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**Report on
Two Generation Expansion Alternatives
for the Island Interconnected Electrical System**

Board of Commissioners of Public Utilities
Newfoundland and Labrador

Date: February 15/2012

Outline

- Introduction
- Options Reviewed
- Review Methodology
- Project Screening and Estimating
- Load Forecast
- Hydrology
- Reliability Study
- AC Integration & NERC Standards
- Infeed Option
- Isolated Island Option
- CPW Analysis
- Conclusions

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."*

Report on Two Generation Expansion Alternatives for the Island Interconnected Electrical System

The report is a summary of the reviews on the Two Generation Expansion Alternatives for the Island Interconnected Electrical System.

The two Generation Expansion Options were identified in the terms of reference, and are as follows:

- Infeed Option which is the Muskrat Falls Generating Station and the Labrador-Island Link HVdc Project, and
- The Isolated Island Option which is largely a thermal generation expansion plan.

Areas not covered in MHI's Review

The Terms of Reference did not include consideration of the following:

- Alternative fuel types
- Other island supply options
- Consideration of export market via Maritime Link
- Technical feasibility of Maritime Link
- Electricity requirements in Labrador
- Potential impacts on island rates

MHI Engagement

- MHI is a wholly owned subsidiary of Manitoba Hydro
- MHI has provided consulting services to over 70 countries worldwide
- Request for Proposal (RFP)
 - MHI was selected by Board following competitive RFP
 - RFP and Proposal are on Board's public website
 - Contract was awarded to MHI on July 4, 2011

The MHI Team

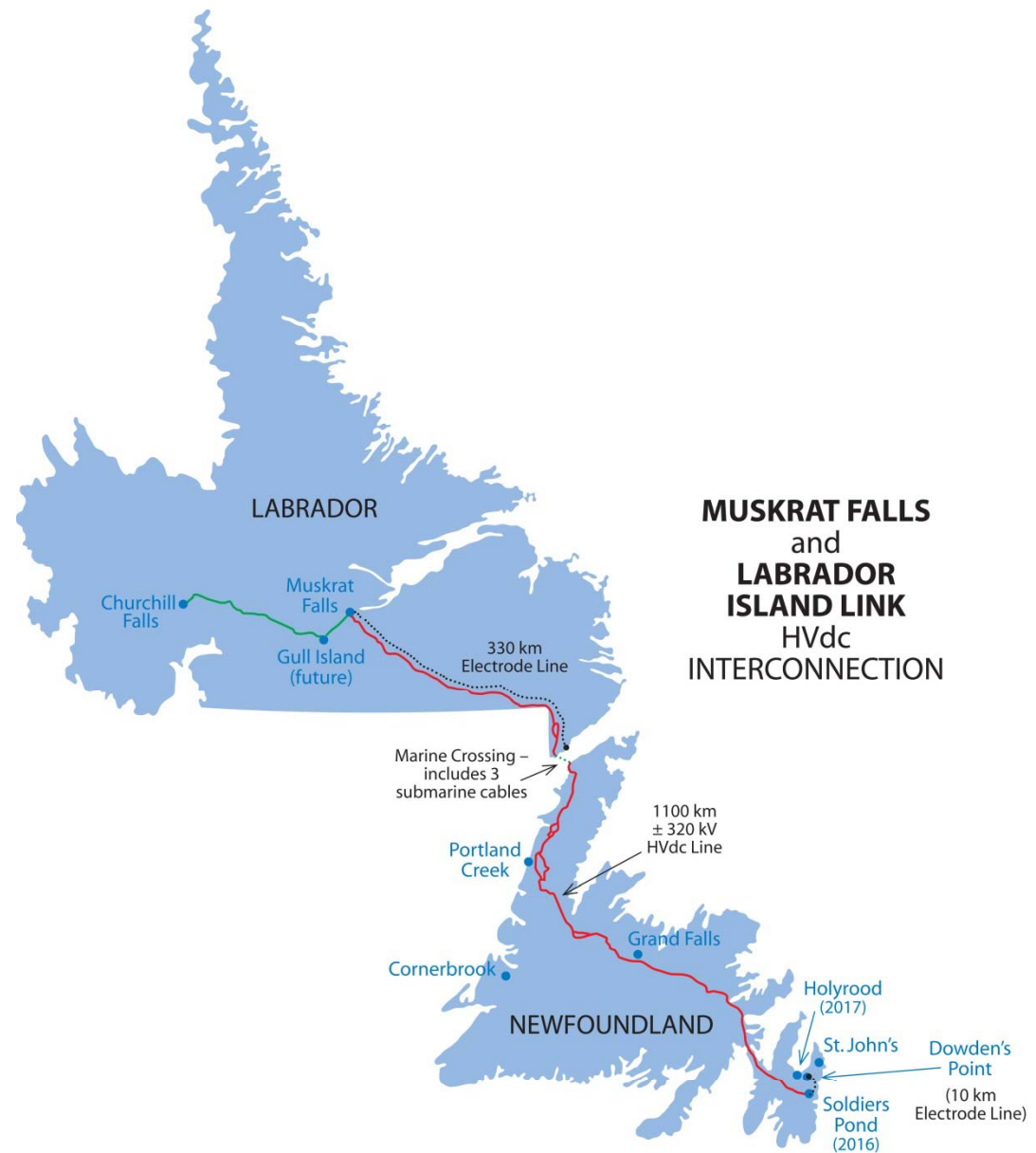
- MHI assembled a team of specialists in:
 - Load Forecasting
 - Project Management
 - Utility Resource Planning
 - Hydroelectric Generation
 - Thermal Generation
 - HVdc Engineering
 - Hydrology
 - Reliability
 - AC Integration and Planning Studies
 - Submarine Cables and Marine Crossings
 - Wind Power
 - Financial Analysis
 - Additional subject matter experts as needed from the parent company



OPTIONS REVIEWED

February 15, 2012

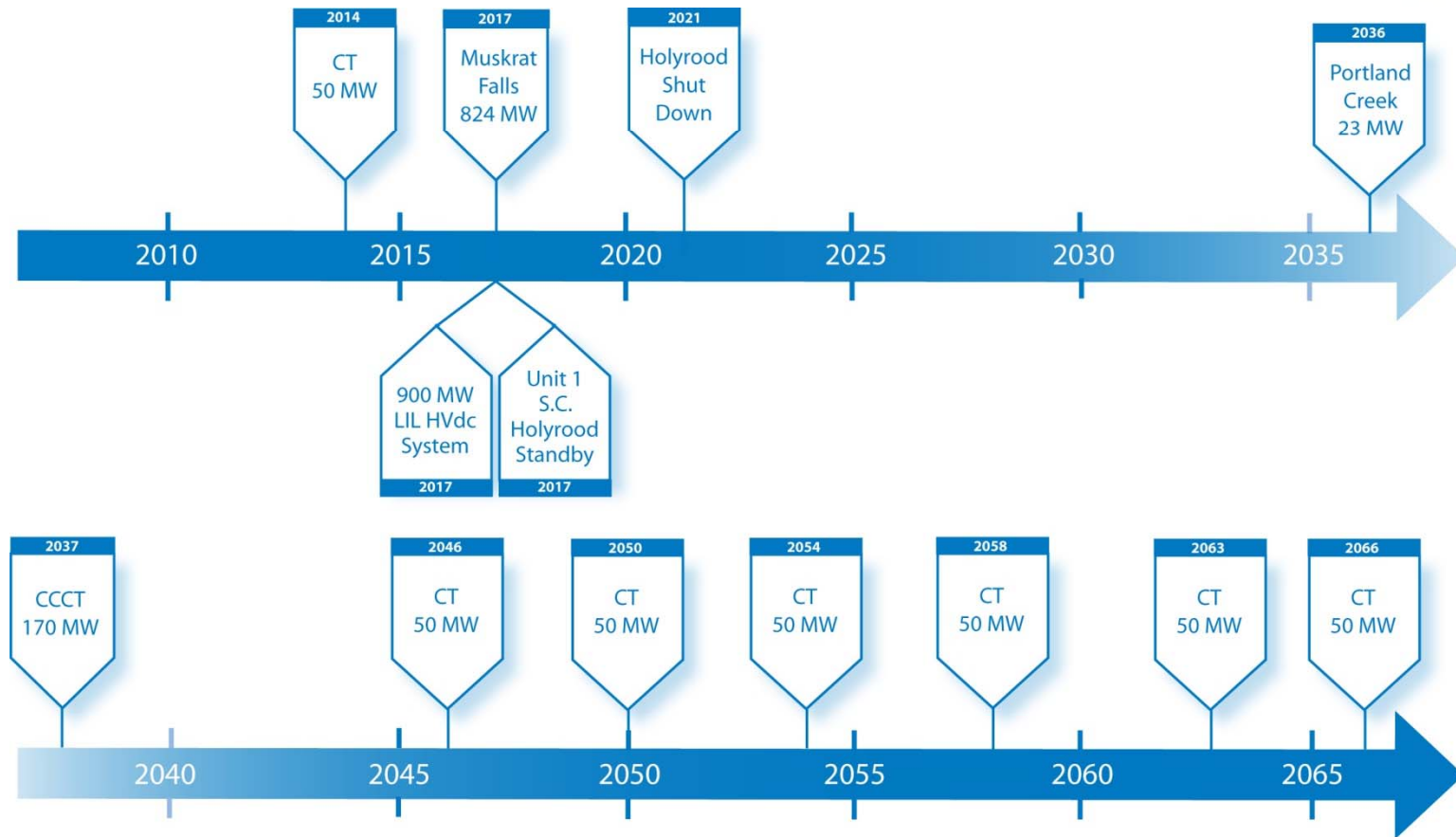
Infeed Option



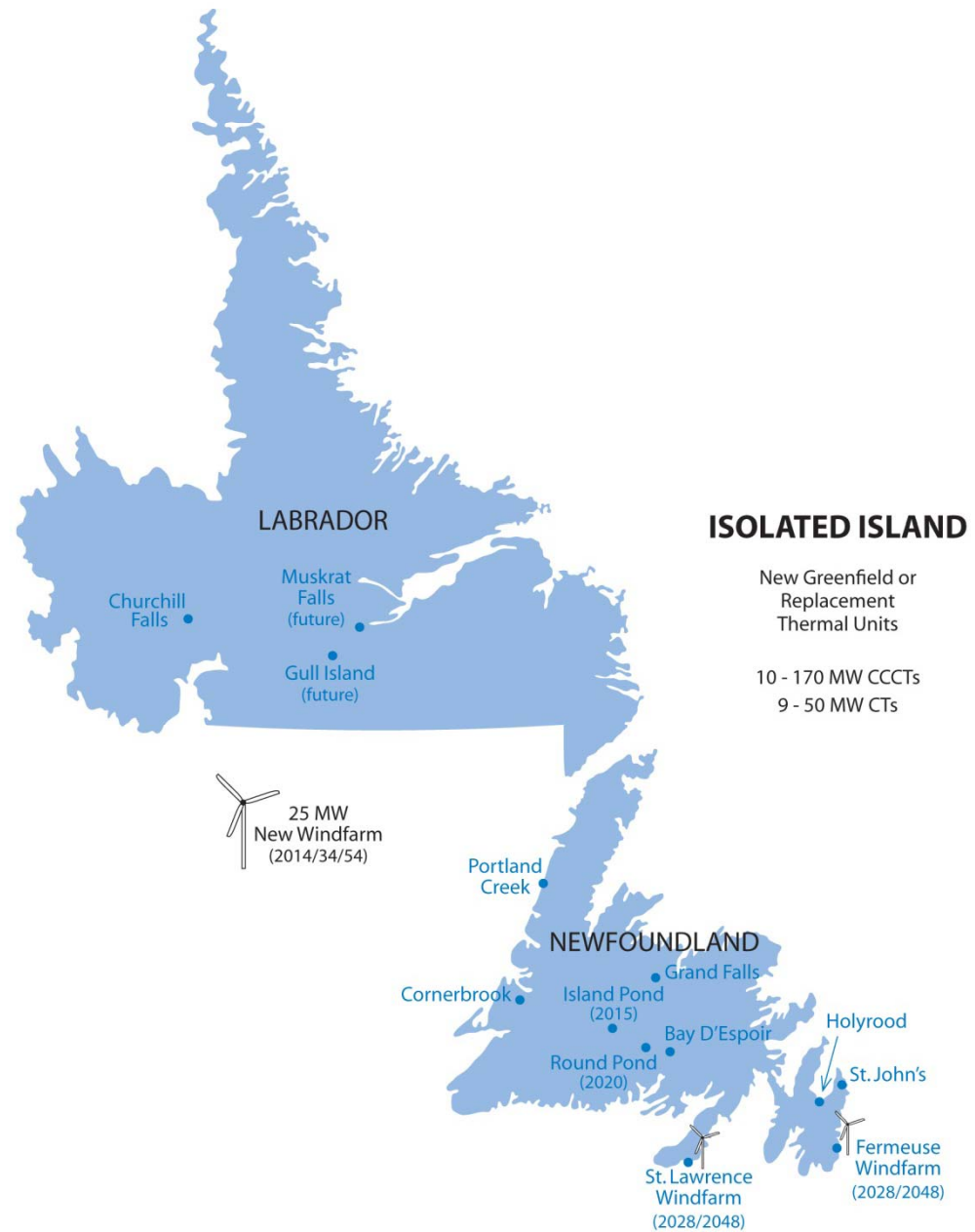
Infeed Option

- Muskrat Falls Generating Station (824 MW with Average Energy of 4.9 TWh/year)
- Labrador-Island HVdc Transmission Link (LIL)
- HVdc Converter Stations
- Strait of Belle Isle (SOBI) Marine Cable Crossing
- Addition of:
 - One Hydroelectric Plant (Portland Creek – 23 MW)
 - One 170 MW Combined Cycle Combustion Turbine (CCCT)
 - Seven 50 MW Combustion Turbines (CT)
 - Synchronous Condenser Conversions at Holyrood (HTGS)

Infeed Option



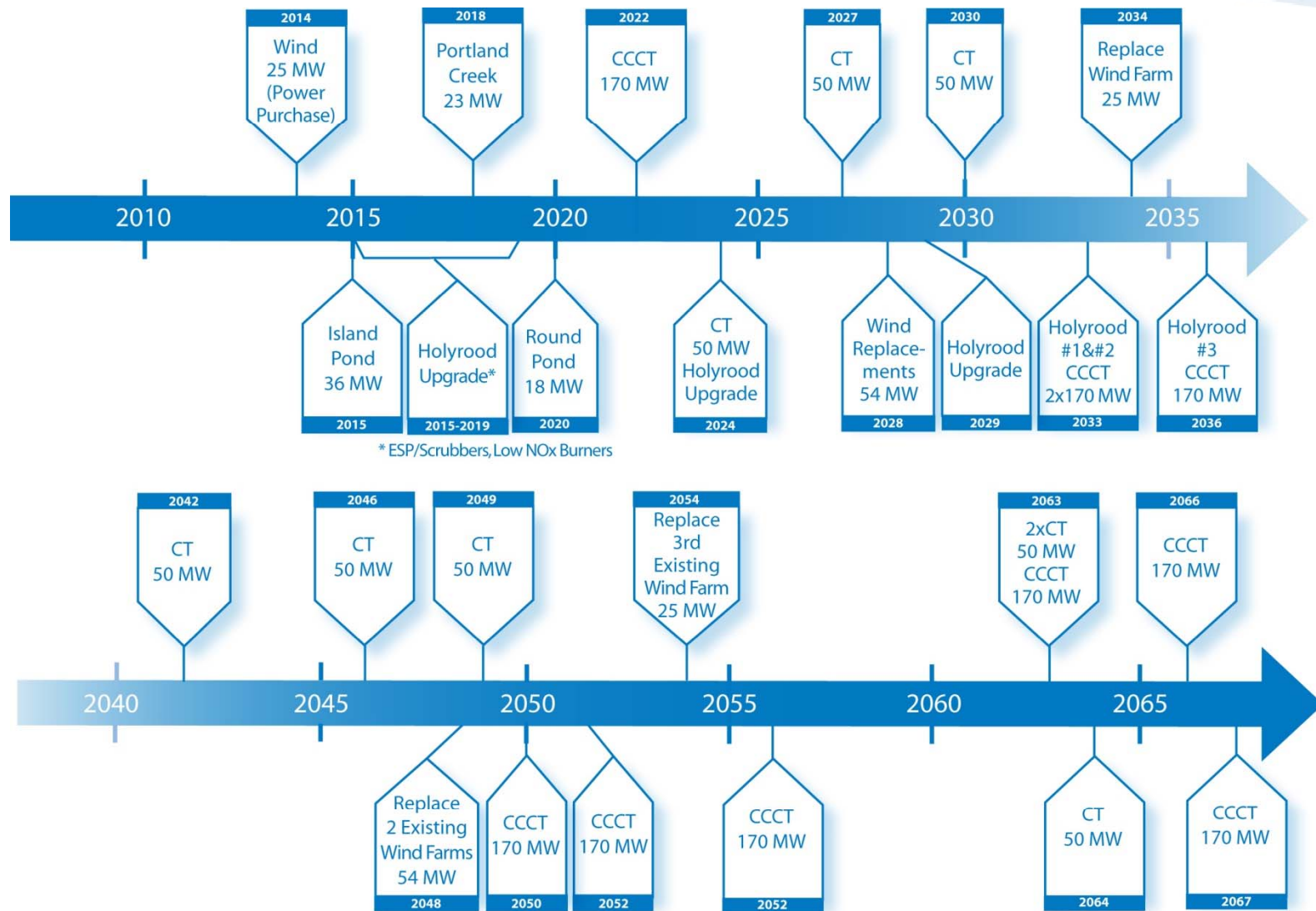
Isolated Island Option



Isolated Island Option

- Holyrood Thermal Generating Station
 - Install pollution control equipment
 - Provide life extensions for generation to 2033 and 2036
 - Plant replaced with three 170 MW CCCTs, two in 2033 and one in 2036
- Three hydroelectric generating sites
 - Portland Creek (23 MW)
 - Island Pond (36 MW)
 - Round Pond (18 MW)
- Addition of thermal units
 - Seven – 170 MW CCCTs
 - Nine – 50 MW CTs
- Wind farms – one new - 25 MW

Isolated Island Option

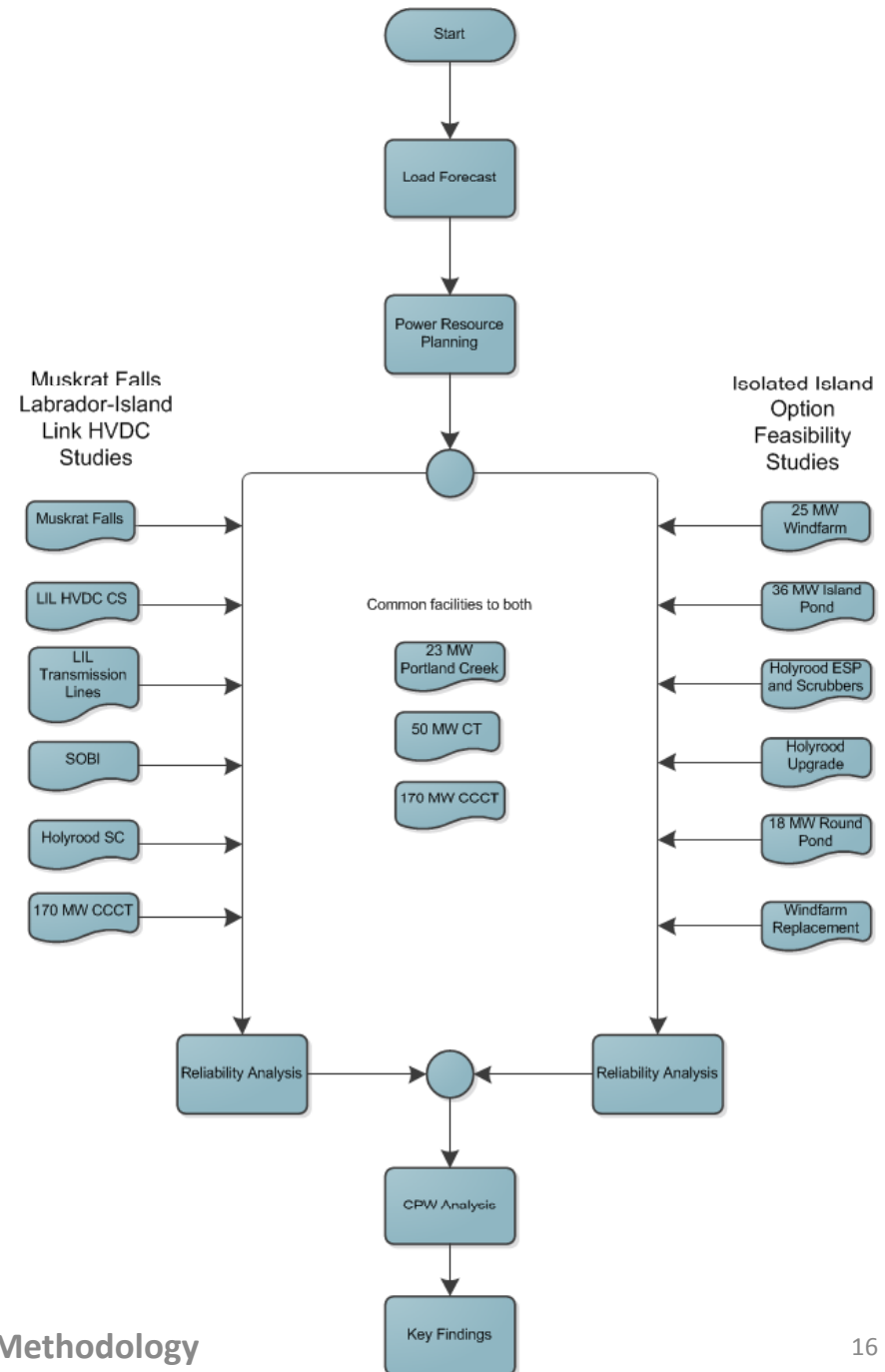


* ESP/Scrubbers, Low NOx Burners



REVIEW METHODOLOGY

MHI Review Process



Technical Perspective

- Generation Resource Planning
- Load Forecasts
- Hydrology
- Reliability
- Feasibility Studies of Various Project Components
- AC System Studies
- Cost Estimates and Estimating Methodologies
- Risk Analysis

Financial Perspective

- Review of Nalcor's CPW methodology
 - Capital and Operating Costs
 - Fuel Price Forecasts
 - Allowance for Funds Used During Construction (AFUDC)
 - Escalation Rates
 - Discount Rates
 - Debt and Equity Components
 - Power Purchase Agreements (PPA)
 - PPA vs Cost of Service Approach for Muskrat Falls
- Sensitivity Analyses

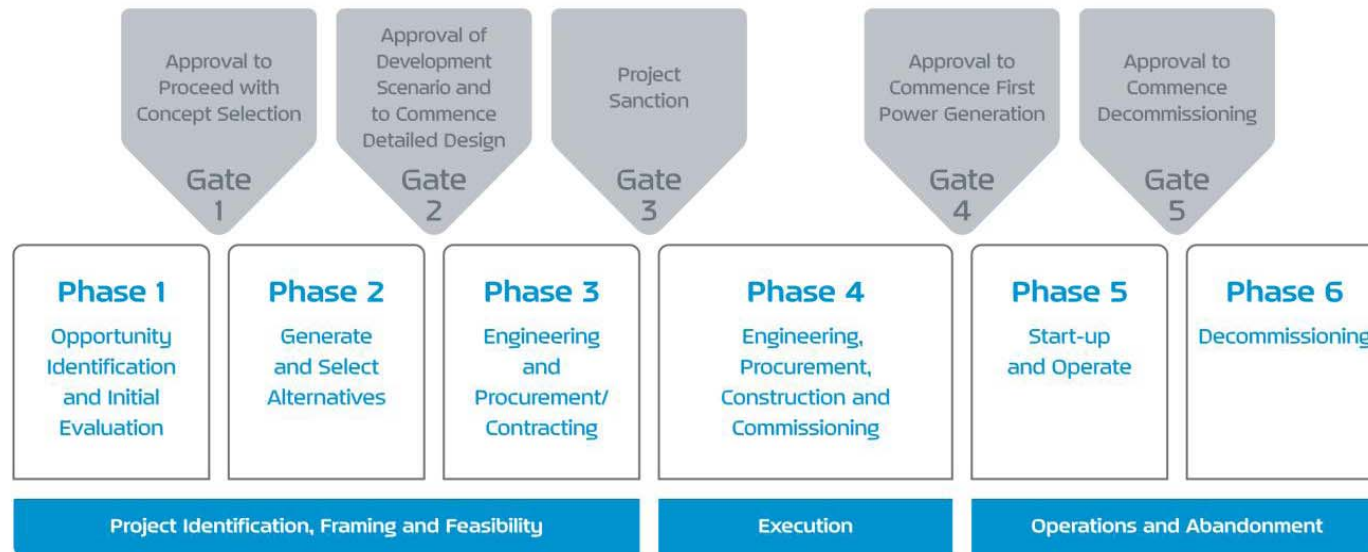


Nalcor's Decision Gate Process

PROJECT SCREENING AND ESTIMATING

Decision Gate Process Overview

- Decision Gate 2 (DG2): Selection of preferred option
- Decision Gate 3 (DG3): Final check and confirmation that the investment decision is well founded (project sanction).



Source: Nalcor's Final Submission, Volume 2, page 35

AACE Cost Estimating Classes

- AACE International Recommended Practices No. 17R-97
- Recognized as a leading authority to cost estimating standards, practices, and methods

Class 5: +100% to -50%,

Class 4: +50% to -30%,

Class 3: +30% to -20%,

Class 2: +20% to -15%,

Class 1: +15% to -10%,

Concept Screening

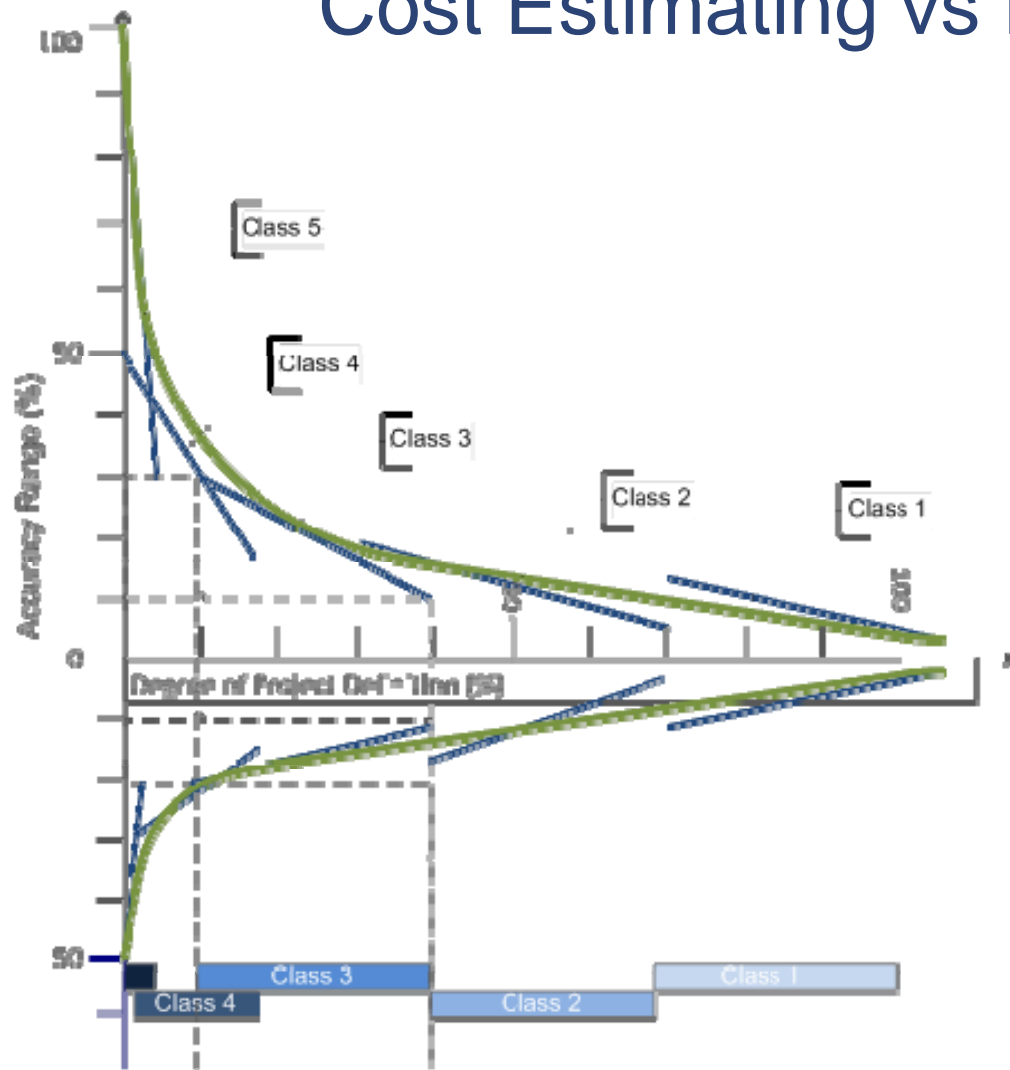
Study or Feasibility (DG2)

Budget Authorization (DG3)

Control or Bid/Tender

Check Estimate

Cost Estimating vs Project Definition



Cost Estimating vs Project Definition (Cont'd)

- Nalcor's project screening is based on DG2 level with cost estimates commensurate with AACE International Class 4
- Range of accuracy (plus 50% to minus 30%)
- Nalcor proposes to use a AACE Class 3 accuracy level for budget authorization and project sanction stage (DG3)
- Range of accuracy for DG3 (plus 30% to minus 20%)
- Refinement of the estimates is critical to outcome of CPW analysis

Risk Review

- Nalcor and their consultants categorize risks under two headings.
 - Tactical Risks
 - Definition – Evaluation of Design and Planning Aspects
 - For example, foundation risks
 - Performance – Associated with Contractors, Weather, Pricing, etc.
 - Strategic Risks
 - Background Risks
 - Changes in Scope
 - Market Condition
 - Location Factors
 - Organization Risks:
 - Size and Complexity of Project

Risk Review

- MHI noted as part of the technical reviews that risks were generally related to three areas:
 - Determination of Costs
 - The Timing of Projects
 - Ongoing Technical and Operational Risk Issues
- MHI has documented these risks where appropriate in its report.

Generation Resource Planning

- Time horizon is generally 20 years or more
- Generation planning is a function of the load forecast, generation retirements, and Government policy
- Timing and sizing of future generation is driven by annual energy needs and peak demand requirements
- Ideally want to keep reasonably tight relationship between supply and demand to maintain reliability
- Increments of both demand and supply can be lumpy

Generation Resource Planning (Cont'd)

- Supply price may impact load curve, thus the analysis is iterative
- Depending on the location, supply choices can involve various preferred sources
- Objective of generation resource planning is to determine the most economic mix to reliably satisfy demand
- Supply equation must also consider security and reliability, environmental, social issues, transmission capabilities, etc.

Generation Resource Planning (Cont'd)

- Reserve requirements must be factored in. The amount is established based on reliability and economic factors.
- Interconnections generally reduce reserve requirements while improving reliability
- A sophisticated modelling program is used to optimize preferred choices (For example, Strategist)
- MHI found Nalcor's generation resource planning process to be consistent with leading North American utilities



MHI's review of Nalcor's Load Forecast

LOAD FORECAST

Load Forecast

- The load forecast is a key input into the generation expansion plan where the generation plan is structured to match load growth increments in both capacity and energy.

MHI's review

- MHI completed a comprehensive review of Nalcor's load forecast methods, data sources, and analysis techniques using the Island of Newfoundland's historical load data and key inputs provided by Nalcor
- MHI reviewed the rationale behind the historical load growth factors and tested these factors and assumptions for future growth
 - For example, penetration of electric heat in the domestic sector or the number of housing starts
- Past forecast performance was measured by examining the accuracy of the last ten forecasts.

Domestic Sector

- Based entirely on econometric modelling techniques
- Consistently has under predicted future energy needs by 1% per year
- The forecast error is naturally mitigated with the annual production of an updated Load Forecast and Generation Expansion Plan.

Domestic Sector

- Methodology is acceptable but does not fully meet utility best practices for this sector
- MHI recommends the incorporation of end-use modelling techniques.
- End-use modelling will improve the capability to:
 - Quantify load growth by end-use
 - Incorporate new end-uses in the forecast
 - Quantify energy-efficiency by end-use
 - Improve the design of Conservation and Demand Management (CDM) programs

General Service Sector

- Methodology has produced excellent results using regression modelling and linear extrapolation techniques.
- Forecast results are only 1% to 2% out as far as eight to nine years in the future.
- Implementation of end-use modelling techniques not required.

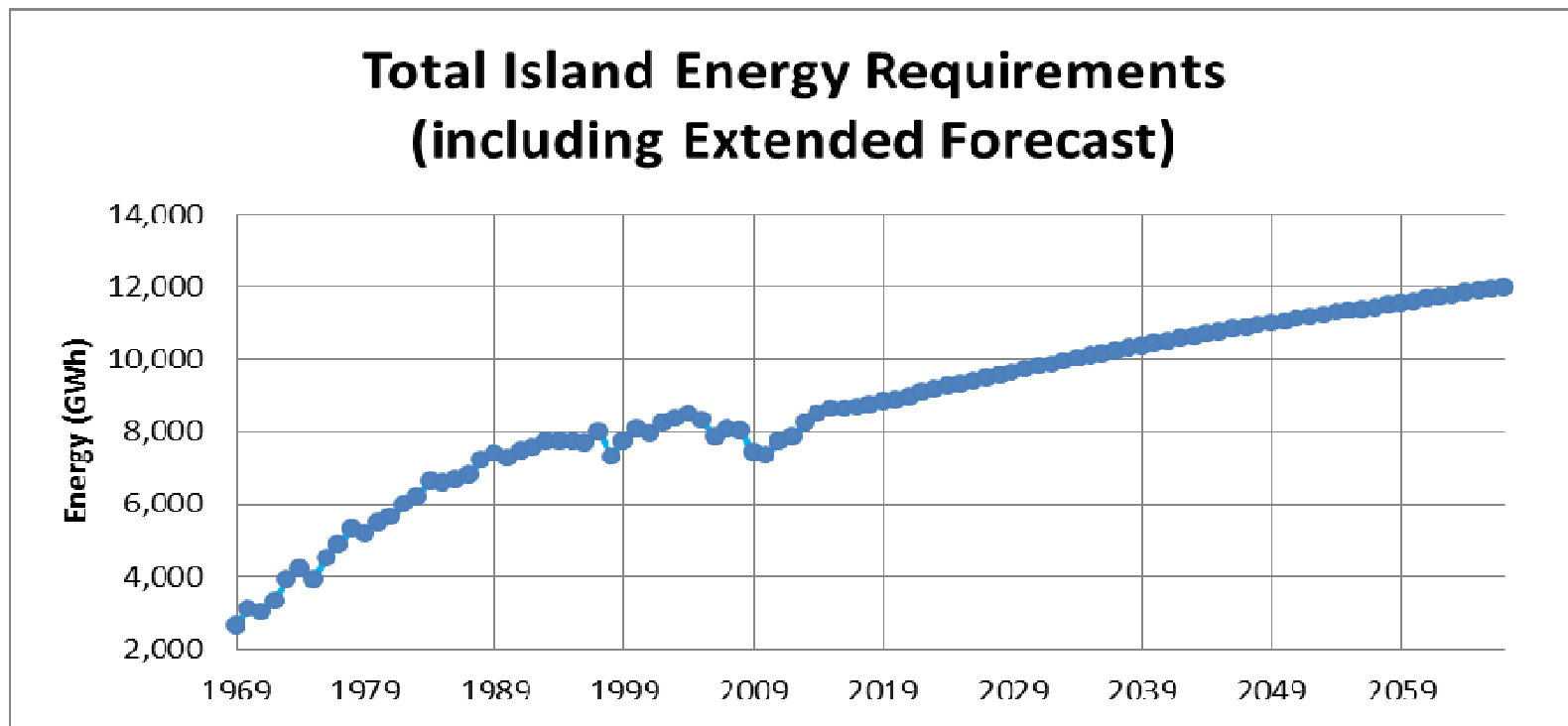
Industrial Sector

- Forecast accuracy has been adversely impacted by unforeseen plant closures
- The Load Forecast for this sector has consistently over predicted load growth due to unanticipated mill closures
- Future status of the existing pulp and paper mill is a critical component of the Industrial Sector Forecast

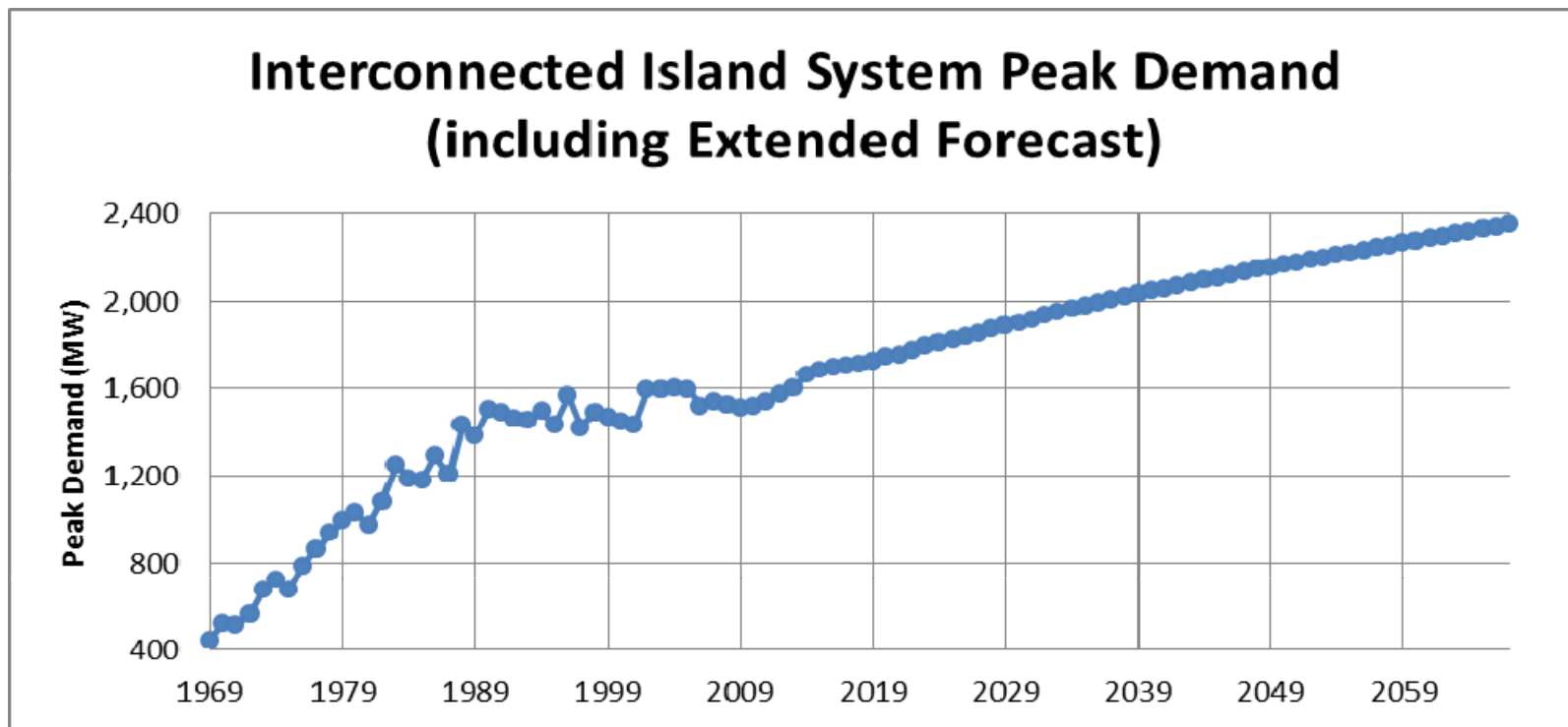
Industrial Load

- Total Island Industrial Load (2010): 1258 GWh
- The industrial load represents approximately 17% of total Island load
- Existing pulp and paper mill consumption (2010): 981 GWh
- This load represents approximately 13% of the total Island load in 2010
- The Vale load is forecast at 80 MW, 640 GWh in 2015.

Total Island Energy Requirements



Interconnected Island System Peak Demand



Load Forecast – Key Findings

- The load forecasting process was conducted with due diligence, skill and care and meets acceptable utility practices with the exception that end-use modelling techniques for domestic loads are not currently employed.
- The load forecasting process has produced reasonable results for the domestic and line loss sectors, excellent results for the general service sector, and very poor results for the industrial sector.

Load Forecast – Key Findings

- The domestic sector forecast consistently under predicts future energy needs at a rate of 1% per future year.

Although the magnitude of the forecast error is acceptable, the frequency of under prediction of energy consumption should be addressed.

Load Forecast – Key Findings

- In the next ten years, the load forecast performance should produce good results, if the remaining pulp and paper mill remains operational.

Conversely, the load forecast will significantly over predict electricity requirements, if the remaining pulp and paper mill closes.

Load Forecast – Key Findings

- In the long term, if the remaining pulp and paper mill stays operational, the load forecast is likely to under predict future requirements because the industrial forecast does not include any new loads for the study period.



RELIABILITY STUDIES

Power System Reliability

The NERC definition of “reliability” consists of two fundamental concepts:

- **Adequacy** is the ability of the electric system to supply power and energy requirements at all times, taking into account scheduled and reasonably expected unscheduled outages of system components.
- **Operating reliability** is the ability of the electric system to withstand sudden disturbances such as electric short circuits or unanticipated loss of system components.

For example, the loss of the HVdc Transmission line

Power System Reliability

- Two Categories of Reliability Evaluation
 - Deterministic
 - Subjective based on engineering judgement
 - Probabilistic
 - More accurate for reliability assessment
 - Recommended as an industry wide standard by working groups. For example, MISO reliability working group.

Power System Reliability

- The following are some examples where the industry performs probabilistic reliability studies:
 - Northeast Power Coordinating Council, Inc. (NPCC) performs annual LOLE studies for the region considering transmission restrictions.
 - Members of Midwest Independent Transmission System Operator, Inc. utilities as part Midwest Reliability Organization or ReliabilityFirst Corporation,
 - BC Hydro, Idaho Power, and the California ISO as part of the Western Electricity Coordinating Council (WECC)

Power System Reliability

- Examples of probabilistic reliability assessment projects:
 - BC Hydro for the Vancouver Island Transmission Reinforcement Project,
 - Manitoba Hydro's HVdc Bipole III alternatives,
 - Hydro One's studies on transmission planning and asset management in Ontario.

Power System Reliability

- MHI reviewed related information provided by Nalcor
 - Generation Expansion Plan Documents
 - Nalcor's Exhibit 106 "Labrador-Island HVdc Link and Island Interconnected Reliability"
 - Cigre HVdc Reliability Surveys
 - Gull Island HVdc Reliability Analysis Studies (1980's)

Power System Reliability

- Nalcor has established Generation Planning Criteria related to the reliability of the Island Interconnected system and the timing of generation additions.
- Nalcor's capacity criteria (adequacy) is Loss of Load Hours with a target of 2.8 hours per year.
- MHI considers this criteria reasonable.

Power System Reliability – Findings

- Probabilistic reliability models performed in the 1980s for the HVdc transmission system have not been updated by Nalcor.
- MHI finds that Nalcor's Forced Outage Rate (FOR) of 0.89% per pole for Labrador-Island Link is within the normally accepted range
- Labrador-Island Link FOR should be replaced by a more advanced and comprehensive reliability model incorporating all components of the Labrador-Island Link HVdc system

Power System Reliability – Findings (cont'd)

- Deterministic assessments, such as those performed by Nalcor, cannot quantify the true risks associated with a power system and are unable to provide some of the important inputs for making sound engineering and business decisions.
- Probabilistic reliability assessment studies including transmission considerations, have not been performed for comparison of the reliability between the two options.

Power System Reliability – Findings (cont'd)

- 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.
- Several Canadian utilities, NERC regions and members have adopted these probabilistic methods for reliability studies particularly for major projects.

Power System Reliability – Findings (cont'd)

- MHI recommends that these probabilistic reliability assessment studies be completed as soon as possible for both options under review. Such studies should become part of Nalcor's planning processes that would allow them to do a comparison of the relative reliability for significant future facilities.



AC INTEGRATION STUDIES

Integration Studies

- AC integration studies are necessary to assess the impact of new facilities on the existing electrical power system.
- Nalcor provided studies for a 1600 MW 3-terminal HVdc link between Labrador, Newfoundland and New Brunswick. The project definition changed at DG2 with the Muskrat Falls development.
- Nalcor initially indicated that studies for the new project configuration would be available by November 2011. This was later revised to March 2012.

Integration Studies

- Not having these studies completed introduces additional design or operational risks, or unknown capital costs in the generation expansion plan.

For example, additional transmission lines, additional ac equipment needed to regulate frequency or voltage, or back up generation to cover operational limitations of the Labrador-Island Link

Integration Studies

- A detailed AC integration study is required prior to DG3 to fully confirm the system requirements, operating parameters, and risks associated with the selected option.

Planning Criteria

- The Planning Criteria is a document that clearly identifies the parameters that would trigger system additions to meet operational criteria as a result of demand.
- Nalcor's Planning Criteria was provided for MHI's review along with a self-assessment of compliance to that criteria.
- In general, the transmission planning criteria in use at Nalcor follows best utility practices. It could be improved by referencing external/internal standards, etc.

NERC Standards

- Some key components of NERC standards include:
 - Reliability
 - Communication
 - Critical Infrastructure Protection
 - Transmission Operations
 - Transmission Planning
 - Personnel Performance, Training, and Qualifications
- Nalcor has stated they do not currently comply with NERC Standards.

NERC Standards

- Eight of ten provinces in Canada now follow NERC Standards
- Adoption of NERC standards is becoming synonymous with “good utility practice”.
- Application of NERC standards is important
 - When the Island interconnects to a neighboring utility.
 - Assurances on operational norms are part of interconnection agreements. NERC standards help define these norms.

AC Integration Studies – Key Findings

- Transmission Planning Criteria
 - Nalcor generally follows utility best practices
- AC Integration Studies
 - Studies completed prior to DG2 do not adequately describe facilities to operate the system under the new configuration
 - MHI finds the absence of these studies a major gap in Nalcor's work to date
- NERC Standards
 - Nalcor does not comply with NERC Standards
 - MHI recommends that Nalcor undertake a self-assessment and prepare for compliance to NERC Standards with or without the Maritime link.



HYDROLOGY STUDIES

Hydrology Studies

- MHI reviewed the engineering documents provided by Nalcor and their consultants related to hydrology for Muskrat Falls and the three small hydroelectric plants.
- MHI reviewed the time series river flows, head, and results the models provided.
- The software tools employed by Nalcor's consultants have been used on numerous hydropower projects globally.

Muskrat Falls – Hydrology Review

- Reviewed project layout and characteristics including:
 - Construction design flood estimate
 - Probable maximum flood
 - Spillway design
 - Numeric modelling of structures
 - Dam break analysis
 - Ice studies
 - Energy Estimates

Muskrat Falls Hydrology – Key Findings

- Muskrat Falls studies, provided by Nalcor, were conducted and prepared by qualified consultants in accordance with utility best practices, and with no apparent demonstrated weaknesses
- The energy and capacity estimates for Muskrat Falls were reviewed by MHI and confirmed to be reasonable for DG2.

Small Hydroelectric Power and Energy

- Island Pond
 - Energy is estimated at 186 GWh/year with a nominal capacity of 36 MW
- Round Pond
 - Energy is estimated at 139 GWh/year with a nominal capacity of 18 MW
- Portland Creek
 - Energy is estimated at 142 GWh/year with a nominal capacity of 23 MW

Hydrology – Key Finding

The key finding from the hydrology reviews is as follows:

- The Muskrat Falls studies were conducted in accordance with utility best practices, comprehensively, and with no apparent demonstrated weaknesses.

Also, the energy and capacity estimates for Muskrat Falls and the three small hydroelectric facilities on the island, which were prepared by various consultants using industry accepted practices, were reviewed and confirmed to be reasonable for DG2.



Generation Plan

INFEEED OPTION



Muskrat Falls Development

Conceptual Drawing of Muskrat Falls Generating Station

Muskrat Falls – Scope of Review

- Technical Review of the Muskrat Falls Development Included:
 - Review the proposed project layout and characteristics to identify any factors that might preclude successful development of the site;
 - Confirmation that the scope of work for the project is comprehensive as a basis for planning;
 - Assessment of the methods used for preparation of the project cost estimates; and
 - Evaluation of the construction schedule.

Muskrat Falls – Scope of Review

- Assessed methods used to prepare cost estimates
 - Nalcor used work breakdown structure approach
 - Extensive focus on:
 - Construction Labour Rates
 - Construction Materials
 - Construction Equipment
 - Project Management and Engineering
 - Provision made for contingencies and cost escalations
- The Capital Cost Estimate has increased by 104% between 1998 and 2010. This can largely be explained by changes in scope and inflation.

Muskrat Falls – Key Findings

- The proposed layout and design of the Muskrat Falls Generating Station appears to be well defined and consistent with good utility practices.
- The general arrangement of the permanent works is a reasonable proposal for the optimum development in terms of cost and construction duration.

Muskrat Falls – Key Findings

- Based on the information provided, the proposed design and construction schedule of Muskrat Falls Generating Station is consistent with good engineering and construction practices, and should not pose any unusual risks for construction or operation of the facilities.
- The available studies have identified technical risks and appropriate risk mitigation strategies.

Muskrat Falls – Key Findings

- Despite the increase in costs, MHI considers the cost estimate at DG2 to be within the accuracy range of an Class 4 estimate (+50%/-30%) which is representative of a feasibility level study.

Labrador-Island HVdc Transmission Link



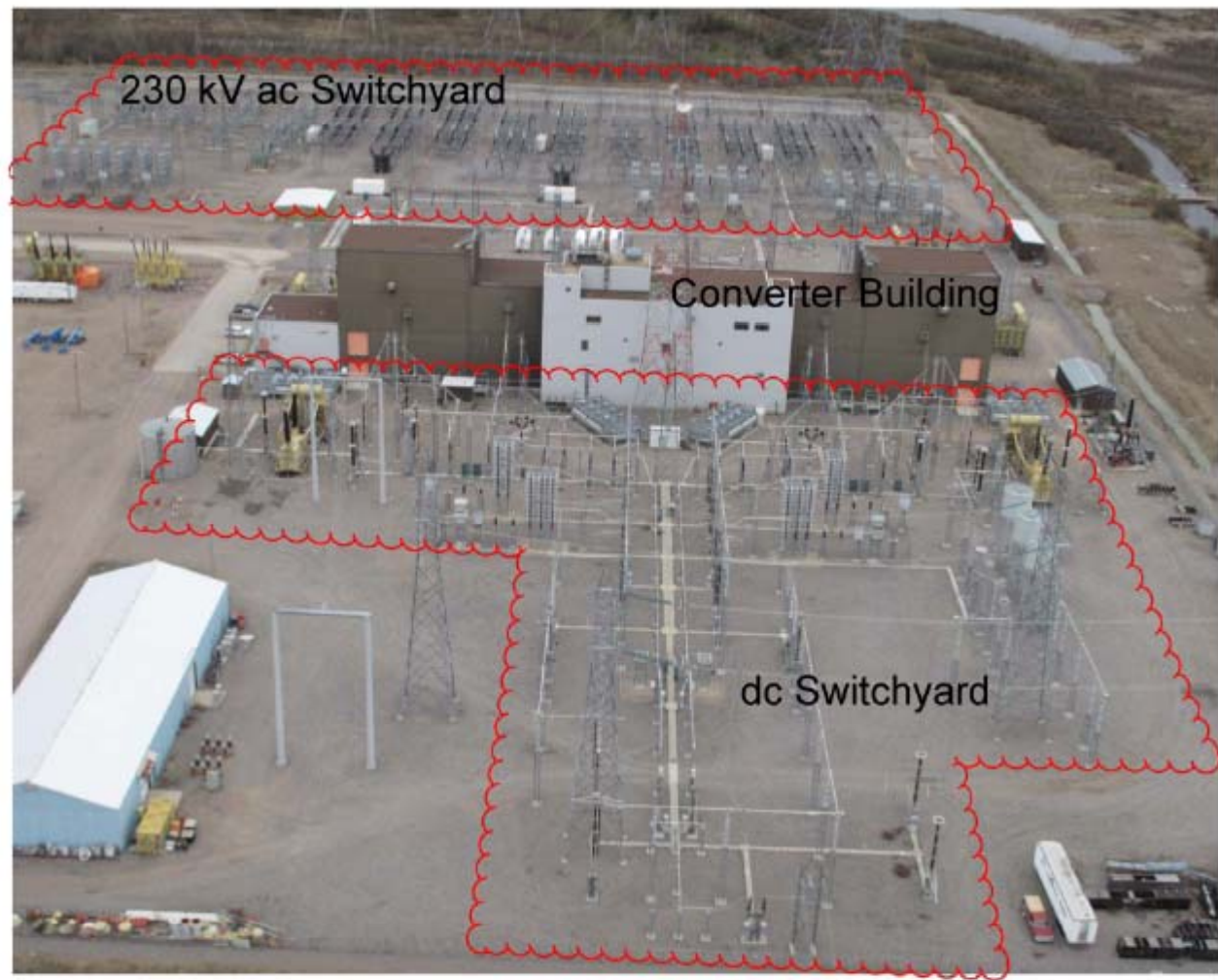
HVdc Converter Stations

- Muskrat Falls Converter Station
 - Each pole will operate at a nominal rating of 450 MW
 - Overload pole capacity of 150% or 675 MW continuous rating
 - Overload pole capacity of 200% or 900 MW for ten minutes (transient)
 - Without overload capability, the loss of the 450 MW for a pole outage could not be supplied without a backup supply and could lead to load shedding or a possible black-out

HVdc Converter Stations

Henday CS is presented as an example.

2000 MW
+/- 500 kV dc
230 kV ac

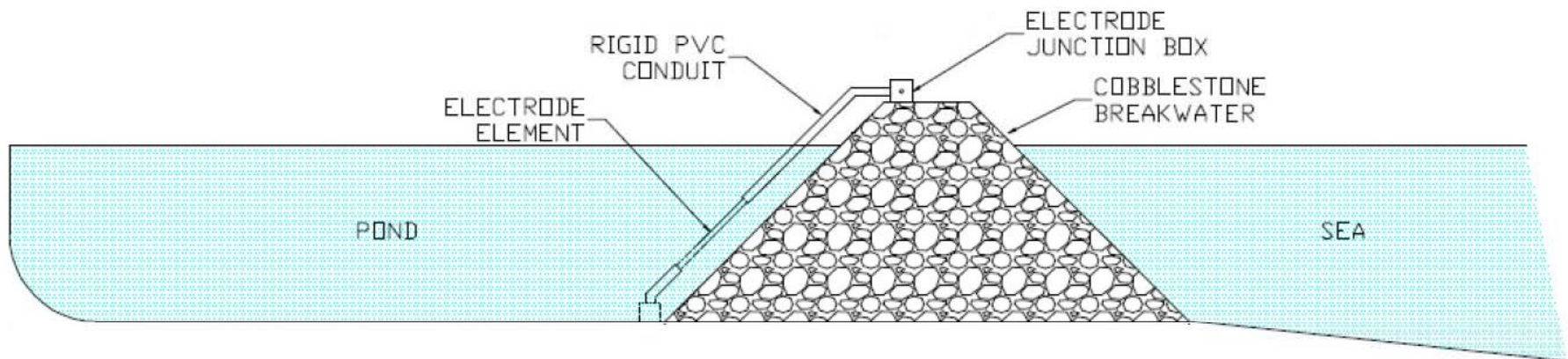


HVdc Converter Stations

- Soldiers Pond Converter Station
 - Design similar to Muskrat Falls converter station
 - Soldiers Pond has three 300 MVar synchronous condensers to support dc conversion and stabilize ac performance
- AC System Upgrades
 - Holyrood Units 1 and 2 will be converted to synchronous condenser units
 - A number of HV breakers will need to be upgraded as a result of higher fault currents

HVdc Converter Stations

- HVdc Electrodes – Distribution type line will be used to reach electrode site location



HVdc Converter Stations – Key Findings

- Most HVdc system documentation was not available such as converter station single line diagrams or a concept transition document since the project definition was changed at DG2. This hampered MHI's review.
- MHI found that the HVdc converter station system design parameters that were available for review are reasonable for the intended application.

HVdc Converter Stations – Key Findings

- The Labrador-Island Link design progression has specified LCC (line commutated converters) HVdc technology which is mature and robust for the application.
- The estimate for the HVdc converter stations and electrodes was reviewed by MHI and found to be within the range of a Class 4 estimate. The cost estimates for the synchronous condensers are low but are still within the range of a Class 4 estimate.

HVdc Converter Stations –Findings

- There was no comprehensive HVdc system risk analysis review of operations and maintenance done for HVdc Converter Stations or the operational aspects of the Labrador-Island HVdc system
 - Outages could be lengthy and repairs expensive
 - Risk analysis should be completed prior to completion of finalization of specifications of HVdc Converter Stations post DG2
- Functional specifications are being prepared by the EPCM contractor to be issued to HVdc suppliers as part of detailed design.

HVdc Transmission Line



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Infeed Option

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HVdc Transmission Line

- MHI reviewed the following exhibits
 - Ex 71-73, Various Metrological Studies
 - Ex 75-85, Climatological Reports 1977-1987
 - Ex 85, Reliability Study of Transmission Lines on the Avalon and Connaigre Peninsulas
 - Ex 91 “HVDC Labrador – Island Transmission Link Review of In-Cloud Icing on the Long Range Mountain Ridge”, 2009
 - Ex 92 “LCP – Preliminary Metrological Load Review”, 2008
 - Ex 95, “Evaluation of In-Cloud Icing in the Long Range Mountain Ridge”, 2010
 - Ex 96 “Evaluate Extreme Ice Loads From Freezing Rain for Newfoundland and Labrador Hydro”, 2010
 - Ex 97, “Review of Existing Meteorological Studies Conducted On The Labrador – Island Transmission Link”, 2011

HVdc Transmission Line

- Nalcor's decision to adopt the IEC Standard and CSA Code for design reliability is appropriate
 - However, Nalcor does deviate from code
 - Nalcor has used 1:50 year return period
 - Nalcor states that the HVdc line need not be designed at a level greater than that of the existing 230 kV ac system
 - A significant icing event could occur in an area remote from the 230 kV system which could down the HVdc line while all 230 kV lines are intact.

Transmission Line Reliability Criteria

- Examples of what other utilities are doing for critical lines that have an alternate supply
 - Manitoba Hydro Bipole III – 1:150 year return period
 - AltaLink – 1:100 year return with a 100% safety factor
- As the HVdc transmission line is a major component of the Island electrical system, given that the line has a singular failure mode, standards dictate a high reliability level.

HVdc Transmission Line

- Outages of the transmission line could be lengthy. If the primary source of power, then rotating outages to interconnected customers could be a reality, if the worst case scenario occurs.
- Length of outage can be mitigated with a well prepared response plan. As an example, best utility practice response plan could include:
 - Inventory of spare towers, conductor, insulators
 - Trained operators and construction forces
 - Mobilization and logistical plans
 - Equipment on site
 - Supply agreements in place with neighbouring utilities, consultants, contractors and manufacturers.

HVdc Transmission Line

- The two week repair period stated by Nalcor in their Exhibit 106 may not be realistic and is not an industry adopted metric.
- Remote regions in Newfoundland and Labrador may require additional infrastructure during periods when access is restricted.
- In Manitoba, in order to achieve a system wide two week repair target, additional berms, roads, and/or equipment located on site are required at many remote locations.

HVdc Transmission Line

- Alternate Supplies
 - Connection to the mainland via the Maritime link may be a viable alternate supply provided the interconnection agreement allows for this, and market conditions allow access to the power.
 - Stand-by thermal sources, CTs and CCCTs.
 - The Holyrood Thermal Generating Station.
 - Curtailable load.

HVdc Transmission Line – Key Findings

- MHI recommends that at a minimum a 1:150 year return period should be used for the design of the Labrador-Island Link HVdc transmission line
 - Design choice by Nalcor is contrary to Best Utility Practices in Canada
 - IEC Industry Standard 60826:2003 recommends a 1:500 year return period for critical single sourced power supply
 - Nalcor should consider enhanced reliability in the remote alpine regions considering potential access problems
 - As a minimum, 1:150 year return period is acceptable where an alternate supply is available

HVdc Transmission Line – Key Findings

- The capital costs for the HVdc overland transmission line fall within the range of an AACE Class 4 estimate but appear to be at the low end of the range
- Incremental cost to extend from 1:50 to 1:150 year return period is approximately \$150 million which is still within an AACE Class 4 estimate

Strait of Belle Isle Marine Crossing



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Infeed Option

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Strait of Belle Isle Marine Cable Crossing

- MHI reviewed the documentation related to the Strait of Belle Isle marine crossing including:
 - Exhibit 35 – Iceberg Risks to Submarine Cables in Strait of Belle Isle
 - Exhibit 37 – SOBI Decision Recommendation
 - Exhibit CE 41 – Feasibility Study of HDD for the Strait of Belle Isle
 - Exhibit CE 42 – Lower Churchill Project Rock Berm Concept Development Study
 - Exhibit CE 55 – Request for Proposal, Strait of Belle Isle Cable Crossing Supply and Install

Strait of Belle Isle Marine Cable Crossing

- Three cables – 36 km length (two load carrying; one spare)
- Width of Strait is only 18 km but cables will follow a circuitous route as a result of maximizing the depth of the cables
- Cable depth will be between 80 and 100 metres

Strait of Belle Isle Marine Cable Crossing

- Cables will enter Strait using horizontal directional drilling techniques to a water depth of 80 meters
- Rock berms will be placed over cables for protection against damage from anchors and fishing gear
- SOBI Crossing is a critical component of the Infeed Option
- Construction of SOBI Crossing is a complex undertaking

Iceberg Risk Assessment

- C-CORE developed a model to assess the probability of cable contact by icebergs
- Data indicated that icebergs scours were mostly present in deep water
- C-CORE postulated that these iceberg scours had taken place in previous glacial periods; however, this could not be positively confirmed.

Iceberg Risk Assessment

- Model results found that the probability of iceberg contact with a submarine cable was 1 in 1000 years at the depths planned for the marine crossing.
- The probability of contacting multiple cables was reduced with increased cable separation.
- Further investigation of iceberg scours and iceberg roll rates was recommended by C-CORE.

SOBI – Key Findings

- The selection of a ± 350 kV mass impregnated cable is an appropriate technology selection for the application of an HVdc marine crossing operating at ± 320 kV.
- Nalcor's total base cost estimate for the marine crossing at DG2 was reviewed and found to be within the range of a Class 4 cost estimate.

SOBI – Key Findings

- The iceberg risks are perceived to be significant. C-CORE has quantified the risks to be less than one iceberg strike in 1000 years. This risk is further mitigated with rock berms, and with increased cable separation
- Additional research, monitoring of iceberg roll rates, and bathymetric surveys of earlier iceberg scours should be done to provide a level of validation to further tune the iceberg strike risk model.

SOBI – Key Findings

- Application of a spare cable with as much separation as practical is a prudent design feature of the Strait of Belle Isle marine crossing considering the potential difficulties of bringing in repair equipment at certain times of the year.



Generation Plan

ISOLATED ISLAND OPTION

Holyrood Thermal Generating Station (HTGS)

- HTGS consists of three heavy fuel oil boilers for a combined net generating capacity of 466 MW.
- HTGS currently supplies approximately one third (up to 2,996 GWh annually) of the island's existing firm energy.
- The plant normally operates all three units during the highest customer demand periods of December through to March.

HTGS Life Expectancy

- As of 2011, units are 41, 40 and 31 years of age
- Operation beyond 50 years may not be viable
- Plant may become unsafe and unreliable to operate before the 2033/2036 planned replacement.

HTGS Life Extension

- Nalcor has included \$230 million in the Isolated Island Option to extend the life of the plant.
- Estimates were not based on detailed engineering but are considered a reasonable value for sustaining capital for the plant for DG2 purposes.

HTGS Pollution Control Equipment Additions

- Projected capital cost of \$603 million in service 2015
- Electrostatic precipitators
- Scrubbers
- Low NOx burners
- Upgrade will not reduce GHG emissions which could be problematic if emission standards change

HTGS Pollution Control Equipment Additions

- Not required to satisfy the current limit of 25,000 tonnes SOx emissions, even at full load.
- Continued use of 0.7% sulphur fuel satisfies the current Certificate of Approval
- Not required by current federal regulations but are based on government direction related to the Provincial Energy Plan.

HTGS Replacement

- The Holyrood replacement is anticipated to consist of 3 – 170 MW No. 2 oil-fired combined cycle combustion turbines installed in 2033 for Units 1 and 2 and 2036 for Unit 3.
- The technology and the costs for the replacement plant appear to be reasonable.

CTs and CCCTs

- The Isolated Island Thermal Generation Plan includes
 - Seven CCCTs
 - Nine CTs
- The technology and base costs assumed for the 50 MW CT and the 170 MW CCCT installations are reasonable.

Small Hydro Plants

- In-Service dates:
 - Island Pond – 2015
 - Round Pond – 2020
 - Portland Creek – 2036
- Project cost estimates and schedules are optimistic in light of more recent stringent environmental requirements.

Wind Farms

- One new 25 MW wind farm is proposed for 2014
- Two existing wind farms would be replaced after 20 years of service in 2028 and 2048
- Capacity factor of 40% is reasonable for a planning study.
- The estimated capital cost and operating expenses used in the CPW analysis are appropriate.

Wind Farms

- Nalcor's 2004 Study which specified upper limit of 80MW for non-dispatchable capacity is considered reasonable.
- Additional wind beyond 80 MW could result in potential spilling of water due to the limited hydraulic storage on the Island.



Cumulative Present Worth

CPW ANALYSIS

CPW Analysis

- Metric of Least Cost was not defined by Government in setting out its mandate to the Board
- CPW metric was defined by Nalcor (July 6, 2011 in letter to the Board)
- Focuses on Costs:
 - Capital Expenditures
 - Fuel Costs
 - Power Purchases
 - Operating Costs
- Excludes costs that are common to both Options
- CPW does not take cash inflows into account

CPW Analysis

- CPW approach is reasonable for purpose intended
- CPW Results as per Nalcor's Final Submission

Option	CPW Amount
Isolated Island	\$ 8.8 billion
Infeed	\$ 6.6 billion
Differential	\$ 2.2 billion

PPA Approach vs COS Approach

- Relates to Muskrat Falls Generating Station
- PPA – Power Purchase Agreement
 - PPA approach avoids impact of rate shock following implementation
 - Uniform rate over period under review
- COS – Cost of Service Approach
 - Rates impacted by carrying costs charged on undepreciated plant
 - Highest rate impact in early years following implementation
- Choice of approach has minimal impact on CPW result

Derivation of PPA Rate for Muskrat Falls

- Plant Cost input for Muskrat Falls based in 2010 \$
 - Assumed to be able to sell 100% output from plant
 - Target of 11% internal rate of return (IRR) on project cash flows.
-
- Resultant rate of \$75.82 per MWh in 2010\$, escalated at 2% per year, first applied with 2017 ISD.

PPA Rate for Muskrat Falls

- Using \$75.82 PPA rate and NLH volumes, results in IRR of 8.4%
- IRR of 8.4% is considered reasonable and positive relative to 8% weighted average cost of capital (WACC) approved by Board in recent rate applications

PPA Rate for Muskrat Falls – Take or Pay

- PPA rate is proposed to be fixed at time of signing PPA contract between Nalcor and NLH, based on then-current NLH planning load forecast.
- PPA contract will be take or pay for a 50-year term
- Minimum revenues from NLH to Nalcor for any given year will be fixed by contract
- If volumes exceed those in contract, unit rate will be, for example, \$75.82 per MWh (escalated)

Discount Rate Sensitivity

- Nalcor Used Discount Rate Based on Weighted Average Cost of Capital (WACC)
 - Debt: 75% weighting at 7.35% debt cost
 - Equity: 25% weighting at 10% equity cost
 - Weighted Average Cost of Capital is 8%
- WACC rate of 8% rate approved by Board in prior applications. WACC is reasonable proxy for discount rate

Discount Rate Sensitivity

- The discount rate would have to increase to 17.1% to make the options equal.

Discount Rate	8.0 %	17.1 %
Isolated Island	\$ 8.8	\$ 3.0
Infeed	\$ 6.6	\$ 3.0
Differential	\$ 2.2	\$ 0.0

Capital Cost Sensitivity

- Nalcor Study Based on DG2 Estimating Accuracy
 - If Both Muskrat Falls and Labrador-Island Link HVdc System capital costs increased by 25%, the CPW differential in favour of Infeed Option would be reduced from \$2.2 billion to \$1.2 billion
 - DG2 Level estimates have the potential for cost estimates to increase by as much as 50%
 - An increase of 50% could cause CPW differential between the two Options to essentially become equivalent

Capital Cost Sensitivity

- Capital cost sensitivity results for 25% and 50% increases

Option	Base Case	25%	50%
Isolated Island	\$ 8.8	\$ 8.8	\$ 8.8
Infeed	\$ 6.6	\$ 7.6	\$ 8.6
Differential	\$ 2.2	\$ 1.2	\$ 0.2

Load Forecast Sensitivity

- Nalcor assumed continuation of operation of pulp and paper mill
- Plant closure would result in increased generation capacity of approximately 880 GWh per year

Load Forecast Sensitivity

- Should the pulp and paper mill closure become a reality and not be replaced by any other load, the CPW differential will be reduced from \$2.2 billion to \$408 million, but still in favour of the Infeed Option

Option	Base Case	Plant Closure
Isolated Island	\$ 8.8	\$ 6.6
Infeed	\$ 6.6	\$ 6.2
Differential	\$ 2.2	\$ 0.4

Fuel Price Sensitivity

- Fuel Price forecasts provided by PIRA Energy Group
- PIRA provides: reference, low, high and expected price forecasts
- Using March 2010 PIRA low price forecast, CPW differential in favour of Infeed is essentially eliminated

Fuel Price Sensitivity

- Sensitivity results using a PIRA low price forecast

Option	Base Case	Low Price Forecast
Isolated Island	\$ 8.8	\$ 6.2
Infeed	\$ 6.6	\$ 6.1
Differential	\$ 2.2	\$ 0.1

- Fuel Price forecasting will remain a challenge over duration of period under review

Combined Sensitivities

- Changes to risk areas acting in unison could have major impact on shifting of the CPW differential
- Example One:
 - Fuel Cost decrease of 20%, and
 - Load Growth decrease of 20%, and
 - Capital Costs for Muskrat Falls and Labrador-Island Link increase by 20%
 - CPW essentially reduced to minimal differential
- Example Two:
 - Pulp and Paper Plant closure, and
 - Capital Costs of Muskrat Falls and Labrador-Island Link increase by 10%
 - CPW essentially reduced to minimal differential

Summary of Sensitivity Analysis

	Scenario	Isolated Island	Infeed	Differential
1	Base Case	\$ 8.8	\$ 6.6	\$ 2.2
2	LIL Cap Cost Increase by 25%	\$ 8.8	\$ 7.0	\$ 1.8
3	MF Cap Cost Increase by 25%	\$ 8.8	\$ 7.2	\$ 1.6
4	LIL and MF C.Cost Increase 25%	\$ 8.8	\$7.6	\$ 1.2
5	Pulp and Paper Mill Closure	\$ 6.6	\$ 6.2	\$ 0.4
6	LIL and MF Cost Increase 50%	\$ 8.8	\$ 8.6	\$ 0.2
7	Fuel Cost Decrease 20% + Load Growth Decrease 20% + LIL & MF Cap Cost Increase 20%	\$ 7.0	\$6.9	\$ 0.1
8	Fuel Costs – Low Price Forecast	\$ 6.2	\$ 6.1	\$ 0.1
9	Plant Closure + LIL & MF Cap Cost Incrs 10%	\$ 6.6	\$ 6.6	\$ 0.0
10	Fuel Cost Decrease of 44%	\$ 6.1	\$ 6.1	\$ 0.0

CPW Analysis – Key Findings

- MHI endorses the CPW method as a valid approach for comparing the least cost of the two alternatives
- Nalcor has determined that the CPW differential is favourable to the Infeed Option by \$2.2 billion relative to the Isolated Island Option
- CPW results for each Option have been validated by MHI based on inputs used by Nalcor at DG2

CPW Analysis – Key Findings

- However, the CPW results may be significantly impacted by variations from the base case used by Nalcor for changes to:
 - Significant additions/deletions of load, (for example: the continued operation of existing pulp and paper mill)
 - Capital costs (based at DG2 level of review)
 - Fuel prices (difficult to forecast over the long term)
- The risks associated with these inputs are further magnified given the length of the period (2010-2067) used in the preparation of the CPW analysis



Inclosing

CONCLUSIONS

Areas of Concern

- Reliability Assessment
- AC Integration Studies
- NERC Standards
- Transmission Line Design Criteria
- Complexity and Risks in the SOBI Marine Crossing
- Uncertainty with the continued operation of the Pulp and Paper Mill

Areas of Concern

- A firm commitment for a large industrial load in Western Labrador could change the Generation Expansion Plan.
- Fuel price forecasting will remain a challenge over the period under review.

Conclusion

- Overall, Nalcor's inputs (for example, the capital cost estimates, fuel pricing forecasts, and load forecasts) into the CPW were developed in accordance with utility best practices.
- The Infeed Option was found to be the least cost option of the two options reviewed, based on Nalcor's assumptions and the level of available information provided by Nalcor for DG2.

Thank you



February 15, 2012