpine region. MHI recommends that the HVdc transmission line be designed to a 1:500-year return period for the Island power system without an alternate supply. MHI considers this a major issue and recommends that Nalcor adhere to these criteria laid out in the IEC Standard for the HVdc transmission line design. Design for less than 1:150 year return period is contrary to best practices carried out by utilities in Canada, and does not reflect current industry practices which follow IEC 60826:2003.”

MHI provided examples of the design periods chosen by other Canadian utilities for new transmission lines. Manitoba Hydro has chosen a 1:150 year return period for its new Bipole 3 and Alta Link is using 1:100 with a 100% safety factor which equates to a higher return period than 1:100.²⁷⁷ During the review it was also stated that Hydro Quebec, when rebuilding its transmission lines after the 1998 ice storm, used a return period of 1:500 years.²⁷⁸

²⁷⁵ MHI Report, Vol. 1, pg. 64

²⁷⁶ MHI Report, Vol. 1, pg. 62

²⁷⁷ Transcript, Feb. 16, 2012, pgs. 37/11-12; 66-69

²⁷⁸ Transcript, Feb 14, 2012, pg. 140/1-4

Nalcor's position is that the Labrador-Island Link HVdc overland transmission line design with a 1:50 return period loading with or without the Maritime Link is appropriate:²⁷⁹

“The HVDC interconnection is designed to obtain the required level of reliability via the HVDC link from Labrador in conjunction with island generation facilities. Any additional reliability benefit as a result of the Maritime link has not been factored into the analysis, and is in addition to the reliability level built into the Labrador link.”

As discussed earlier in this report the Terms of Reference require that the Maritime Link and its role in the reliability of the Interconnected Option not be considered. Accordingly MHI did not review the technical feasibility of the Maritime Link.²⁸⁰

Nalcor stated in Exhibit 106 that, as there is other available generation (for example, over the Maritime Link), a higher return period is not necessary:

“Given that Phase 1 of the Lower Churchill Project includes a second HVdc transmission line, the Maritime Link, which is geographically diverse from the Labrador-Island Link and provides a connection to an alternate supply of power in the event of a failure of the Labrador-Island Link, loss of the Labrador-Island Link does not imply the serious consequences as suggested in the design standard for use of the 1:500 year return period. Further, given that the project includes the availability of generating capacity from alternate, geographically diverse sites implies that the suggested 1:150 year return period is questionable.”

Nalcor relied on the fact that the Island ac transmission system has a lower reliability level (1:25 year return period) to justify its decision on the 1:50 return period for the HVdc line.²⁸¹ MHI did not accept this position. MHI pointed out that a significant icing event could occur in an area remote from the 230 kV system which could affect the HVdc line while all the 230 kV lines would remain intact. MHI stated:²⁸²

“Nalcor argues that since the existing 230 kV ac system is designed to a lesser reliability level, there is no justification to increase the reliability level of the HVdc link as the ac transmission system would fail for an event greater than 1 in 50 years. This argument is contrary to best practices carried out by utilities in Canada for transmission line design, and does not reflect current industry practices which follow IEC 60826:2003. Also, the ice storm could be isolated to an area where only the HVdc line is present. The 230 kV transmission system would be completely intact while the HVdc line is out of service.”

Nalcor also stated it does not plan on installing additional back up generation.²⁸³

“Given that this level of line design provides for an Interconnected Island alternative having a probability of exposure to an outage and a level of unsupplied energy during an outage similar to that of the Isolated Island system today, Nalcor sees no justification in increased capital expenditures on additional combustion turbines and is therefore recommending no additional CTs at this time.”

²⁷⁹ MHI-Nalcor-24

²⁸⁰ MHI Report, Vol. 1, pg. 23

²⁸¹ PUB-Nalcor-171, 172 and 173

²⁸² MHI's Report, Vol. 2, pg. 120

²⁸³ Nalcor Submission, Nov. 10, 2011, Vol. 1, pgs. 136-137; PUB-Nalcor-174; Transcript, Feb. 14, 2012, pgs. 193/25; 194/1-7

Nalcor summarized its position related to the return period loading for the Labrador-Island Link HVdc line:²⁸⁴

“Through decades of experience operating transmission infrastructure in harsh environments, NLH has gained considerable knowledge of the necessary design criteria for its electricity infrastructure. NLH has designed transmission lines in recent years to ice loads higher than those published in the CSA Standard.”

Nalcor further stated:²⁸⁵

“In the case of Newfoundland and Labrador, Nalcor has determined that the design ice loads should be higher than those published in the CSA Standard based on a substantial amount of historical data.”

Nalcor acknowledged that the design loading in the alpine areas would be higher than in other areas of the line and that the costs to increase the design loading would be in the range of \$20-25 million.²⁸⁶ These costs were not included in the Decision Gate 2 capital cost estimate. Increasing the design loading for a particular section of line does not necessarily mean an increase in return period loading and an improvement in reliability.

Nalcor’s position is that the design ice loadings for the Labrador-Island HVdc overland transmission line approximate or exceed the CSA recommended 500-year maximum ice loads.²⁸⁷ Taken in isolation, this statement could be misinterpreted. As noted above, it is a given that ice loadings quoted in the CSA Standard for Newfoundland and Labrador are inadequate. Appropriate design of the HVdc overland transmission line should follow the recommended reliability based methodology using all available meteorological data and historical experience as outlined in CAN/CSA-C22.3 No. 60826.06.

Nalcor concludes:²⁸⁸

“The chosen Labrador-Island Transmission Line design provides an adequate level of reliability and an increase in the design standard will not significantly improve customer reliability. As Nalcor stated during the Board public hearings, should a higher level of customer reliability be deemed necessary by the Board, Nalcor believes that the increased reliability can be best achieved through the addition of combustion turbines on the island as opposed to an increase in line design.”

However, as noted above, Nalcor does not plan on adding additional combustion turbines.

²⁸⁴ Nalcor’s Final Submission, pg. 41

²⁸⁵ Nalcor’s Final Submission, pg. 42

²⁸⁶ Transcript, Feb. 15, 2012, pg. 96/10-14

²⁸⁷ Nalcor’s Final Submission, pg. 44

²⁸⁸ Nalcor’s Final Submission, pg. 44

Nalcor had used a 1:150 return period in previous studies for the HVdc transmission line design associated with earlier proposed developments of the Lower Churchill. Nalcor acknowledged that the decision to reduce the return period to 1:50 was made prior to Decision Gate 2.²⁸⁹

In assessing the impact of the loss of the Labrador-Island Link on the reliability of the Island system, Nalcor assumed a two-week worst case scenario for the repair of the HVdc transmission line in the event of a failure of that line.²⁹⁰ It explained that this assumption was based on its experience with outages to major transmission lines on the Avalon Peninsula. MHI stated that this two-week repair period may not be realistic and is not an industry accepted metric.²⁹¹

Nalcor also explained how it would address the failure of the HVdc line through load shedding, which would be more extensive than its current practices and could include tripping the load to the Avalon Peninsula and potentially the Burin Peninsula. Nalcor outlined the significant changes that would have to be made to the existing underfrequency load shedding scheme to deal with the impact of the loss of both poles of the HVdc system as follows:²⁹²

“The existing under frequency load shedding (UFLS) scheme is set to arrest frequency decay following sudden loss of generation such that load shed, in conjunction with governor action, will restore the balance between generation and load, thereby returning the system frequency to normal (60 Hz) and avoiding system collapse. The existing UFLS scheme is set based upon a largest unit load of 175 MW.

By comparison the sudden loss of both poles of the bi-pole system at Soldiers Pond would result in approximately 750 MW of supply for an 800 MW HVdc system loading. The 575 MW difference in loss of supply between the two scenarios will therefore require modifications to the existing UFLS scheme. Studies underway in detailed design will address the sudden loss of the bi-pole at Soldiers Pond and parameters for a special protection scheme (SPS) for the contingency will be developed. At this stage it is envisioned that any exports via the Maritime Link will be curtailed for the loss of the bi-pole. In addition tripping of load centers on the Island to rebalance load with the remaining hydroelectric generation will result in an electrical island as opposed to a system wide blackout. It is expected that the Avalon Peninsula, and potentially the Burin Peninsula depending upon system load conditions and HVdc Link load conditions, will need to be tripped to maintain an electrically isolated island containing remaining hydroelectric resources.

Recovery of the interconnected island system from the operating hydroelectric resources will occur more quickly than if there was a complete island blackout for the event.

This is described in more detail in Exhibit 106 – Technical Note: Labrador Island HVdc Link and Island Interconnected System Reliability.”

²⁸⁹ Transcript, Feb. 14, 2012, pgs. 143/25; 144/1-6

²⁹⁰ Exhibit 106, pg. 27

²⁹¹ Transcript, Feb. 15, 2012, pgs. 143/24-25; 144/1-2

²⁹² PUB-Nalcor-31

Additional costs to design the line to a 1:150 year return period are estimated by Nalcor to be \$150 million.²⁹³ Additional costs to design the line to a 1:500 year return period are estimated at between \$225 to \$250 million.²⁹⁴

Several parties took the position that Nalcor's proposed transmission line design was inadequate.

The Consumer Advocate stated:²⁹⁵

"A reliable electrical system is, of course, of critical importance and value to customers. As customers, we tend to take the reliability of our system for granted until we are faced with a power outage and we find ourselves in darkness. At that point, electrical reliability is at top of mind. Reliability must always be top of mind for electrical utilities and system planners. In the case of the proposed 1100 km HVdc transmission line, the line will be running through areas with harsh meteorological conditions and through remote areas which might well not be readily accessed by emergency response electrical crews. The 1998 ice storm in Quebec is a fresh memory for many customers, where following this catastrophic event, transmission lines were rebuilt to a 1:500 year standard. The MHI report constitutes evidence that generally accepted sound public utility practice would be to select a greater than 1:50 reliability return period for a line of this criticality even if an alternative supply is available.

The Consumer Advocate concurs with the judgment of MHI on this issue and believes that its judgment is deserving of considerable weight. The Consumer Advocate believes that whether the International Standard is mandatory or recommendatory, deviation from it should require clear and compelling reasons supported by ample analysis as to how such a deviation would impact reliability for customers and whether those impacts were acceptable.

The Consumer Advocate considers that adding the incremental cost of the line being designed to a 1:150 year return period to the cost of the Interconnected Option does not significantly alter the preference for this Option."

In their presentation Ron Penney and David Vardy made several references to the issue of the HVdc line reliability:²⁹⁶

"Nalcor has selected a 1 to 50 year reliability return period, a basis for design loading criteria for the HVDC transmission line, which is inconsistent with the recommended 1 to 500 year reliability return period outlined in the international standard. Nalcor has stated that the additional capital cost increase for the 1 to 150 year return period for the transmission line would be 150 million. In the latter case, Nalcor should also give consideration to an even higher level reliability return period in the remote Alpine regions. MHI recommends that Nalcor adhere to these criteria for the HVDC transmission line design.

We believe that Nalcor should include the additional capital cost for the 1 to 150 year reliability return period, and for the even higher 1 to 500 standard in the higher and more remote regions. Since achieving the 1 to 150 year return period adds 150 million to the capital cost, we presume that the higher standard recommended by MHI would cost somewhat more. A high standard of reliability on such a distant source is crucial and this expense should be added to the reference case for the Muskrat Falls calculation of CPW and all the sensitivity analyses performed on that reference case."

²⁹³ PUB-Nalcor-15

²⁹⁴ Transcript Feb. 14, 2012, pg. 3/1-6

²⁹⁵ Consumer Advocate's Submission, pgs. 48-49

²⁹⁶ Transcript, Feb. 20, 2012, pgs. 56/3-25; 57/1-7

They made the following recommendation to the Board:²⁹⁷

“We recommend that the Board accept the higher reliability standard for the transmission lines, particularly those in higher elevations and remote locations. Should the Board’s report make recommendations on this matter of reliability, we urge the Board, and we ask the Government really, to give the Board the opportunity to review any further work which is done to improve reliability. In assessing the interconnected and isolated options, the Board should recognize the higher risk exposure and the potential threat to reliable service on the Avalon upon decommissioning of the Holyrood generating plant.”

The Industrial Customers accepted MHI’s findings on the HVdc transmission line design and suggested a Board process should be established to further examine this issue. They stated:²⁹⁸

“Transmission Line Design Criteria

Nalcor has selected a 1:50-year reliability return period for the HVdc transmission line. MHI has identified a 1:150-year reliability return period as the acceptable standard where an alternate supply is available. Nalcor/Hydro, in its presentation to the Board, has continued to strongly reject this MHI recommendation, on the basis that (1) the word ‘suggested’ is used in the applicable standard instead of mandatory language, (2) Hydro’s operational experience indicates that a major failure of the HVdc transmission line could be restored within a two-week timeframe, (3) the existing Hydro transmission system is built to a 1:50-year (or less) reliability return period standard and (4) pending repair, the impact of a major failure of the HVdc transmission line could be mitigated by an as-of-yet incompletely defined plan for additional back up thermal generation on the Island (or by the Maritime Link, which however is outside of the mandate of the Review).

In the view of the current Island Industrial Customers, the MHI report has presented evidence that generally accepted sound public utility practice would be to select a greater than 1:50-year reliability return period for a critical transmission line, even if an alternate supply is or becomes available. The evidence is that, in recent Canadian utility experience, HVdc transmission lines, are designed (in Alberta, to a 1:100-year standard; in Manitoba, to a 1:150 year standard) or restored (Quebec, post 1998 ice storm, to 1:500-year standard), exceed the 1:50-year standard, even when an alternate supply is available. Reliance on Hydro’s own experience as evidence supporting a lower reliability return period standard for critical transmission lines than that used by these other Canadian utilities is undermined by the fact that Hydro has no experience with transmission line conditions in Alpine areas such as those that will be traversed by the Labrador-Island interconnect. This Province is no stranger to extreme weather conditions like those experienced, for instance, in the 1998 Quebec ice storm.

In the view of the current Island Industrial Customers, the cost saving of \$150 million that it is estimated would be achieved by building the HVdc transmission line to a 1:50-year standard instead of a 1:150-year standard may not have been sufficiently weighed against the economic costs to the Province of a major failure of the HVdc transmission line, particularly in the absence, or prior to the establishment, of an adequate backup power supply, or against the costs of establishing sufficient back up power supply and/or retrofitting the HVdc transmission line to a higher standard at some further time, either before or after a major transmission line failure event.

²⁹⁷ Transcript, Feb. 20, 2012, pgs. 73/17-25; 74/1-6

²⁹⁸ Island Industrial Customers, Letter of Comment, Feb. 29, 2012, pgs. 4-5

The current Island Industrial Customers are of the view that a process should be established before the Board, to further examine whether the selection of a 1:50-year reliability return period for the HVdc transmission line is consistent with the Energy Plan objective that the ‘electricity supply is adequately planned and is provided on a reliable basis at the most reasonable cost’, applying the standard of generally accepted sound public utility practice.”

10.2 AC Integration Studies

AC integration studies are performed when major equipment and/or facilities are to be added to electric power systems. These studies model the existing system with the additional facilities to assess potential operational problems against a prescribed set of performance criteria e.g. voltage levels, frequency excursions, thermal limits, etc. The studies identify any other system additions, upgrades or changes necessary such that the required performance criteria can be met. Examples of these include synchronous condensers, transmission lines, shunt capacitors, static VAR compensators and modifications to existing protection and control schemes.

The most recent comprehensive integration studies conducted for a development on the Lower Churchill River were completed in 1998 and 2008. The 1998 study by Teshmont was for a Gull Island development with 735 KV lines connected to Churchill Falls and a 800 MW, ± 400 kvdc bipole transmission line to Soldiers Pond. The 2008 study by Hatch was for a Gull Island development with a 1600 MW, ± 450 kv 3-terminal HVdc system to Salisbury, New Brunswick, and Soldiers Pond.²⁹⁹ The current system configuration proposed for the Interconnected Option is for a much smaller Muskrat Falls development with a 900 MW, ± 320 kvdc bipole to Soldiers Pond.

MHI found that ac integration studies for the proposed project configuration had not been completed. In its report MHI stated:³⁰⁰

“The ac system integration studies made available by Nalcor to MHI for review were conducted for the Gull Island Generating Station and the 3-terminal 1600 MW HVdc interconnector, with one termination at Soldiers Pond and another termination at Salisbury, New Brunswick (Exhibits CE-01 through CE-09). The project definition changed, in November 2010 following completion of the Nalcor project alternatives screening study (DG2) with Nalcor’s decision to proceed with generation at Muskrat Falls using a point-to-point HVdc transmission system (Labrador-Island Link) with the inverter station at Soldiers Pond. There was insufficient information provided to form an opinion on the suitability of the ac system integration studies for the project, as redefined.”

MHI found that the system integration studies should have been completed at Decision Gate 2 and this was a major gap in Nalcor’s work. Its key finding with respect to the ac system integration studies is:³⁰¹

²⁹⁹ MHI’s Report, Vol. 2, pg. 75

³⁰⁰ MHI’s Report, Vol. 2, pg. 73

³⁰¹ MHI’s Report, Vol. 1, pg. 10

“AC Integration Study Findings

7. *AC Integration Studies – System integration studies completed as part of the project alternatives screening process, and provided to MHI by Nalcor were for a Gull Island development with a 1600 MW three terminal HVdc system to Newfoundland and New Brunswick. Significant changes were made to the overall project definition with the proposed Muskrat Falls development, and the deletion of the New Brunswick link. Integration studies that would support the changes have not been completed and Nalcor now advises that the studies will not be available until March 2012. As the full requirements for integration of the Labrador-Island Link HVdc system are not known, there may be additional risk factors that may impact the cumulative present worth of the Infeed Option. For example, installation of backup supplies to cover operational limitations in the Labrador-Island Link HVdc system may be required, and additional transmission lines may be needed to maintain acceptable system performance. Spare equipment requirements also need to be taken into consideration. Good utility practice requires that these integration studies be completed as part of the project screening process (DG2). MHI considers this a major gap in Nalcor’s work to date. These integrations studies must be completed prior to project sanction (DG3).”*

After hearing Nalcor’s evidence that previous work provided a level of comfort so the studies weren’t necessary to be completed by Decision Gate 2, MHI confirmed their finding that the lack of a completed integration study is a significant gap in the work to date. MHI stated:³⁰²

(Mr. Snyder): We still consider it a significant gap. They have suggested they were doing it. Those two previous studies were looking at different size generation, different transmission sizes, different relocations. So, saying that they’re similar is a bit of a stretch to me. Some of the same characteristics, yes.

Nalcor responded to several requests for information on the completion of ac integration studies for the Interconnected Option during the review. Nalcor first advised that the studies were underway with an expected completion date of November 2011.³⁰³ Nalcor later advised the studies were delayed to the end of March 2012.³⁰⁴

During the review Nalcor stated that system integration planning is one of the activities to be completed leading up to Decision Gate 3 and that it had analyzed Teshmont’s 1998 integration studies³⁰⁵ for a 800 MW point-to-point HVdc link from Gull Island to Soldiers Pond, and compared the 1998 study to the 2007 study for Gull Island and a 1600 MW, 3-terminal HVdc system to Soldier’s Pond and New Brunswick. Nalcor’s analysis determined that the point-to-point link will have similar characteristics, regardless of change in generation source, provided there is a line to Churchill Falls. Nalcor stated that, as a result, it had sufficient input data to move through Decision Gate 2, with the intention of completing full integration studies for Decision Gate 3.³⁰⁶

³⁰² Transcript, Feb. 15, 2012, pg. 196/9-15

³⁰³ MHI-Nalcor-44

³⁰⁴ PUB-Nalcor-143

³⁰⁵ Exhibit CE-31 Rev. 1 (Public)

³⁰⁶ Transcript, Feb. 13, 2012, pgs. 78/17-25; 79/1-21

Nalcor commented in relation to the possible impact of not having complete ac integration studies as of Decision Gate 2 as follows.³⁰⁷

A. (Mr. Humphries): Based on -- it's our view, based on our understanding of our system and the previous studies, that the items identified in these studies were representative of what we would be faced with with the integration of the Muskrat Falls scenario and further to that, the studies, the current studies are ongoing and while they're not complete yet, we have seen some preliminary results or indication -- I haven't seen them, but I've talked to -- some of my staff are participating and we have not identified it and don't expect to.

Q. (Mr. Johnson): MHI refers specifically, and I'm not taking away from your answer, but they refer specifically to possibilities such as installation of backup supplies to cover operational limitations in the Labrador-Island link system maybe required and additional transmission lines may be needed or spare equipment, and I guess I'd be interested in knowing are those the type of things that you could get into at the stage that -- at DG3?

A. (Mr. Humphries): We don't think so, no. We don't think we would get into those.

MHI noted that when they undertook its review the only information available was the original Gull study and the Teshmont study.³⁰⁸ Nalcor provided additional information on February 29, 2012 as follows:³⁰⁹

Attachment 1:

- Working notes assessing the power factor requirements for the Muskrat Falls generators
- Additional load flow plots for Labrador with Muskrat Falls developed before Gull Island
- An investigation of Muskrat Falls construction power requirements

Attachment 2:

- A 2008 Nalcor internal memo entitled "Island System Upgrades – No New Oil Refinery"

The correspondence accompanying the attachment concluded:

"Nalcor took comfort in the results of the entire body of work completed prior to DG2, including the above. With the knowledge that these results and assumptions would be further tested and studied as part of its Phase III engineering, Nalcor concluded the results of the body of system integration work were acceptable and passed through DG2."

³⁰⁷ Transcript, Feb. 13, 2012, pgs. 197/9-25; 198/1-9

³⁰⁸ Transcript, Feb. 16, 2012, pg. 43/5-8

³⁰⁹ Undertaking # 9, Feb. 29, 2012, pg. 1

Nalcor summarizes its position with respect to proceeding through Decision Gate 2 without completing ac integration studies for the new project configuration as follows:³¹⁰

“The question still remains whether the scheme studied in Exhibits CE03, CE04 and CE 10 is representative of DG2 because of the difference in the multi-terminal and larger sending end arrangement. Nalcor maintains that the island integration requirements are insensitive to the sending end differences and this can be supported by reviewing the results of Exhibits CE10 and CE31. Exhibit CE 31 is based on the 1998 studies of an 800 MW point-to-point HVdc system from Gull Island to Soldier’s Pond a configuration very similar to the current arrangement with the exception of generation source, (Gull Island versus Muskrat Falls) the impact of which has been addressed above. The Island systems studies in CE10 and CE31 are very similar and the resulting island upgrades identified in the two studies are very similar. This consistency between required upgrades supports Nalcor’s view that the island upgrades are more reliant on the island system arrangements and are relatively insensitive to the sending end system configuration.

Based on the above analysis, Nalcor believes that its decisions and assumptions regarding System Integration at DG2 were reasonable and is confident the new system integration studies currently being completed will validate those decisions and assumptions.”

The Consumer Advocate noted that MHI was present throughout the hearing process and, notwithstanding Nalcor’s familiarity and comfort level based on its two previous studies from 1998 and 2007, MHI stated that they still consider this issue a significant gap. The Consumer Advocate stated that he placed considerable weight upon the judgment of MHI on this issue and concurred with MHI.³¹¹

The current Island Industrial Customers stated:³¹²

“AC Integration Studies

It appears from the presentation to the Board that Nalcor has accepted the MHI recommendation that AC Integration Studies need to be completed before proceeding to DG3. In the view of the current Island Industrial Customers those studies (apparently scheduled to be completed in March 2012) should be filed with the Board, and thereby made available to the public, once completed and prior to DG3.”

³¹⁰ Nalcor’s Final Submission, pg. 50

³¹¹ Consumer Advocate’s, Submission, pg. 45

³¹² Island Industrial Customers, Letter of Comment, Feb. 29, 2012, pg. 3

10.3 Reliability Assessment

Reliability assessment is used by utilities to determine the adequacy of generation and/or transmission to meet the load. As noted by MHI in its report, additions to a power system should not degrade the reliability performance of the system. Because the island of Newfoundland is isolated from the national electrical grid, reliability is an important issue, especially when large remote generation sources are proposed to be connected to a system through a long transmission line.³¹³

Reliability evaluation methods can be generally classified into two categories: deterministic and probabilistic. MHI sets out the difference in these methods in its report.³¹⁴ Deterministic methods are subjective and based on engineering judgment. While these deterministic methods are simple, intuitive, and easy to understand, elements of power system behaviour are unpredictable and random in nature and power systems are becoming more complex. Probabilistic reliability methods are a more accurate method for reliability assessment. Deterministic techniques are being augmented by probabilistic methods by many North American electric power entities, including Manitoba Hydro, BC Hydro, Hydro Quebec, Hydro One in Ontario and the Northeast Power Coordinating Council, Inc. Industry working groups, who provide guidance to reliability practitioners, are now recommending that these methods be adopted as industry wide standards.³¹⁵

Nalcor's planned generation and transmission requirements are determined based on two different sets of criteria.

For generation, the criteria provides for a minimum reserve capacity and that energy be available to the system to ensure an adequate supply for firm demand allowing for short-term deficiencies at an acceptable minimal risk. From a capacity perspective, generation must be available such that a Loss of Load Hours (LOLH) of 2.8 hours/yr is not exceeded. This target "represents the inability to serve all firm load for no more than 2.8 hours in a given year."³¹⁶ On the energy side, firm generation must be available to the system to supply all firm energy needs. It should be noted that this generation planning criteria assumes that all transmission infrastructure is in place such that the generation can be delivered without restrictions. Nalcor's *Ventyx Strategist* computer program, which is used for generation planning purposes, uses probabilistic methods to determine the optimum generation expansion plan based on a specific load forecast.

Nalcor's transmission planning criteria is summarized as follows:³¹⁷

- Hydro's bulk transmission is planned to be capable of sustaining the single contingency loss of any transmission element without loss of system stability.
- In the event a transmission element is out of service, power flow in all other elements of the power system should be at or below normal rating.
- Hydro's system is planned to be able to sustain a successful single pole reclose for a line to ground fault based on the premise that all system generation is available.

³¹³ MHI Report, Vol. 2, pg. 57

³¹⁴ MHI Report, Vol. 2, pg. 57

³¹⁵ MHI Report, Vol. 2, pg. 57

³¹⁶ Exhibit 16, pg. 8, Footnote 3

³¹⁷ Exhibit 42, pg. 2

This criteria is tested on a single contingency basis, e.g. loss of a line or loss of a transformer, to ensure the system performance is acceptable for the specified disturbances. Nalcor uses the Power Technologies Inc. PSS/E software to model current and plan future transmission assets. This process is deterministic in nature.

With reference to the Interconnected Option Nalcor has modeled in its *Strategist* resource planning software the four 206 MW units at the Muskrat Falls generating facility and the 1,100 km HVdc line with associated converter station equipment and submarine cables as a 900 MW unrestricted thermal source connected to the Soldiers Pond bus. This element was assumed to have a forced outage rate of 0.89% per pole based on reliability studies for various infeed options assessed in the 1980s.

MHI reviewed Nalcor's work to determine if reliability studies were conducted with due diligence, skill and care, consistent with best practice. MHI's key findings in relation to Nalcor's power system reliability assessments are:³¹⁸

“Power System Reliability Findings

5. *Forced Outage Rates – The forced outage rates (FOR) assumed for various types of generating units are based on reliable sources and considered to be reasonable. The information documenting the derivation of the Labrador-Island Link HVdc system FOR of 0.89% on a per pole basis was not available for MHI's review. MHI has compared the Labrador-Island Link HVdc system pole FOR of 0.89% with published information and that of Manitoba Hydro's HVdc system and finds it within the normally accepted range. However, this FOR should be replaced by a more advanced and comprehensive reliability model incorporating all components of the Labrador-Island Link HVdc system.*
6. *System Reliability Studies – Probabilistic adequacy studies, including considerations related to transmission for comparison of the reliability of the two options, have not been completed by Nalcor. This is a gap in Nalcor's practices as various Canadian utilities including Manitoba Hydro, BC Hydro, Hydro Quebec, and Hydro One in Ontario have adopted these probabilistic methods for reliability studies for major projects. Probabilistic reliability methods utilize standard terms and indices such as Loss of Load Expectation, or Expected Unserved Energy, and make the risk analysis results plainly understandable in terms of dollars and/or loss of load.*

Deterministic assessments, such as those performed by Nalcor in Exhibit 106, cannot quantify the true risks associated with a power system and are unable to provide some of the important inputs for making sound engineering decisions such as risk and associated costs, including the potential large societal costs related to outages. Probabilistic assessment is a valuable means to assess system risk, reliability and associated costs/benefits for various system improvement options, particularly for major projects proposed by Nalcor. MHI has determined that choosing between the two options under review without such an assessment is a gap in Nalcor's work to date. Typically, these studies are completed at DG2. MHI recommends that these probabilistic reliability assessment studies be completed as soon as possible. Such studies should become part of Nalcor's processes that would allow for a comparison of the relative reliability for future facilities.”

³¹⁸ MHI Report, Vol. 1, pg. 9

MHI recommends that comprehensive probabilistic reliability assessments should be completed for both the Interconnected and Isolated Island Options. MHI expands on this recommendation in its report:³¹⁹

“The components and/or subsystems that should be modeled in a probabilistic reliability assessment usually consist of generating units and major transmission facilities...

The model and study development may involve:

- 1. A review of technical specifications of the proposed system and operating history of similar installations around the world;*
- 2. An estimate of specific risks, for example: icebergs, fishing dredges and ocean currents for the Strait of Belle Isle cable crossing and rime ice and salt contamination for the overhead HVdc line;*
- 3. Develop reliability component models of the proposed cable, overhead line and converter stations; and*
- 4. Amalgamate the various component reliability models to form the overall Labrador-Island Link HVdc system reliability model.*
- 5. Link the Labrador-Island Link HVdc system model into the island power system reliability model.*
- 6. Perform the reliability study.”*

MHI further comments on the distinction between the two types of reliability assessments.³²⁰

“Deterministic reliability assessment is predominantly used in Nalcor’s Exhibit 106 to assess impacts of the loss of generation: either the largest unit on the Island, the Labrador-Island Link HVdc system in one or two pole blocks, or the Emera link. This type of assessment provides snapshots in time of system performance based on a set of assumptions and fixed load pattern.

Deterministic approaches are rather simplistic and do not provide an exhaustive examination for system resource adequacy based on more sophisticated models and techniques.

One of the important factors that should be considered in evaluating power system enhancement alternatives is the reliability benefit associated with each option. Risk based or probabilistic reliability evaluation is widely accepted in the power industry to determine the ability of a component, a subsystem or a system to perform its intended function. The numerous uncertainties facing the industry drive a need to use probabilistic evaluation methodologies in power system reliability. The electric power industry particularly in North America is, therefore, adopting the use of the probabilistic reliability assessment approach.

In probabilistic methods, a full model of the generators, transmission lines, HVdc system, maintenance schedules, unit dependencies, and other significant risk factors are considered along with variations in the system load. A commonly used method to process reliability calculations is to use Monte Carlo simulations. These tools randomly change various element states (fail the element) across the model.”

³¹⁹ MHI Report, Vol. 2, pg. 66

³²⁰ MHI Report, Vol. 2, pg. 67

In discussing the reliability comparison of the two options MHI stated:³²¹

“The proposed Labrador-Island Link HVdc system is a crucial part of the Infeed Option. The impacts of the HVdc link on the overall system reliability performance should, therefore, be quantitatively evaluated in order to provide valuable inputs to the decision making process. The most performed studies in the power industry is resource adequacy assessment considering transmission restrictions. The primary concern in resource adequacy studies is to assess the capability of system resources to serve the total system demand.

The impact of the proposed Labrador-Island Link HVdc system can be quantified in terms of these commonly used reliability indices of load carrying capability, LOLE/LOLH or EUE. However, there are no such probabilistic study results available for review. The studies described in Exhibit 106 do not use the probabilistic methods nor fully address this concern.

Comparisons of the two options in terms of reliability should be one of the important inputs to the decision making process. The relative reliability level of these options can be determined based on a series of comparative analyses with a do nothing option, Isolated Island Option, and the Infeed Option. Reliability assessment for the Infeed Option could consider the generation, load, firm export/import sales, demand side management programs and interruptible load, particularly as related to the proposed Labrador-Island Link HVdc system associated with Muskrat Falls’ generation. The Isolated Island Option evaluation may include all of the above with the exception of the transmission. A comparison of system reliability in terms of LOLH for the two alternatives produced from the Strategist Program shows that the reliability of the Infeed Option is slightly better than that of the Isolated Island Option. A full Labrador-Island Link HVdc system reliability modelling is, however, not considered in this comparison as the HVdc system was only modelled as an unrestricted thermal source with an FOR of 0.89%.”

MHI gave the following as recent examples of Canadian utilities that are using probabilistic reliability assessments for major projects:³²²

- BC Hydro for the Vancouver Island Transmission Reinforcement Project;
- Manitoba Hydro’s HVdc Bipole 111 Alternatives; and
- Hydro One’s studies on transmission planning and asset management in Ontario.

Nalcor is of the view that it has assessed reliability in an appropriate way. Nalcor stated:³²³

“...both the Isolated Island and Interconnected Island alternatives were tested for compliance against NLH’s accepted generation planning and transmission planning criteria. These planning criteria adhere to industry accepted practice and compliance with them assures a level of reliability that is at least consistent with historical experience.”

Nalcor’s Exhibit 106 assesses the impact of the Labrador-Island HVdc transmission line on the Island system reliability, including an examination of the effects on the Island system for pole and bipole outages with and without the Maritime Link. To compare the level of unsupplied energy to Island customers under the Interconnected Option (without the Maritime Link) with

³²¹ MHI Report, Vol. 2, pg. 69

³²² Transcript, Feb. 15, 2012, pg. 125/11-18

³²³ Nalcor Submission, Nov. 10, 2011, Vol. 1, pg. 130

the current Isolated Island system of today, Nalcor uses a “worst case two-week” situation. It assumes that a simultaneous two week outage of TL202/206 (Bay D’Espoir to Sunnyside) is equivalent to a two-week outage of the Labrador-Island HVdc Link bipole, i.e. these are both worst case scenarios. Table 5 of Exhibit 106 demonstrates that without the Maritime Link for the period 2017-2037, the Isolated Island Option has less unsupplied energy than the Interconnected Option.

To compare the relative unserved energy over time Nalcor was requested to complete a sensitivity analysis of the CPW assuming combustion turbines were added to the Interconnected Option (without Maritime Link) such that the unserved energy was approximately equal to the Isolated Island scenario over the period 2017 to 2037. Nalcor’s response stated:³²⁴

“...the addition of eleven 50 MW combustion turbines would need to be advanced in the Interconnected Island scenario to make the level of unsupplied energy comparable to the Isolated Island case...”

The CPW for the Island Interconnected scenario with the advanced installation of combustion turbines would increase to \$7,016 million (2010\$) from \$6,652 million (2010\$), an increase of \$364 million (2010\$).”

Nalcor did not accept MHI’s recommendation on the completion of probabilistic reliability studies. Paul Humphries of Nalcor explained that probabilistic adequacy studies introduce new factors into the reliability assessment such as the cost of interruptions to customers, which could lead to additional system requirements and additional costs.³²⁵

Nalcor summarizes its position related to reliability studies as follows:³²⁶

“MHI maintains that while Nalcor has completed a probabilistic analysis to ensure that both generation expansion alternatives meet the reliability criteria, it is not possible to assess the relative overall reliability of the alternatives without completing a similar probabilistic analysis incorporating the transmission system effects. Nalcor’s assessment determined that when the transmission systems for the two alternatives are examined, the only difference in the systems is the 1100 km HVdc link between Muskrat Falls and Soldier’s Pond. The remaining transmission elements are identical. As all of the remaining transmission elements would be common to both alternatives, Nalcor’s opinion is that a probabilistic analysis of those elements is not necessary to compare the overall reliability of the alternatives.

Nalcor’s probabilistic generation adequacy analysis does include a probabilistic analysis for the Labrador-Island Transmission Link including the effects of converter equipment, submarine cables and overhead transmission lines. As a result, a comparison of the annual Loss of Load Hours (LOLH) for the Isolated Island and Interconnected Island alternatives is a measure of the relative reliability of the alternatives. Nalcor acknowledges that the model for the transmission link used for DG2 is dated and may not be completely representative of the current scheme. Nalcor will be developing a new model and redoing the analysis prior to DG3.

³²⁴ PUB-Nalcor-175

³²⁵ Transcript, Feb. 15, 2012, pg. 3/2-11

³²⁶ Nalcor’s Final Submission, pgs. 45-46

The deterministic reliability analysis that Nalcor discusses in Exhibit 106 is not intended to take the place of a more detailed probabilistic analysis. Rather, the analysis intended to demonstrate the extent of customer impact should a failure occur at the worst possible time. The probabilistic generation adequacy analysis that includes a model for the Labrador-Island Transmission Link demonstrates that ‘probabilistically’ the Interconnected Island alternative as proposed meets Nalcor’s reliability criteria by maintaining an LOLH of less than 2.8 hours.

Nalcor is aware that many jurisdictions do utilize probabilistic reliability assessment methods that include transmission in their decision making process. However, Nalcor has not yet adopted this practice because it has concerns with the appropriateness of the (sic) this type of analysis and believes that an analysis could produce misleading results for the isolated alternative that could misinform the decision making process.

A two-week outage over a 50 year period would still result in 99.9 percent availability. Such a high performance level does not adequately communicate the impact of a two week outage if it occurs during a peak period. A deterministic approach is required to assess the consequences during worst-case conditions and structure an appropriate remedy.

Nalcor will continue to assess a probabilistic methodology and its impacts on the current planning criteria but believes the probabilistic analysis incorporating the generation and the HVdc link is appropriate to compare the reliability of the two alternatives and properly inform the decision making process. Should the island system become interconnected to the North American grid these types of studies will become a normal part of the planning process and Nalcor will transition to a transmission planning criteria comparable to that used in other interconnected jurisdictions.”

On this issue the Consumer Advocate stated:³²⁷

“The Consumer Advocate notes MHI’s point that various Canadian utilities have adopted the probabilistic method for major projects and that choosing between the two options is a gap in Nalcor’s work to date. The Consumer Advocate accepts this judgment.”

The Industrial Customers stated:³²⁸

“In the view of the current Industrial Customers, the MHI report presents evidence that probabilistic reliability assessments for major projects are considered to be a generally accepted sound public utility practice by other Canadian utilities (Manitoba Hydro, BC Hydro, Hydro Quebec, Hydro One (Ontario)). The process of consultation with Nalcor’s/Hydro’s stakeholders, customers and the Board on the implications of probabilistic reliability assessment could be conducted by a streamlined process. It appears to the current Island Industrial Customers that there remains an opportunity to complement the deterministic reliability assessment of the Infeed Option based on Hydro’s own experience with a probabilistic reliability assessment, prior to DG3.”

³²⁷ Consumer Advocate’s Submission, pg. 50

³²⁸ Island Industrial Customers, Letter of Comment, Feb. 29, 2012, pg. 4

10.4 Adherence to NERC Standards

As a result of the August 2003 blackout affecting Canada and the United States, most jurisdictions in North America have adopted North American Electric Reliability Corporation (NERC) standards as their reliability standards. In September 2006 the National Energy Board (NEB) recognized NERC as the single Electric Reliability Organization for all of North America. MHI stated:³²⁹

“This common action in the USA and Canada allows NERC’s reliability standards to meet the requirement of being a practice that is consistent with the methods or acts engaged in or approved by a significant portion of the electric utility industry, even if the scope of those methods or acts is limited to Canada.”

Eight of the ten jurisdictions in Canada have adopted NERC standards as their reliability standards.³³⁰ Nalcor does not currently comply with NERC standards.

MHI’s key finding with respect to adherence to NERC standards is as follows:³³¹

“Nalcor does not currently comply with North American Electric Reliability Corporation (NERC) standards. A majority of utilities in Canada have adopted the definition of ‘good utility practice’ that incorporates adherence to NERC standards. Also, should the Maritime Link proceed, and Nalcor participates in the electricity marketplace, NERC standards will ultimately apply. MHI recommends that Nalcor complete a self-assessment and prepare for compliance to NERC standards with or without the Maritime Link.”

During the review Nalcor advised that it accepted this recommendation and is doing a self-assessment prior to Decision Gate 3 to determine the actual level of compliance that would be required.³³²

Nalcor summarized its position on this issue as follows:³³³

“Nalcor is in the process of completing a self-assessment to determine the implications of the adoption of NERC standards. As noted by MHI, eight of Canada’s 10 provinces have adopted NERC standards. As outlined in the summary of provincial models below, there is flexibility in how jurisdictions implement these standards. In considering the adoption of NERC standards, it is Nalcor’s intent to exercise flexibility and maintain a balanced approach that 1) pays due consideration to cost and the impact on customers and 2) takes into consideration the unique characteristics of the Island Interconnected system.”

Nalcor goes on to summarize current key points regarding the adoption of NERC standards within the eight Canadian jurisdictions.³³⁴

³²⁹ MHI Report, Vol. 2, pg. 77

³³⁰ MHI Report, Vol. 2, pg. 77

³³¹ MHI Report, Vol. 1, pg. 10

³³² Transcript, Feb. 14, 2012, pgs. 106/24-25; 107/1-4

³³³ Nalcor’s Final Submission, pg. 46,

³³⁴ Nalcor’s Final Submission, Table, pgs. 47-48

10.5 Board Comments

The Board is concerned with the gaps in Nalcor's work as identified by MHI in its review. All the gaps relate to the Interconnected Option and would, if incorporated, likely increase the capital costs of this option.

Nalcor has stated that the ac integration studies will be completed prior to Decision Gate 3. The detailed results of the current ac integration studies will be invaluable in determining any system equipment additions and associated costs required to operate the Labrador-Island Link transmission line at an acceptable level of performance. The studies will also identify specifics related to the special protection scheme required and the implications it will have particularly with respect to significant parts of the island being tripped for extended bipole outages and potential load rationing. Until these studies are completed the full extent of the system configuration and its resultant costs cannot be determined.

Nalcor has also confirmed that it is in the process of completing a self-assessment to determine the implications of adopting NERC standards. This may be a critical issue with the development of the Maritime Link and access to export markets. Before completion of this assessment it is not possible to determine whether compliance with NERC standards will result in additional costs for the Interconnected Option, both for additional equipment needed to meet system performance criteria and also for operational and administrative costs related to training, personnel qualifications, infrastructure protection and compliance auditing. The Board notes that in Nova Scotia all NERC standards are adopted and enforceable. Nova Scotia Power reviews NERC standards and submits them to the Nova Scotia Utility and Review Board for approval, and all registered entities are subject to NERC's compliance monitoring and enforcement program.

According to MHI's findings Nalcor should also have completed comprehensive probabilistic adequacy studies, as part of its Decision Gate 2 process, including considerations related to transmission, for both options to compare the reliability of each, similar to that being done by other Canadian utilities for major projects. The Board notes that the Consumer Advocate and the Industrial Customers accept this finding. According to MHI this gap in Nalcor's practices means that some of the necessary inputs for making sound engineering decisions such as risk and associated costs, including the potential large societal costs related to outages are not available. In particular, the impact of the proposed Labrador-Island Link transmission line on the existing system reliability cannot properly be assessed. MHI also suggested that this practice should be incorporated into Nalcor's ongoing processes. The Board also notes that until such studies are completed the impact on the final costs of the Interconnected Option cannot be determined.

Of particular concern to the Board is the fact that Nalcor does not accept MHI's recommendation with respect to the transmission line design criteria. The Board accepts MHI's opinion that the design criteria of 1:50 year return period proposed by Nalcor for the HVdc overland transmission line is inadequate and contrary to Canadian utility standards and practices. MHI recommended that, in accordance with these standards and practices, a return period of 1:150 years should be used with an alternate supply and 1:500 years should be used without an alternate supply and that Nalcor should consider an even higher standard in the alpine areas. The Consumer Advocate and

the Industrial Customers also agree with this finding. In the Board's view MHI's recommendation is in accordance with generally accepted sound public utility practice.

Nalcor's reasoning for its rejection of this recommendation is not supported by the facts. Nalcor is relying on its own operational experience to support a design standard for a critical component of the Island's transmission infrastructure, even though it has no experience with the transmission line conditions in the alpine areas contemplated by the proposed route. Nalcor proposed a "worst case" two-week scenario to compare a prolonged HVdc bipole outage to a similar two-week outage on the existing system. The Board agrees with MHI that this two-week period is not realistic and is not an industry accepted metric. Nalcor does not plan to add backup generation, such as combustion turbines, on the Island in the event of a major failure of the HVdc line with or without the Maritime Link. The Board is of the view that Nalcor should address these significant gaps related to a major component of the Interconnected Option before proceeding to the next decision phase.

The gaps identified by MHI and discussed above are linked to the issue of the reliability of the Island Interconnected system. The Board has an explicit mandate with respect to reliability of the system as set out in s. 3(b)(iii) of the *EPCA*. While Nalcor is exempted from the *EPCA* and the *Public Utilities Act* the Board still has a responsibility to ensure that electricity supply for the Island Interconnected system is adequately planned and operated reliably at the lowest possible cost consistent with an acceptable level of reliability. Any outage on the system caused directly or indirectly by the loss of the HVdc bipole could significantly impact Hydro's Utility and Industrial Customers and lead to additional costs for the system and customers, in addition to the possible societal and economic impacts that could result from an extended outage.

In the Board's opinion, when considered together, these gaps related to power system reliability raise serious concerns in relation to Nalcor's assessment of the interconnection of the significant generation associated with the Muskrat Falls generating facility to the Island Interconnected system. These deficiencies should be addressed by Nalcor in a meaningful way should the Interconnected Option proceed to project sanction.

In closing the Board notes the comments of the Industrial Customers on the issue of these gaps and the need for an open and transparent process to assess the implications of the issues raised by MHI, particularly with respect to the issue of the appropriate transmission line design criteria. The Industrial Customers suggested that the Board should have the opportunity under its statutory mandate, by a streamlined process if necessary, to further review the areas of concern identified by MHI before the Interconnected Option is sanctioned.

LIST OF APPENDICES

APPENDIX	DESCRIPTION
“A”	Terms of Reference and Reference Question
“B”	Public Participation - Comments

Terms of Reference and Reference Question

In the Energy Plan, 2007, Government committed to the development of the Lower Churchill hydro resource. It has been determined that the least-cost option for the supply of power to the Island Interconnected system over the period of 2011-2067 is the development of the Muskrat Falls generation facility and the Labrador-Island Link transmission line, as outlined in Schedule "A" attached hereto (the "Projects"), as compared to the isolated Island development scenario, as outlined in Schedule "B" attached hereto (the "Isolated Island Option"), both of which shall be outlined further in a submission made by Nalcor Energy ("Nalcor") to the Board of Commissioners of Public Utilities (the "Board"). It is contemplated that Newfoundland and Labrador Hydro ("NLH") would enter into a long-term power purchase agreement and transmission services agreement with Nalcor, or its subsidiaries, the costs of which would be included in NLH's regulated cost of service with the full cost of the Projects being recovered from NLH's Island interconnected system customers (the "Island Interconnected Customers").

Pursuant to section 5 of the *Electrical Power Control Act, 1994* (the "EPCA"), Government hereby refers the following matter to the Board:

The Reference Question

The Board shall review and report to Government on whether the Projects represent the least-cost option for the supply of power to Island Interconnected Customers over the period of 2011-2067, as compared to the Isolated Island Option, this being the "Reference Question".

In answering the Reference Question, the Board:

- shall consider and evaluate factors it considers relevant including NLH's and Nalcor's forecasts and assumptions for the Island load, system planning assumptions, and the processes for developing and comparing the estimated costs for the supply of power to Island Interconnected Customers; and
- shall assume that any power from the Projects which is in excess of the needs of the Province is not monetized or utilized, and therefore the Board shall not include consideration of the options and decisions respecting the monetization of the excess power from the Muskrat Falls generation facility, including the Maritime Link project.

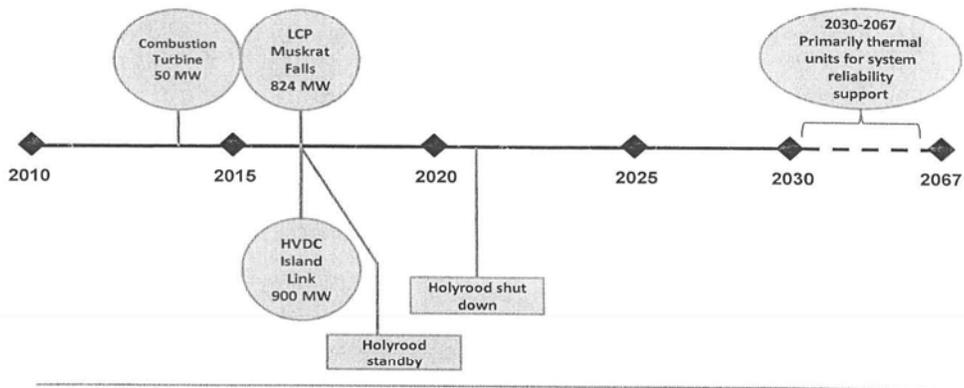
Where Nalcor or NLH determine that any information to be given to the Board for this review is commercially sensitive as defined in the *Energy Corporation Act*, it shall advise the Board, and the Board and its experts and consultants may use such information for this review but shall not release such information to any party.

For the purposes of this review, a consumer advocate shall be appointed pursuant to section 117 of the *Public Utilities Act*.

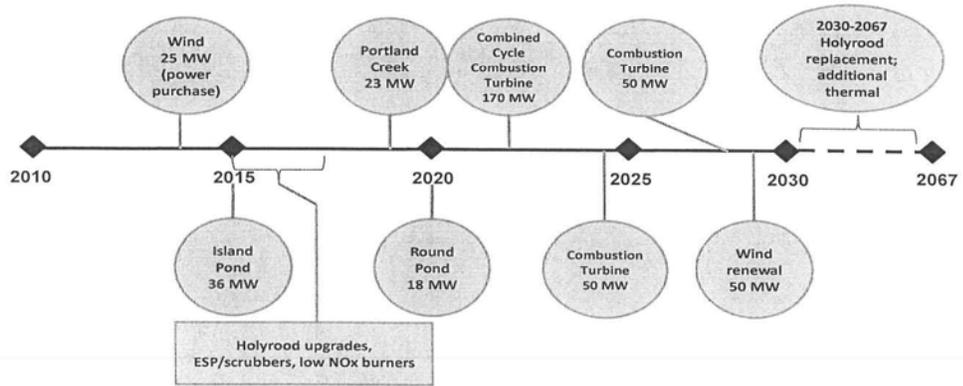
Any costs of the Board in respect of this review, including the costs of the consumer advocate, shall be paid by Nalcor.

The Board's report shall be provided to the Minister of Natural Resources by December 30, 2011. The Minister shall make this report public.

Schedule A – The Project



Schedule B - Isolated Island Option



Public Participation - Comments

	NAME	DATE RECEIVED
1.	WM	January 11, 2012
2.	JW	January 31, 2012
3.	MC	February 6, 2012
4.	SB	February 13, 2012
5.	LC	February 14, 2012
6.	MK	February 15, 2012
7.	BC	February 15, 2012
8.	BC	February 20, 2012
9.	Lorraine Michael, M.H.A.	February 21, 2012
10.	GP	February 27, 2012
11.	JM (Revision 1)	February 29, 2012
12.	St. John's Board of Trade	February 28, 2012
13.	MA	February 28, 2012
14.	MC	February 28, 2012
15.	Island Industrial Customers	February 29, 2012
16.	EC	February 29, 2012
17.	MC	February 29, 2012
18.	BG	February 29, 2012
19.	Consumer Group for Fair Gas Prices	February 29, 2012
20.	BG	February 29, 2012
21.	WA	February 29, 2012
22.	Dr. James Feehan	February 29, 2012
23.	Edward Conway, LL.B.	February 29, 2012
24.	Richard Cashin, Q.C. Edward Hearn, Q.C. Dennis Browne, Q.C.	February 29, 2012
25.	KL	February 29, 2012
26.	ND	February 29, 2012
27.	Jerome P. Kennedy, Q.C., Minister of Natural Resources	February 29, 2012
28.	RG	February 29, 2012

NOTE: *Initials used to protect confidentiality of personal information.*

Newfoundland & Labrador

BOARD OF COMMISSIONERS OF PUBLIC UTILITIES

120 TORBAY ROAD, ST. JOHN'S, NL

Website: www.pub.nl.ca

E-mail: ito@pub.nl.ca

Telephone: 1-709-726-8600

Toll free: 1-866-782-0006
