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Auburn



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Todd Williams ---09/09/2011 08:23:19 AM---Thanks. Todd

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Thanks.

Todd

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I had been using just the electronic version, but think a hardcopy version would be handy today.

Thanks,

Todd

---

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**Discussion Draft – for Internal Use Only**

## **Independent Supply Decision Review**

Prepared for:



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September 9, 2011



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## 1 EXECUTIVE SUMMARY

Navigant was retained by Nalcor to undertake an independent review of Nalcor's Decision Gate 2 (DG2) Island Supply Decision covering two alternative cases for the long-term supply of electricity to the Island of Newfoundland: the Isolated Island case and the Interconnected Island expansion case.

- **Isolated Island:** The key elements of the Isolated Island expansion plan are the development of limited renewable resources in the near-term, pollution abatement, and life extension improvements at the Holyrood plant over the period from 2015 to 2018, replacement of the Holyrood plant and the continued development of thermal power resources across the planning period 2010 to 2067. This alternative would entail continued isolation of the Island power grid and the inherent supply and operational limitations associated with isolation.
- **Interconnected Island:** the Interconnected Island case would include two major new facilities: the Muskrat Falls generation facility and the Labrador-Island Link transmission facility. This alternative would interconnect the Island power grid with regional North American power grids and provide the capability to displace the Holyrood plant and meet the growth in provincial power requirements for years to come.

Specifically, Navigant was asked to review and assess the reasonableness of:

- The long-term Island supply options considered by Nalcor;
- Nalcor's assumptions associated with Island supply options; and
- The process followed to screen and evaluate the supply options.

Based on this review, Navigant was to provide an opinion on:

- Whether the Interconnected Island case represents the least cost option that also fulfills the additional criteria requirements of security of supply and reliability, environmental responsibility, and risk and uncertainty; and
- The accuracy of the rate projections given the underlying assumptions.

### Key Findings

Based on its independent review, Navigant has found that the supply options considered and assumptions used by Nalcor were reasonable, as was the process followed to screen and evaluate the supply options and to estimate the rate projections under the two cases.

Navigant believes that the \$2.2 billion Cumulative Present Worth (CPW, present value in 2010\$) preference for the Interconnected Island case as estimated by Nalcor in the DG2 decision case represents a reasonable estimate of the expected difference between the two cases.



All of the sensitivities explored by Navigant and Nalcor resulted in a CPW advantage for the Interconnected Island case. This clearly indicates that the DG2 decision preference for the Interconnected Island case was robust given the underlying risk and uncertainty in key assumptions as well as possible refinements to the Isolated Island case as identified by Navigant. ~~Further, currently available information—specifically, the updated May 2011 PIRA fuel forecast and recent federal load guarantee commitment—increases the preference for the Interconnected Island case.~~

Navigant's conclusion is that the Interconnected Island case is the long-term least cost option for the Island of Newfoundland within the context of the DG2 decision. Short-term increases in the real average regulated wholesale rate ~~tariff~~ would occur over the next few years under either case. Adjusted for inflation ~~However,~~ a gradual decrease in real average unit costs ~~rates~~ occurs for the Interconnected Island case ~~brings these rates back to current levels by 2067.~~

Relative to the Isolated Island case, the Interconnected Island case is also expected to provide similar levels of security and reliability (need to confirm), significantly reduced GHG emissions and, based on the sensitivity results ~~presented above~~, significantly less risk and uncertainty.

Navigant recognizes that further analysis will be undertaken by Nalcor in the period leading up to the Decision Gate 3 (DG3) decision. In order to provide a more robust decision, Navigant recommends that Nalcor undertake a more holistic, integrated approach in its development of options for and analysis for DG3 that would include: TO REVIEW WITH GILBERT

- Additional renewables, CDM and transmission expansions/upgrades, with a primary focus on their application in the Isolated Island case.
- Explicit consideration of the impact of potential GHG legislation on costs.
- Explicit identification and consideration of scenarios (plausible combinations of key assumptions) in its analysis with re-optimized expansion plans for each of the scenarios.
- Monte Carlo analysis of assumptions to more fully explore the variability in costs in the alternative cases being considered.

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## 2 INTRODUCTION

Nalcor is ~~proposing to move moving forward to plan the long-term electricity supply for the Island of Newfoundland. To that end, with major generation and transmission elements of the Lower Churchill Project and other generation resources to meet the electricity requirements of Newfoundland.~~ Nalcor has retained Navigant to conduct an independent review of this plan. This independent report summarizes Navigant's review.

### 2.1 Summary of the Situation

#### 2.1.1 Newfoundland Electricity System

The Island of Newfoundland is an isolated system with no connection to any other electrical system. This section describes the utilities, the generation, the transmission, and the load on the Island.

##### *Island Utilities*

Two regulated electric utilities serve the Island: Newfoundland and Labrador Hydro and Newfoundland Power. The utilities operate under the ~~jurisdiction regulations approved by of~~ the Board of Commissioners of Public Utilities of Newfoundland & Labrador (PUB), which has ~~regulatory authority jurisdiction~~ over rates, policies, capital expenditures and the issue of securities.

- **Newfoundland and Labrador Hydro** (~~"NL Hydro"~~) is a fully regulated, crown-owned electric utility which owns and operates facilities for the generation, transmission and distribution of electricity to utility, industrial and retail customers in the Province of Newfoundland and Labrador. It is primarily a wholesale and transmission utility, and Newfoundland Power is its largest customer.

NL Hydro serves approximately 31,000 residential customers in 220 communities across the province. NL Hydro also operates 21 diesel systems to provide service to 4,300 customers in isolated communities throughout coastal areas of Newfoundland & Labrador.

NL Hydro is a subsidiary of Nalcor. This report will use the term "Nalcor" both in reference to the parent company and the subsidiary unless there is direct reference to NL Hydro.

- **Newfoundland Power** ~~is~~ an investor-owned company, is primarily a distribution utility that ~~distributes-sells~~ electricity to approximately 86% or over 243,000 of the retail customers on the Island interconnected system. The Company generates approximately 7% of its electricity needs and purchases the remainder from NL Hydro.

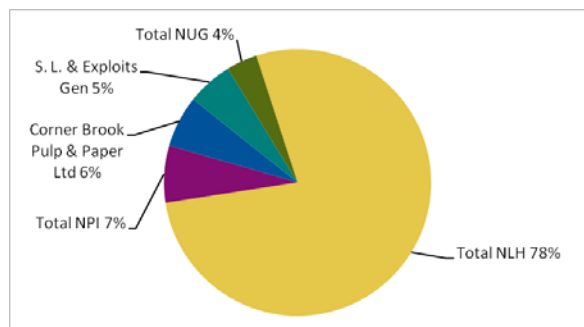
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## NAVIGANT

### Generation

The Island ~~interconnected electricity~~ system has a total generating capacity of 1,956 MW. Most of this capacity (78%) is owned by NL Hydro, with the remainder owned by Newfoundland Power, Corner Brook Pulp & Paper, Star Lake & Exploits River Generation, and non-utility generators (NUGs). ~~The non-utility generators NUGs~~ include 54 MW of wind, which is sold to NL Hydro.

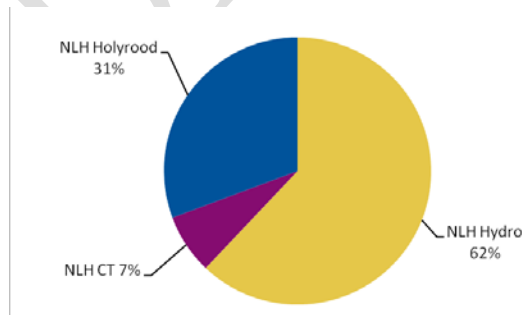
**Figure 1: Newfoundland Generation by Owner**



Source: Nalcor. "Synopsis of 2010 Generation Expansion Decision" Exhibit 13b. July 2011.

As shown in Figure 2, the majority ~~Most~~ (62%) of NL Hydro's ~~owned~~ generation capacity is hydro-electric, as shown in Figure 2, followed by the oil-fired Holyrood plant (31%) and oil-fired combustion turbines (7%). The Holyrood plant Units 1 and 2 came on line in 1971, Unit 3 came on line in 1979.

**Figure 2: NL Hydro Generating Capacity**



Source: Nalcor. "Synopsis of 2010 Generation Expansion Decision" Exhibit 13b. July 2011.

### Transmission

Figure 3 illustrates the Newfoundland and Labrador transmission system. The 230 kV transmission system east of Bay d'Espoir has a transfer limit of 365 MVA in the summer and 509

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S.L. & Exploits Gen should be Star Lake & Exploits Generation?  
Total NLH should be NL Hydro?  
Total NPI should be Newfoundland Power?  
Total NUG should be Other Non-Utility Generators?  
  
Consider adding # MWs

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MVA in the winter. The existing transmission system is operating near full capacity and efficient scheduling of existing hydro-electric and thermal generation is at times a challenge. This transmission capacity ensures the efficient use of the existing hydroelectric and thermal generation on the Island.<sup>1</sup> Figure 3 illustrates the Newfoundland and Labrador transmission system. Approximately 67% of the Island demand is located east of Bay d'Espoir.<sup>2</sup> This, coupled with transmission constraints noted above, creates voltage support requirements on the eastern part of the Island.

DRAFT

<sup>1</sup> "Nalcor Response to Panel Information Request March 21, 2011." April 1, 2011.

<sup>2</sup> "Nalcor Response to Panel Information Request March 21, 2011." April 1, 2011.



Figure 3: Newfoundland and Labrador Transmission

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Source: NL Hydro System Planning Department 2009.

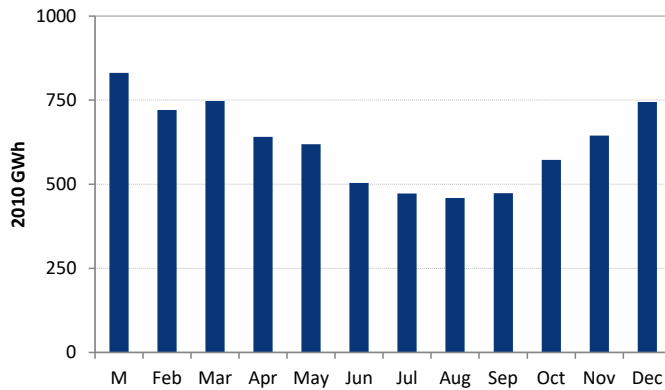
### Load

The Newfoundland Island Interconnected electricity system had a peak demand of 1,478 MW and an energy requirement of 7,608 GWh in 2010. Error! Reference source not found. Figure 4 presents monthly energy use, showing substantially higher winter energy use.



**Figure 4: Island Hourly Demand, 2010** Winter Demand is Substantially Higher than Summer (January label is misspelled in this chart)

Commented [AW6]: 8760 chart

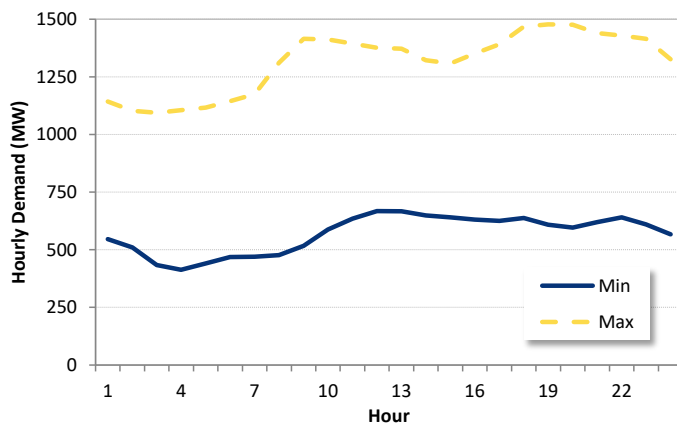


Source: Nalcor data for 2010 and Navigant analysis

Peak Electricity demand is typically highest in the colder winter months of January or February, in the evening. Nalcor NL Hydro defines the peak period as the morning period from 7:00 AM to noon and the evening period from 4:00 to 8:00 PM on the four coldest months days during the of December to March period; this is a total of 36 hours per year. As shown in Figure 5, peak day use is over twice as high as lowest day use.

**Figure 5: Minimum and Maximum Island Peak Daily Demand, 2010** Use is over Twice as High as Lowest Day Use

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Source: Nalcor

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~~Approximately 67% of the Island demand is located east of Bay d'Espoir.<sup>3</sup> This, coupled with transmission constraints noted above, creates voltage support requirements on the eastern part of the Island.~~

## 2.2 Options for Meeting Island Supply

NL Hydro conducted an optimization analysis to identify the best plan for meeting Island supply. The analysis involved considering the ~~cumulative~~ Cumulative present Present worth Worth (CPW) of different combinations of resources. The factors reflected in the CPW calculation included:

- capital cost of new facilities
- fuel cost
- line losses
- outage factors
- required environmental improvements
- operations and maintenance cost
- heat rates
- expected generation output
- discount rates

NL Hydro used the Strategist planning model to enumerate the different combinations and identify the least cost ones. The process resulted produced two alternative cases: the Isolated Island and the Interconnected Island expansion plans.

### 2.2.1 Isolated Island Expansion Plan

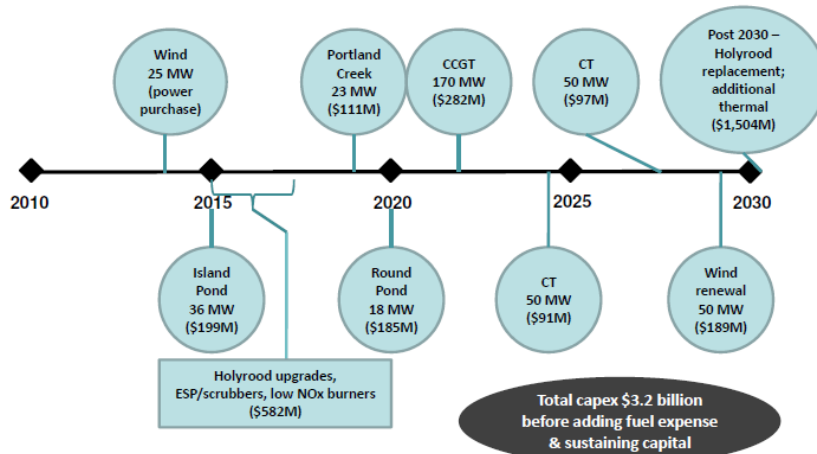
The key element of the Isolated Island expansion plan is pollution abatement and life extension improvements at the Holyrood plant over the period from 2015 to 2018. Environmental concerns related to emissions from Holyrood led the Province in the 2007 *Energy Plan* to direct NL Hydro install flue gas desulphurization (scrubbers) and electro-static precipitators at Holyrood, in the event the Lower Churchill Project does not proceed. These upgrades would allow the plant to operate until 2030. In addition, NL Hydro would also install several wind projects, combined cycle gas turbines, combustion turbines, and small hydro facilities, as shown in ~~Error! Reference source not found.~~ Figure 6.

<sup>3</sup> "Nalcor Response to Panel Information Request March 21, 2011." April 1, 2011.





**Figure 6 - Isolated Island Expansion Plan (to be updated)**



Source: Nalcor Energy. "Technical Briefing for Media." April 14, 2011

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## 2.2.2 Interconnected Island Expansion Plan

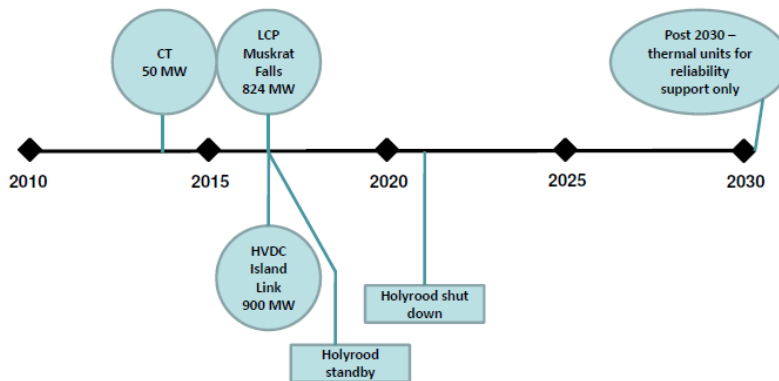
The Churchill River in Labrador is a source of renewable, clean electrical energy; however, the potential of this river has yet to be fully developed. The existing 5,428 MW Churchill Falls generating station, which began producing power in 1971, harnesses about 65 per cent of the potential generating capacity of the river. The remaining 35 per cent is located at two sites on the lower Churchill River, known as the Lower Churchill Project (LCP).

The LCP's two proposed installations, Gull Island and Muskrat Falls, would have a combined capacity of 3,074 MW with annual output of 16.7 Terawatt hours of electricity per year. That is enough to supply hundreds of thousands of households annually and contribute significantly to the reduction of air emissions from fossil fuel-fired power generation.

The Interconnected Island case would include two major new facilities: the Muskrat Falls generation facility and the Labrador-Island Link transmission facility. In addition, Nalcor would add a 50 MW CT in 2014, put Holyrood in standby mode in 2017 and shut it down in 2021, and add thermal units after 2030. The major components of the Interconnected Island case are presented in [Figure 7](#).



**Figure 7: Interconnected Island Expansion Plan (to be updated)**



**Commented [AW9]:** Consider updating figure with updated graphic to be provided by Nalcor

Source: Nalcor Energy. "Technical Briefing for Media." April 14, 2011

The proposed 1,100 km High Voltage direct current (HVdc) Labrador - Island Transmission Link (LIL) would be the first of its kind in Newfoundland and Labrador and would be constructed from Muskrat Falls, in the central region of Labrador, down to Soldiers Pond on Newfoundland's Avalon Peninsula.

### 2.3 Scope of the Independent Supply Decision Review

Nalcor charged Navigant with reviewing and assessing the reasonableness of:

- The long-term Island supply options considered by Nalcor;
- Nalcor's assumptions associated with Island supply options; and
- The process followed to screen and evaluate the supply options.

Based on this review, Navigant was to provide an opinion on:

- Whether the Interconnected Island case represents the least cost option that also fulfills the additional criteria requirements of security of supply and reliability, environmental responsibility, and risk and uncertainty; and
- The accuracy of the rate projections given the underlying assumptions.

The scope of the Independent Supply Decision Review does not extend to a review of the financing decision for Muskrat Falls or the monetization of any excess power from Muskrat Falls beyond the commitment for Muskrat Falls power assumed in the Interconnected Island case.



The inputs for Navigant's review include:

- Necessary financial and engineering models, reports, and discussions with management and personnel.
- The 2007 Energy Plan (available at [www.nr.gov.nl.ca/nr/energy/plan/](http://www.nr.gov.nl.ca/nr/energy/plan/)) that forms the policy framework used by Nalcor in determining the Island supply option.

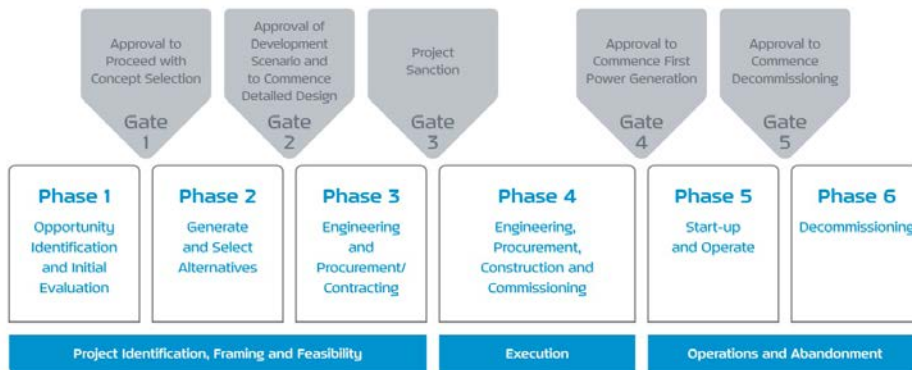
The Island supply option evaluation criteria used by Nalcor were:

- Security of supply and reliability
- Cost to ratepayers
- Environmental responsibility
- Risk and uncertainty
- Generally accepted utility practices for the evaluation of Island supply options.

Nalcor's Decision Gate process is designed to ensure decisions are made at appropriate times, with the appropriate levels of information, and at appropriate levels of expenditure. Nalcor's Decision Gate process focuses on key milestones to achieve gateway readiness and builds in "cold eyes" reviews at key decision points throughout the process. The process, illustrated in Figure 1, is a staged or phased decision gate assurance process that is used to guide the planning and execution of the Project from identifying the opportunity through determining how it should be developed (e.g. transmission access, plant capacity, etc.), obtaining project approvals, completing engineering and commencing construction. It serves as a means of quality assurance for key decisions at crucial points in a project's lifecycle.

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**Figure 8: Gateway Process**



The Island supply analysis recently passed through Decision Gate 2 (DG2). DG2 is of strategic importance to the LCP as it signifies that the development scenario, including phasing and



sequencing has been confirmed, and that Nalcor is ready to move forward with detailed engineering and procurement / contracting and prepare to commence early construction works following release from environmental assessment. During Gateway Phase 3, engineering will progress to a level of completeness required to facilitate the award of key construction and supply contracts required to maintain the overall project schedule as well as provide the level of cost and schedule certainty for the Decision Gate 3 (DG3) process.

Nalcor asked Navigant to:

1. Opine on the reasonableness of the process and decision based on the information available at the time of the DG2 decision
2. Observe whether current information reinforces the reasonableness of the DG2 decision.

Navigant will provide a second report using DG3 estimates and assumptions prior to the conclusion of the DG3 process.

Navigant's key findings with respect to the Nalcor's Gateway process and the level and accuracy of information considered by Nalcor in the DG2 Island Supply Decision are summarized below:

**1. Nalcor's Gateway process is a deliberate means of providing quality assurance for key decisions at crucial points in a project's lifecycle and is consistent with best practices.**

**2. Within the context of Nalcor's Gateway process, the level and accuracy of the information used in Nalcor's DG2 Island Supply Decision was appropriate for the decision stage.**

NB – Navigant's key findings elsewhere in this report are similarly highlighted at the end of the appropriate section.

## 2.4 Overview of this Report

The next section discusses reasonableness of the supply options considered, including whether other options should have been considered. This is followed by a review of the assumptions Nalcor used in screening those options. The fifth section discusses the process Nalcor used to screen the options. Section Six discusses the reasonableness of the rate impact analysis. The final section summarizes Navigant's findings.



### 3 REASONABLENESS OF THE ISLAND SUPPLY OPTIONS CONSIDERED BY NALCOR

This section presents Navigant's assessment of the reasonableness of the supply options considered and whether other options should have been considered in the Island supply decision. The specific options covered in this section are:

1. Hydro
2. Transmission
3. Other Renewables
4. Fossil
5. Nuclear, and
6. Conservation and demand management (strictly speaking not a supply option).

#### 3.1 Hydro

The hydro-electric generation options considered by Nalcor in the analysis were:

- Muskrat Falls and Gull Island in Labrador, and
- Island Pond, Portland Creek and Round Pond on the Island.

The cost and performance characteristics of these projects are relatively firm based on detailed engineering estimates and feasibility studies. Their inclusion as options in the analysis is reasonable.

While Gull Island was considered as a potential supply option by Nalcor, it was found to be much less economically attractive for the Island supply decision as compared to Muskrat Falls. This is primarily due to the fact that the isolated Island does not require all of the output of Muskrat Falls in the early years of the Nalcor analysis period. Since Gull Island would have significantly higher energy production than Muskrat Falls, a significantly higher percentage of Gull Island power would not be utilized in supplying the Island. Using the same pricing framework as used to determine the \$76 / MWh price of purchased power from Muskrat Falls (described more fully in section 4.2.94.2.9 *Power Purchases from Muskrat Falls* ~~Power Purchases from Muskrat Falls~~ on page 44), Nalcor estimates the price of purchased power from Gull Island would be approximately \$122 / MWh. Given this significantly higher price, Muskrat Falls was clearly a more economically attractive option to serve the Island than Gull Island.

Discuss Churchill Falls power becoming available in 2041– would incur the same transmission costs (in real \$) and would still incur most of the capital costs in the isolated Island case and all of the fuel costs through 2041. Also, reasonable to assume that sufficient transmission access to

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other markets would be available at that time so would be reasonable for Nalcor to consider the opportunity cost of power for Churchill Falls power. Don't want to have to do a sensitivity case, but "kill" it based on qualitative arguments. If do run sensitivity case, would need to consider unamortized capital costs for all fossil upgrades and expansions through 2041. Only thing you would avoid is fossil post 2041. Could consider a simplistic analysis as to whether the CPW delta for the Interconnected Island case through 2041 is still positive (this is relatively simplistic in that doesn't consider remaining PPA term for Muskrat Falls, but also doesn't consider unamortized capital for fossil upgrades – essentially, can Nalcor pursue Interconnected Island case through 2041 on a "no regrets" basis).

There are other potential hydro generation sites on the Island. In a 1986 study, Shawmont Newfoundland (Shawmont) identified 196 potential sites with capacities between 1 – 20 MW. Island Pond, Portland Creek and Round Pond were three of the sites identified in the Shawmont study. That Nalcor included these three undeveloped sites from the Shawmont study and excluded the others suggests that these three sites were more favourable to Nalcor given their combination of production costs, capacity factor and storage capabilities. As discussed below and in the following section, Navigant believes that the electricity from the other undeveloped sites in the Shawmont study would be significantly more expensive than wind power. Given this, Navigant believes that Nalcor's exclusion of other potential hydro facilities as options was reasonable.

In 1992, NL Hydro initiated a small hydro-electric facility procurement based on a ceiling price for of 6.68 cents per kWh for a plant with steady output year-round. A total of eleven bids were received<sup>4</sup> in mid-1993, and the four lowest cost bids (all of which had bid prices below the ceiling price) were offered contracts. Of these four contracts offered, two proceeded – Algonquin Power Inc.'s Rattle Brook and Abitibi-Price's Star Lake facilities – and the other two proposed facilities offered contracts were ultimately stopped through government regulations in 19XX [NTD – can Nalcor provide the date when this regulation was issued].

Assuming a two year construction cycle and given escalation in capital construction costs since 1992 and noting that the average cost for the seven proposals submitted as part of the procurement that were not selected by NL Hydro had an average bid price of \$66.51 / MWh (1993\$), Navigant expects that the cost of output from these potential facilities would be approximately \$114 / MWh<sup>5</sup> based on a Commercial Operation Date (COD) of 2015, exclusive of contingencies and transmission interconnection costs.

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**Commented [AW14]:** Please footnote calculation

<sup>4</sup> Newfoundland and Labrador Hydro, Tender Opening Record, Request for Proposals for Non-Utility Generation From Small Hydro Projects, RFP 92-195, August 13, 1993

<sup>5</sup> 1993 average bid price of \$66.51 / MWh for unselected bids has been escalated using the capital cost escalation for hydraulic plant construction per "Exhibit 3 NLH Escalation Indices at Jan 2010 PUB Review." The average escalation rate from 2000 – 2009 of 3% has been applied in the period from 1993 through 2009 and the projected escalation rate of 1.64% from 2010 through 2025 was applied post 2009. The escalated price was calculated as follows:

2015 price = \$66.51 / MWh x (1.03)^(2009 - 1993) x (1.0164)^(2013 – 2009) [with two year construction cycle to 2015]



Even if this potential resource was economically attractive, NL Hydro's transmission system does not currently have sufficient capacity to collect significantly more electricity from the central part of the Island and transmit this electricity to the Island's load centre in the Avalon Peninsula. Nalcor's Isolated Island case includes a transmission upgrade of NL Hydro's 230 kV network from Bay D'Espoir to the Avalon Peninsula largely to provide sufficient transmission capacity for the Island Pond, Portland Creek and Round Pond hydro facilities included in the Isolated Island case. Once these upgrades are completed in 2017, NL Hydro expects to have sufficient capacity to transmit approximately 100 MW more (above that necessary for the Island Pond, Portland Creek and Round Pond hydro facilities) from the central part of the Island to the Avalon Peninsula.

Assuming sufficient transmission capacity for additional hydro facilities beyond those in the Isolated Island case was available starting in 2017, incremental hydro production would not necessarily displace fossil-fuel fired thermal output at all times of the year. During some times of the year, incremental hydro production would increase the probability of spill at existing hydro facilities. NL Hydro estimates that load growth sufficient to ensure that all incremental hydro output displaces thermal output would not occur until approximately 2025 in the Isolated Island case. Given this, the output of other potential hydro facilities could not be fully utilized by NL Hydro until approximately 2025. Based on the same costing methodology as described previously, the expected production cost from the other potential hydro sites would be approximately \$134 / MWh based on a Commercial Operation Date of 2025, exclusive of contingencies and transmission interconnection costs, using the same escalation methodology as for the 2015 estimate provided above.

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Given the expected cost of electricity from other potential hydro facilities, Navigant believes that it was reasonable for Nalcor not to consider other potential hydro facilities as an option – particularly given the expected price and availability of wind power in Newfoundland and Labrador as discussed in the next section.

It should also be noted that given the relatively limited 100 MW of available transmission capacity after the planned 230 kV upgrade included in the Isolated Island case and the uncertainty surrounding the ability of the other potential hydro facilities to contribute to NL Hydro's peak capacity requirements, Navigant does not expect that additional hydro would obviate the need for the capacity available from Holyrood. This is also true for other renewable resources, such as wind, tidal or solar, that do not provide firm capacity.

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$$= \$66.51 / \text{MWh} \times 1.605 \times 1.067$$

$$= \$114 / \text{MWh}$$



3. Using the same pricing framework as used to determine the \$76 (2010\$) per MWh initial price of purchased power from Muskrat Falls, the initial price of purchased power from Gull Island would be significantly higher at \$122 (2010\$) per MWh. Given this higher price, it was reasonable for Nalcor not to include Gull Island in the Interconnected Island case.

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#### 4. Churchill Falls conclusion

5. Given that the expected cost of power from other potential hydro facilities would be substantially higher than wind power, it was reasonable for Nalcor not to include other potential hydro facilities in either system expansion case.

Navigant's key findings elsewhere in this report are similarly highlighted at the end of the appropriate section.

### 3.2 Interconnection Transmission

The HVdc Labrador-Island Link (LIL) was identified as the recommended option to serve the Island in the Interconnected Island case<sup>6</sup>. Nalcor also considered a number of other alternative transmission supply options for the Interconnected Island case including reinforcement of the existing AC system. However, given the existing AC transmission system on Newfoundland, supplying 930MW of power transfer capacity solely through AC system reinforcement would require at least four new 230kV transmission lines or two new 345kV lines east of Bay d'Espoir.

Commented [AW17]: Please provide rationale

Nalcor's Isolated Island case includes a transmission upgrade of NL Hydro's 230 kV network from Bay D'Espoir to the Avalon Peninsula largely to provide sufficient transmission capacity for the Island Pond, Portland Creek and Round Pond hydro facilities included in the Isolated Island case.

<sup>6</sup> "Synopsis of 2010 Generation Expansion Decision", July 6, 2011.



6. The transmission options considered by Nalcor in both system expansion cases were reasonable.

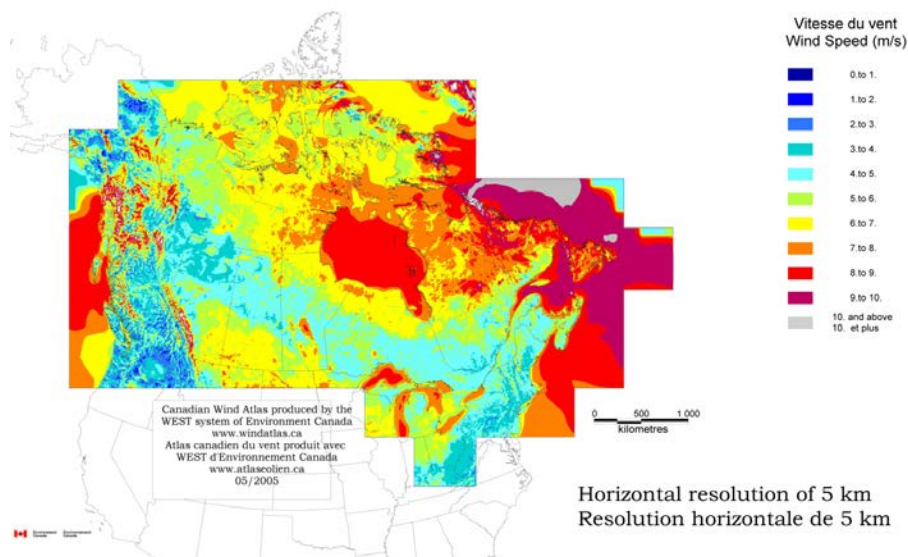
### 3.3 Other Renewables

#### 3.3.1 Wind

Newfoundland has abundant wind resources as shown in ~~Figure 9~~ ~~Figure 7~~. It was reasonable for Nalcor to consider wind in the supply decision. Nalcor included a 25 MW addition in 2013 in the Isolated Island, with renewal in 2029 of the 54 MW wind currently on line now.

Commented [AW18]: More direct; to discuss further development of this section

Figure 9: Wind Map of Canada (mean wind speed 50 m above ground)



Source: Environment Canada. [http://www.windatlas.ca/en/EU\\_50m\\_national.pdf](http://www.windatlas.ca/en/EU_50m_national.pdf). Downloaded 12 August 2011.

NL Hydro conducted a study in 2004 assessing non-dispatchable wind generation as an alternative to fossil based generation<sup>7</sup>. The study found:

- Additional amounts of non-dispatchable wind generation up to 80 MW may be incorporated into the system with little risk of additional spill

<sup>7</sup> Newfoundland and Labrador Hydro. "An Assessment of the Limitations for Non-Dispatchable Generation on the Newfoundland Island System. 2004.



- Amounts of non-dispatchable wind generation up to 130 MW may be integrated into the system as a whole without significant technical performance repercussions.

As discussed in the previous section, NL Hydro estimates that incremental renewable output of approximately 100 MW could displace thermal output at almost all times while still allowing the Holyrood units on-line to maintain their minimum output levels (in order to ensure they are able to respond to variability in wind output to maintain system stability) starting in 2025 in the Isolated Island case based on expected load growth. Forecast load growth in the 2025 to 2035 time frame would require additional thermal output which would enable up to 100 MW more wind power to be added in 2035 (again subject to the constraint of displacing thermal output at almost all times while still allowing the Holyrood units on-line to maintain their minimum output levels).

Commented [AW19]: To discuss – 800 MW wind on Island

Given this potential for limited amounts of renewable output to displace thermal output starting in approximately 2025 based on projected load growth, Navigant believes that Nalcor could have considered adding 100 MW of wind power in the Isolated Island case starting in 2025, plus another 100 MW of wind power in 2035, perhaps up to 100 MW more (for a total of approximately 275 MW) provided that the 130 MW wind capacity system constraints in the 2004 study can be addressed cost-effectively.

Commented [AW20]: Discuss

Navigant believes that 275 MW of wind power by 2035 should be considered as an upper limit given the need to maintain the Holyrood or other thermal units at minimum load to maintain their responsiveness to ensure system stability. Higher amounts of wind power would either require reducing the number of thermal units on-line at any one time (which would cause system stability problems) or curtailing wind output which would otherwise increase the purchase price for wind power (to ensure wind developers are able to earn their required revenue during those periods when they are not curtailed).

Graph of wind output profile for random week (or day) from 8760 wind output data from Nalcor with accompanying text.

Based on NL Hydro's projected cost of the 25 MW wind project planned for the Isolated Island case starting in 2014, Navigant estimates that the cost of wind power with a 2025 start date would be approximately \$112 / MWh (\$2025) and would escalate as per the current contracts. Note that this is significantly less than the estimated cost of \$134 / MWh from other hydro facilities with a similar Commercial Operation Date as described in section 3.13-1 Hydro/Hydro on page 13.

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To explore the impact of additional wind power on the costs for the Isolated Island case, Nalcor and Navigant ran a sensitivity analysis with 100 MW of additional wind power in 2025, and a further 100 MW of wind power in 2035.

For conservatism, this analysis also assumed that all of the additional wind power would be located on the Avalon Peninsula and, as result, would not require any significant transmission

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upgrades. The results of this sensitivity analysis are provided in Section 5.45.4 Uncertainty and Risk Analysis

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*This could be a new, standalone section 7 to be moved just before Key Findings and Conclusions* Uncertainty Associated with Key Inputs and the Related Risk for each Generation Supply Option Considered on page 52 and indicate that, even with significant level of wind generation, the Cumulative Present Worth estimates still favour the Interconnected Island case by approximately \$1.7 billion (2010\$).

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As with any incremental hydro, Navigant does not expect that 200 MW of incremental wind would obviate the need for the peaking capacity of the Holyrood facility.

7. Wind power is expected to be the lowest cost of the other renewable electricity supply options on the Island and Nalcor's inclusion of wind power in the Isolated Island case was reasonable.

8. Nalcor's Isolated Island case could have considered additional wind power - 100 MW in 2020<sup>5</sup> and a further 100 MW in 2035 - when such power would be expected to displace fossil fuel-fired generation most of the time.

9. The ability of the isolated system to integrate an additional 200 MW of wind power while still maintaining stable system operations would require more study. Integrating more than 200 MW of wind power would likely create system instability problems due to the limited ability of the Island's fossil and other generation facilities to moderate supply given the variability of wind power.

10. An additional 200 MW of wind power - which ~~does not~~ provides only limited and uncertain firm capacity during periods of peak demand - would not obviate the need for the firm capacity provided by the Holyrood facility.

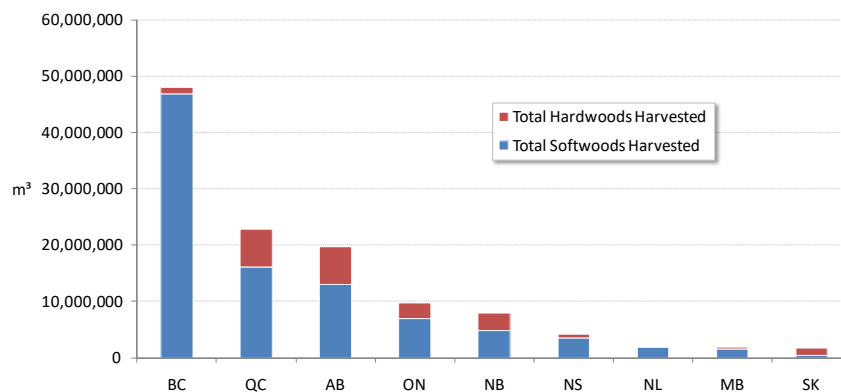
Commented [AW21]: Additional conclusion re: Holyrood not able to be replaced by wind



### 3.3.2 Biomass

Biomass is a relatively expensive form of electricity even where biomass resource availability and infrastructure to harvest the biomass resource are good. As shown in [Figure 10](#)~~Figure 108~~, Newfoundland and Labrador ranks seventh amongst Canadian provinces in terms of total forestry harvest.

**Figure 10: 2009 Forestry Harvest by Province**



Source: National Forestry Registry. [http://nfdp.cfm.org/index\\_e.php](http://nfdp.cfm.org/index_e.php). Accessed August 22, 2011.

Generally speaking, electricity production from biomass leverages the infrastructure used to harvest forestry products for other purposes (such as lumber and pulp and paper production). Hence, it is not surprising that British Columbia, with the highest forestry harvest, also has the most electricity (1,711 GWh in 2009) produced from wood and spent pulping liquor of all Canadian provinces<sup>8</sup>.

Based on recent Navigant work on several biomass projects, Navigant expects capital costs in the range of \$3,500 / kW and variable fuel costs (including harvesting and transportation) would fall in the range of \$50 - \$100 (2011\$) / MWh. Given these costs, Navigant estimates an all-in electricity cost (inclusive of capital recovery [depreciation, interest, debt service and equity return], fixed operating costs and variable fuel costs) in the range of \$150 - \$200 / MWh for NL.

Given the relatively limited biomass accessible through NL's existing forestry infrastructure and Navigant's estimated cost of electricity from biomass in NL (relative to NL Hydro's projected cost of \$94 / MWh (\$2014) for a wind power contract starting in 2014), Navigant believes that it was reasonable for Nalcor not to include biomass either system expansion case.

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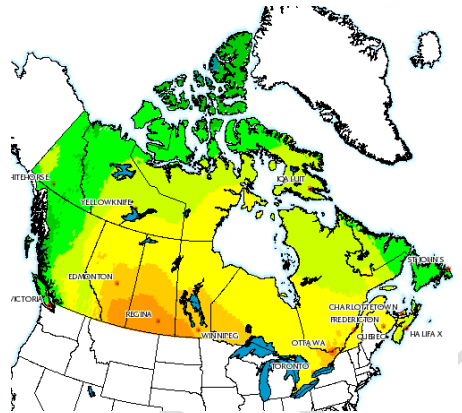
<sup>8</sup> Statistics Canada, Report on Energy Supply and Demand in Canada, 2009

## NAVIGANT

### 3.3.3 Solar

Newfoundland's high latitude (49° N) and cloudy conditions cause its insolation rates to be among the lowest in Canada, as shown in Figure 11.

**Figure 11: PV Potential and Insolation**



Source: Natural Resources Canada. "PV Potential and Insolation. [www.nrcan-rncan.gc.ca](http://www.nrcan-rncan.gc.ca). Downloaded August 5, 2011.

The U.S. Energy Information Administration estimates that the levelized cost of solar power installed in 2016 will range from \$159 to \$324 per MWh<sup>9</sup>. The cost of power from solar PV installations in Newfoundland is likely to be at or beyond the high end of this range due to Newfoundland's low insolation rates.

Due to Newfoundland's low insolation rates and the cost of power from solar PV installations, Navigant believes it was appropriate for Nalcor not to include PV generation in either system expansion case.

Commented [AW23]: Conclusion box

### 3.3.4 Wave and Tidal Power

Wave and tidal electricity generation has not been commercially applied in any meaningful quantities and does not appear likely to be commercially viable in the foreseeable future. As noted on the Wave Power in Canada web site:

*Although there are many companies that have overcome the challenges to harnessing ocean wave energy, there are still two main obstacles to overcome:*

<sup>9</sup> Ibid.



*Among the wide variety of wave energy systems, competing against each other, there is no clear technology leaders. The wave systems that are closer to a commercial stage cost about three times more than onshore wind systems.*

*Clearly it will take time along with government and investor support to overcome these obstacles. At present nobody is willing to even estimate the time required to identify the technology leaders and to make them cost competitive.*

Due to the as-yet unproven commercial viability of wave and tidal generation, Navigant believes it was appropriate for Nalcor not to include wind and tidal generation in either system expansion case.

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### 3.4 Fossil Fuel

NL Hydro currently uses oil-fired generation at its fossil fuel-fired facilities. As such, Nalcor's consideration of oil-fired generation as a supply option was reasonable. As discussed below and given the size and location of Newfoundland, Navigant does not believe there are any other physically or economically viable fossil fuels that warrant inclusion in the supply decision analysis.

#### Natural Gas

Natural gas is available as an associated product from Newfoundland's offshore oil production. Depending on the specific well conditions and natural gas volumes, natural gas may be pumped into existing oil wells to increase their yield. The closest natural gas pipeline is in Nova Scotia.

According to a 2001 Gas Pipeline Study<sup>10</sup> by the Government of Newfoundland and Labrador, the sustainable economic natural gas extraction rate needed to support a submarine natural gas transportation system offshore of Newfoundland and Labrador would be approximately 700,000 Mcfd<sup>11</sup> ~~and would require capital costs of almost \$6 billion (2000\$) and incur operating costs over a fifteen year period of more than \$4 billion (2000\$).~~ The Gas Pipeline Study also concluded that "Delivery of gas for domestic [provincial] use such as for power generation, industrial, commercial and residential is not economically feasible within integral development of delivery to Eastern Canada and the U.S.<sup>12</sup>" The peak demand for a 500 MW natural gas-fired CCCT of 84,000 Mcfd<sup>13</sup> would represent 12% of this "sustainable" extraction rate. As such, it would not be possible for

Commented [AW25]: Discuss reference to older study

<sup>10</sup> Technical Feasibility of Offshore Natural Gas and Gas Liquid Development Based on a Submarine Pipeline Transportation System, Offshore Newfoundland and Labrador, Final Summary Report to the Government of Newfoundland and Labrador, Department of Mines & Energy, Petroleum Resource Development Division, submitted by Pan Maritime Kenny – IHS Energy Alliance, October 2001

<sup>11</sup> 1Mcfd = 1,000 cubic feet per day ~ 1MMBtu per day

<sup>12</sup> Page 5.

<sup>13</sup> 500 MW x 7 MMBtu / MWh x 24 hours x 1 Mcf/MMBtu = 84,000 Mcf/day



Nalcor's potential natural gas demand for electricity generation to warrant development of such a submarine natural gas transportation system without securing significantly more commitments from other customers and regions to make up the remaining 88% of the "sustainable" extraction rate.

Because natural gas is not commercially available on the Island and there are, as yet, no firm commitments or government policy direction to either bring natural gas to the Island or to distribute it on the Island, Nalcor's exclusion of this option is reasonable.

#### Liquefied Natural Gas (LNG)

Commented [AW26]: Discuss build up of rationale

Another possible fossil fuel is liquefied natural gas (LNG). However, Navigant's analysis indicates that the cost of natural gas from such a facility would be significantly more expensive than oil.

Navigant explored the feasibility of a LNG regasification facility that would serve (and be located in the vicinity of) a 500 MW natural gas-fired CCCT. The regasification facility would in turn receive liquefied natural gas from offshore supply locations by ship.

As discussed in the previous section, the regasification facility would require capacity of just under 84,000 Mcfd if sized to meet the peak demand of the CCCT. This would translate into a facility that was significantly smaller than 'standard' in the LNG business. Regasification terminals are typically built with sendout capacities of 500,000 Mcfd to 4.0 Bcfd. Most LNG regasification terminals in North America have sendout capacities of 1 Bcfd or more. For example, the Canaport LNG facility in Saint John, NB has a reported send-out capacity of 1.2 Bcfd<sup>14</sup>.

The other aspect of the regasification facility is economics. While the capital costs for such a facility are unknown, the operating costs of typical LNG regasification facilities are typically in the \$1.50 to \$2.00 per Mcf range. Shipping costs from production areas can range depending upon distance from just less than \$1.00 per Mcf from Europe to almost \$2.50 per Mcf from the Middle East. Even deliveries from Trinidad – another potential supply location – would be expected to incur shipping costs of more than \$0.60 per Mcf, for a best case operating cost estimate of \$2.10 per Mcf (\$1.50 plus \$0.60 per Mcf).

The commodity costs for LNG also need to be considered. The current market price for LNG in Northwestern Europe is \$12 per Mcf. In Southwest Europe the market price is even higher.

Inclusive of operating costs and commodity LNG costs, the delivered natural gas cost from the regasification facility would be in the order of \$14 per Mcf (not including capital recovery on the

<sup>14</sup> According to the Canaport homepage at: <http://www.canaportlng.com/>



capital costs for the facility) based on current market prices for LNG. These delivered costs are significantly higher than current North American natural gas prices but there is currently no LNG export capacity in North America. If several pending North American LNG export projects go forward, this could become an option but it is unlikely that any North American exporters, having invested significant capital in the gasification and export facilities, would want to accept anything less than the market price for LNG (i.e., exporters would build the export facilities to access the global LNG market, not to sell natural gas at the North American market price).

Based on this analysis, Navigant has concluded that LNG is not an economic fossil fuel for the Island of Newfoundland and Nalcor's exclusion of this option is reasonable.

### *Coal*

With respect to coal-fired generation, Navigant notes the proposed federal regulation that would limit the CO<sub>2</sub> emissions from new coal-fired generating facility to that of a highly efficient combined cycle natural gas facility. This regulation is discussed in Section 4.2.8.4.2.8 Environmental Restrictions on page 42. Without some form of carbon capture and sequestration, a coal facility would not be able to meet this requirement. Given this, Navigant believes that Nalcor's exclusion of coal-fired generation as an option for Island supply was reasonable.

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**11. Nalcor's consideration of oil-fired generation, and exclusion of natural gas, LNG and coal as fossil fuel sources for electricity generation in both system expansion cases, was reasonable given the size, electricity consumption and location of Newfoundland and the unfavourable attributes of these other fossil fuels relative to oil in the context of the Island supply decision. Could expand or provide a conclusion for each fuel**

## 3.5 Nuclear

As a supply option alternative, nuclear generation was not considered by Nalcor. The primary reason for this omission is the fact that Newfoundland Electrical Power Control Act of 1994 establishes a policy which rejects consideration of nuclear power in power supply planning. Recent estimates of overnight nuclear generation capital costs set the cost range from \$5,339<sup>15</sup> to \$10,000/kW<sup>16</sup>. Using this range, a new 1,000 MW nuclear generation facility would cost between \$5.4 and \$10 billion.

<sup>15</sup> Source: Updated Capital Costs for Electricity Generation Plants – November 2010. US Energy Information Agency, Department of Energy. Available at [http://www.eia.gov/oiaf/beck\\_plantcosts/pdf/updatedplantcosts.pdf](http://www.eia.gov/oiaf/beck_plantcosts/pdf/updatedplantcosts.pdf)

<sup>16</sup> Source: The Brattle Group – "Prospects for a Nuclear Revival in the United States." February 2011. Available at [http://www.brattle.com/\\_documents/UploadLibrary/Upload921.pdf](http://www.brattle.com/_documents/UploadLibrary/Upload921.pdf)





It is also worth noting that nuclear generation cannot readily start up and stop or ramp up and down like fossil fuel-fired plants and storage hydro facilities and must generally operate at a steady output 24-7 as baseload generation. The typical size for new nuclear facilities is in the 1,000 MW per unit range, significantly more than the minimum demand on the Island. Such a facility could operate as baseload generation on the Island.

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There are additional barriers to nuclear generation. Due to the recent and ongoing events in Japan, the regulatory framework which governs new nuclear plant licensing has been shaken and has taken an increasingly conservative path with regards to the approval of new nuclear facility applications. Public perception of nuclear generation has also been greatly damaged, which would create substantial project risk even after the facility completes the permitting process. All these challenges coalesce to increase the timing risks (and associated costs) of new nuclear generation.

Given the stated policies, project capital costs and risk factors discussed above, Navigant believes it was appropriate for Nalcor not to include nuclear generation in either system expansion case.

### 3.6 Conservation and Demand Management

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Conservation and Demand Management (CDM) are resource options, although not “supply” options, strictly speaking. Nalcor incorporated “naturally occurring conservation” in its base load forecast (discussed further in Section 4.1) and considered additional conservation (energy efficiency) through the use of sensitivity analysis as described in Section 4.4 Uncertainty and Risk Analysis

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This could be a new, standalone section 7 to be moved just before Key Findings and Conclusions ~~Uncertainty Associated with Key Inputs and the Related Risk for each Generation Supply Option Considered.~~ It was reasonable to consider energy efficiency. The assumptions regarding CDM are discussed in Section 4.1.

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Nalcor did not consider demand response. Given the vast quantities of hydro storage available, shifting load from on-peak to off-peak is of limited value. Ceramic storage of electric heat is technically feasible, but has not seen significant commercial application. Navigant believes it was reasonable for Nalcor not to consider demand response in either system expansion case.

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## 4 NALCOR'S ASSUMPTIONS ASSOCIATED WITH ISLAND SUPPLY OPTIONS.

This section reviews the reasonableness of the assumptions Nalcor used with respect to the supply options it considered. These assumptions are grouped into:

- Demand projections
- Supply options characteristics
- Anticipated legislative mandates

### 4.1 Demand Projections

#### 4.1.1 Base Forecast

Nalcor used an econometric analysis that consists of multivariate regression equations that model various domestic and commercial electricity requirements as a function of population, income or gross domestic product (GDP), prices, housing and commercial stock, weather, and efficiency gains. This forecast does not explicitly consider utility or government sponsored efficiency.

Electric heat share is expected to increase from 59% in 2010 to 66% in 2029<sup>17</sup>. The prevalence of electric heat as a driver of demand and energy is expected to continue in view of recent and forward looking energy prices which impact equipment and fuel choice decisions for space heating<sup>18</sup>. Heating requirements are driven by both temperature and wind.

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Other key assumptions to the forecast:

- Single Island newsprint mill and oil refinery operations are maintained;
- Teck Resources mine expected to operate through 2013;
- The Vale Inco NL nickel processing facility is scheduled to be provided a transmission connection in late 2011 with commercial production expected in the 2013 to 2014 time frame; and
- Economic growth resulting from the development of the Hebron oil field.

The results of the 2010 load forecast analysis yield a projection of 1.2% demand and 1.3% energy growth over the 20 year period from 2010 to 2029. After the Vale plant comes on line in 2015, the projected growth drops to 0.8% and 0.7% for demand and energy from 2015-2029.

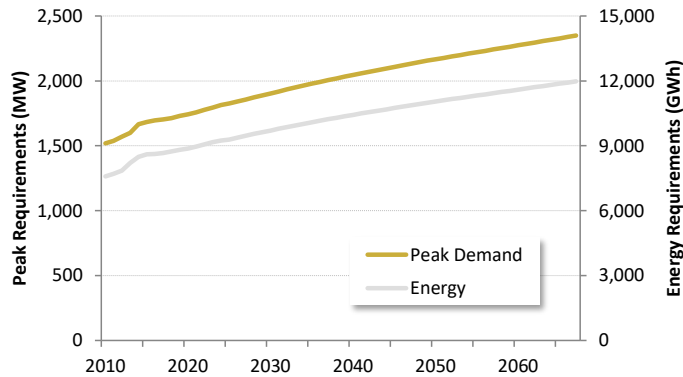
<sup>17</sup> "Synopsis of 2010 Generation Expansion Decision" Exhibit 1 Addendum, July 2011.

<sup>18</sup> "Nalcor Response to Panel Information Request March 21, 2011." April 1, 2011.



Figure 12 presents the forecast peak demand and energy requirements for the Island.

**Figure 12: Newfoundland Peak Demand and Energy Requirements**



Source: Nalcor. "Synopsis of 2010 Generation Expansion Decision" Exhibit 13b. July 2011

The energy growth projected post-Vale from 2015 to 2029 is lower than the EIA projection for the U.S. of 0.8%.<sup>19</sup> The Canadian National Energy Board projects a 1.6% growth rate in electric generating capacity for the country as a whole from 2008 to 2020<sup>20</sup>.

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**12. Nalcor's base forecast for demand and energy growth is reasonable.**

#### 4.1.2 Conservation and Demand Side Management Projections

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Many utilities in North America are conducting conservation and demand-side management (CDM) programs. Aggressive pursuit of CDM by NL Hydro, Newfoundland Power, and/or the government could potentially reduce demand for electricity. This potential is addressed below.

The energy reduction and cost effectiveness of energy efficiency measures in Newfoundland is significantly reduced in many cases because of the interactive effects with heating, particularly in electrically-heated buildings. As noted in a study by Canada Mortgage and Housing Corporation<sup>21</sup>, the impact of a 318 kWh savings from five compact fluorescent bulb retrofits is reduced by 270 kWh (85%) if the building is electrically heated and not cooled. This configuration is common in Newfoundland where, as noted above, the saturation of residential electric heat is 59% and growing, and residential air conditioning load is near zero. This effect

<sup>19</sup> U.S. Energy Information Administration. *Annual Energy Outlook 2011*. Electricity Supply, Disposition, Prices, and Emissions, Reference case.

<sup>20</sup> Canadian National Energy Board. "2009 Reference Case Scenario: Canadian energy demand and supply to 2020."

<sup>21</sup> Canada Mortgage and Housing Corporation. "Benchmarking Home Energy Savings from Energy-Efficient Lighting." January 2008.



has also been noted by the CANMET Energy Technology Centre, which has stated “The reductions in the lighting energy use are almost offset by increase in the space heating requirements.”<sup>22</sup> This effect would be similar for any efficiency measure installed in an electrically heated home without cooling.

The next section discusses projections for CDM. This is followed by discussion of the current CDM programs, then the potential effect on the forecast of aggressive CDM.

#### *The Potential for CDM in Newfoundland and Labrador*

NL Hydro and Newfoundland Power commissioned a study of conservation and demand management in 2008.<sup>23</sup> Marbek, a reputable consultancy based in Ontario, conducted the analysis. The study considered the technical, economic, and achievable potential for CDM in the residential, commercial, and industrial sectors from 2006 to 2026. Marbek used an avoided cost of new electricity supply for this analysis of \$0.0980/kWh for the Island and Isolated service region. The avoided costs are developed from the framework of an earlier study conducted by NERA Economic Consulting<sup>24</sup>. Because of the abundant hydro storage, there is no daily, monthly or seasonal variation in marginal energy cost. These avoided costs represent a future in which the LCP is not built and there is no transmission link from Labrador to the Island. The avoided costs used in this study include generation, transmission and distribution.

The achievable potential is the proportion of the savings identified in the economic potential forecast that could be achieved within the study period. Achievable potential recognizes that it is difficult to induce customers to purchase and install all the electrical efficiency technologies that meet the criteria defined by the Economic Potential forecast. The results are, therefore, presented within an “upper” and “lower” range. The upper achievable potential assumes a very aggressive program approach and a very supportive context, e.g., healthy economy, very strong public commitment to climate change mitigation, etc.

#### *Current CDM Programs*

Current CDM programs include utility programs and government programs as described below.

<sup>22</sup> CANMET Energy Technology Centre – Ottawa. “Benchmarking of Energy Savings Associated with Energy Efficient Lighting in Houses.” July 2005.

<sup>23</sup> Conservation and Demand Management (CDM) Potential Newfoundland and Labrador: Residential, Commercial and Industrial Sectors. Prepared by: Marbek Resource Consultants Ltd. January 31, 2008.

<sup>24</sup> NERA Economic Consulting. “Newfoundland and Labrador Hydro. Marginal Costs of Generation and Transmission.” May 2006



### Utility Programs

NL Hydro and Newfoundland Power jointly filed with the PUB a 5 Year Energy Conservation Plan (ECP) plan in June 2008<sup>25</sup>, outlining a target of 79 GWh/year savings by the Plan's final year in 2013. This plan will be updated in 2011 as a joint utility effort and will explore an expansion of programs and increased savings targets. To date, the utilities have seen lower than predicted initial savings, but with positive signs of growth. The ECP reflects the key roles of each utility – NL Hydro as the primary generator of electricity for the province and Newfoundland Power as having the majority of the customer base. The resulting CDM programs are then administered by the utilities to their direct customers, meaning Newfoundland Power is the administrator of the majority of the commercial and residential programming and NL Hydro for the industrial sector. Jurisdiction for these programs rests with the PUB, and NL Hydro and Newfoundland Power file annual activity reports with the PUB.

takeCHARGE is a joint utility energy efficiency program administered by Newfoundland Power and Newfoundland & Labrador Hydro. NL Hydro launched programs in 2009. takeCHARGE residential rebate programs for insulation, thermostats and ENERGY STAR windows, commercial lighting program

NL Hydro issued a request for proposals for the design and possible implementation of a residential coupon based energy efficiency program. An industrial energy efficiency program was launched in 2010.

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NL Hydro and Newfoundland Power expects to achieve 10.4 GWh and 2.1 MW of savings in 2011, as shown in Table 4-1.

**Table 4-1. CDM Savings 2009-2011**

|                 | 2009 | 2010 | 2011 (Forecast) |
|-----------------|------|------|-----------------|
| Energy (GWh/yr) | 2.7  | 5.2  | 10.4            |
| Demand (MW)     | 0.9  | 1.7  | 2.1             |

Source: Nalcor Response to Panel Information Request March 21, 2011. April 1, 2011.

### Government Programs

Three government programs provide opportunities for residents and businesses in the province.<sup>26</sup>

1. **Newfoundland and Labrador EnerGuide for Houses Program.** This program provides \$300 towards the cost of a home energy evaluation and a grant of up to a maximum of \$1,500 for specified energy efficiency improvements.

<sup>25</sup> SOURCE

<sup>26</sup> <http://www.takechargenl.ca/ProgramsAndRebates/MoreRebatePrograms/>. Downloaded August 4, 2011.



2. **Residential Energy Efficiency Program (REEP).** Offered through Newfoundland and Labrador Housing, REEP is designed to assist low-income households in making energy efficient retrofits to their homes. Owners of single, row and semi-detached housing may be eligible for a grant up to \$3,000 per unit on the Island and \$4,000 per unit in Labrador. In addition, funding is provided for the completion of a pre and post-energy inspection of the home.
3. **Natural Resources Canada ecoENERGY Retrofit Incentive for Buildings.** Owners of small and medium-sized buildings in the commercial and institutional sectors can receive up to \$10 per gigajoule of estimated energy savings, 25% of eligible project costs or \$50,000 per project.

#### **Potential Effect on the Forecast of Aggressive CDM**

Nalcor and Navigant modeled two sensitivity cases that provide insight into the effects of CDM programs. These cases assumed that CDM equivalent to that projected by the Marbek low and high achievable amounts would be realized in the Isolated Island Case. These cases examined whether additional, aggressive CDM could make the Isolated Island more cost effective than the Interconnected Island case. The results of both the sensitivities found that, as discussed in Section 5.4.5.4 *Uncertainty and Risk Analysis*

*This could be a new, standalone section 7 to be moved just before Key Findings and Conclusions. Uncertainty Associated with Key Inputs and the Related Risk for each Generation Supply Option Considered* on page 52, the CPW of the Interconnected Island case is still less than the Isolated Island in both sensitivity cases.

13. **Aggressive pursuit of CDM would not make the Isolated Island case more economic than the Interconnected Island case.**

## **4.2 Supply Option Characteristics**

### **4.2.1 Capital**

While the two cases evaluated for meeting the Island supply entail numerous capital additions over the analysis period, the major projects from a near-term capital cost perspective are the Muskrat Falls Generation Facility and the Labrador – Island Transmission Link which are planned for commercial service in 2016. These facilities are projected to cost \$2,869 million and \$2,060 million, respectively, both in nominal dollars and including estimated contingencies and escalation allowances. These estimates include the base costs for the projects along with allowances for contingencies and escalation. However, the estimates do not include Allowance for Funds Used During Construction (“AFUDC”). This could be substantial as a multi-year construction period is involved. According to Section 2 of the August 9, 2011 “Muskrat Falls Generation Facility and Labrador-Island Link Overview of Decision Gate 2 Capital Cost and Schedule

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*Estimates", Interest During Construction provisions are excluded. TBD with Nalcor re: use of interest during construction period or return on capital employed during construction?*

The Base Estimate was developed using four key inputs: (i) scope, (ii) construction methodology and schedule, (iii) price factors and (iv) performance factors. With respect to estimating capital costs, the projects were divided into the major construction components (e.g., powerhouse, dams, turbines, submarine cables, transmission towers, converter stations) for which the costs of materials, labor and equipment were estimated. Indirect costs and support facilities were added to the estimates. The following table shows a breakdown of the final DG2 Base Estimate.

**Table 2: DG2 Base Cost Estimate**

| Component   | DG 2 Base Estimate<br>(Direct 2010\$ millions CAD) |
|---|--|
| <b>Muskrat Falls</b>  |  |
| Site Preparation, Access and Reservoir Clearing                               | \$149  |
| Accommodations Complex, Supporting Infrastructure, Site Services and Catering | \$224  |
| Main Excavation Works   | \$77   |
| Intake, Powerhouse, Turbines and Generators                                   | \$846  |
| Spillway Structure  | \$121  |
| RCC Dams (North & South), Cofferdams, and North Spur Stabilization            | \$153  |
| Switchyards and MF to CF Transmission Lines                                   | \$261  |
| Owner Team, EPCM, Insurance, and HADD   | \$375  |
| <b>MF Total</b>   | <b>\$2,206</b>                                     |
| <b>Labrador-Island Link</b>   |  |
| Converter Stations and Electrodes   | \$432  |
| SOBI Crossing   | \$312  |
| HVdc Overland Transmission  | \$434  |
| Island System Upgrades  | \$194  |
| Owner Team, EPCM, Insurance, and HADD   | \$244  |
| <b>LIL Total</b>  | <b>\$1,616</b>                                     |
| <b>Grand Total</b>  | <b>\$3,822</b>                                     |

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With respect to the contingencies, a probabilistic tactical risk assessment was employed. This assessment considered the impact of a combination of such factors as schedule, performance factors and price risks on the Base Estimate. The assessment entails developing high and low ranges for each major cost item predicated on the uncertainties associated with each of the four key inputs. Based on the results of the risk assessment, a Contingency Component of \$564 million, or 15 percent of the Base Estimate, was considered appropriate and has been incorporated in the capital estimates (\$328 million for Muskrat Falls and \$236 million for the Labrador – Island Link).

While inflation has historically been treated in a simplistic manner, e.g., an overall rate applied across the project, Nalcor recognized that because of changes in the economic climate, a more sophisticated approach to developing the Escalation Component was warranted. In connection with the Escalation Component, recommended best practices were developed. Based on the identified best practices, a methodology for estimating cost escalation linking estimated capital costs with project scheduling was developed. This methodology provides escalation estimates on commodity, project component and aggregate levels that ultimately produced escalation index categories for each line item. Indices provided from forecasting services were applied to the escalation index categories resulting in cumulative escalation factors for the two projects as shown in the table below.

**Table 3: Escalation Factors (%)**

| Component                         | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Estimated Cumulative Escalation |
|-----------------------------------|------|------|------|------|------|------|------|------|------|---------------------------------|
| Muskrat Falls Generating Facility | 1.00 | 1.02 | 1.05 | 1.11 | 1.16 | 1.20 | 1.23 | 1.26 | 1.30 | \$335 million                   |
| Labrador – Island Trans. Link     | 1.00 | 1.02 | 1.04 | 1.08 | 1.12 | 1.16 | 1.20 | 1.24 | 1.29 | \$208 million                   |

Combining the three components described above, with one minor adjustment for pre-2010 historical costs, results in the projected capital costs listed in the introduction to this section as shown in the following table.

**Table 4: Summary of Muskrat Falls and Labrador-Island Link Capital Cost Estimate (\$ millions CAD)**

| Project                           | Base Estimate | Historical Cost (pre 2010) | Adjusted Base Cost (Base Cost – Historical) | Estimate Contingency | Escalation Allowance | Total Project Cost (Escalated Nominal) |
|-----------------------------------|---------------|----------------------------|---|----------------------|----------------------|--|
| Muskrat Falls Generating Facility | \$2,206       | \$20                       | \$2,186                                     | \$328                | \$335                | <b>\$2,869</b>                         |

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|                                     |         |      |         |       |       |                |
|-------------------------------------|---------|------|---------|-------|-------|----------------|
| Labrador – Island Transmission Link | \$1,616 | \$42 | \$1,574 | \$236 | \$208 | <b>\$2,060</b> |
|-------------------------------------|---------|------|---------|-------|-------|----------------|

Navigant has reviewed the multi-step procedure employed by Nalcor to estimate the capital cost and schedule for the Muskrat Falls Generation Facility and the Labrador-Island Link and finds that the process was both thorough and reasonable. Developing a cost and schedule for long-term construction projects such as Muskrat Falls Generation and the Labrador – Island Link is an extremely complicated process. The process becomes substantially more complex when the project involves two completely separate and different facilities that need to commence commercial service at the same time. If one of the two projects is completed on schedule, while the other is delayed, it is doubtful that cost recovery for the completed project could begin since neither project would likely be considered “used and useful” without the other. Nalcor has taken steps to mitigate this risk by (i) incorporating uncertainties associated with major excavations and structures in the contingency allowance; (ii) scheduling installation of the undersea HVDC cable one year before it would be required; and (iii) engaging the same EPCM Consultant for Muskrat Falls and the Labrador-Island Link. In addition, the overall plan entails a 345 KV transmission interconnection between Muskrat Falls and Churchill Falls which would accommodate more flexible water storage arrangements, i.e., the Muskrat Falls project could potentially be used and useful even if completion of the Labrador-Island Link is delayed. Nalcor will continue to assess potential project-on-project risks as part of its overall project planning leading to the DG3 decision and may incorporate additional steps to mitigate such risks as appropriate.

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In addition to the two major projects described above for the Interconnected Island case, Navigant also reviewed the capital cost projections for the smaller generating projects that would be added over the analysis period for both cases as well as estimated costs for the Holyrood environmental improvements and life extension upgrades under the Isolated Island case. Following is a discussion of that review. It is noteworthy that because the Generation Expansion Plan study period (through 2067) is longer than the expected service life of thermal and wind generators, the plan reflects a generation replacement cycle in the Isolated Island case. The replacement cycle is not apparent in the Interconnected Island case because of the large capacity and long service lives of Muskrat Falls and the Labrador-Island Link.

Table 5 sets forth the projected capital costs (on a \$/kW basis) for the proposed generation additions. Projecting installed generation costs on a per kilowatt basis and by generation technology (e.g., hydro, wind, thermal) is a standard utility industry practice.

**Table 5: Unit Capital Costs for Projected Supply Additions**

| Projected Capital Costs (\$2010) | Capital Cost - \$/kW |
|----------------------------------|----------------------|
| <b>Hydroelectric Projects</b>    |                      |

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|  |         |
|--|---------|
| Island Pond Development - 36 MW          | \$4,617 |
| Round Pond Development - 20 MW           | \$7,110 |
| Portland Creek - 23 MW                   | \$3,909 |
| <b>Wind Projects</b>                     |         |
| Replace Fermeuse Wind - 27 MW            | \$2,323 |
| Replace St. Lawrence Wind - 25 MW        | \$2,323 |
| <b>Thermal Projects</b>                  |         |
| Holyrood/Greenfield Unit 2 CCCT - 170 MW | \$1,213 |
| Greenfield CCCT Unit 1 - 170 MW          | \$1,611 |
| Greenfield CT - 50 MW                    | \$1,303 |

Navigant has reviewed the capital costs in the table and determined that such costs are reasonable based on its experience with similar projects using the three distinct generating technologies. It must be emphasized that comparing the costs on a generation technology basis is not appropriate as there are many unique factors that impact the overall economics of each, e.g., the expected service life of a hydro project may be three times that of a thermal plant or wind project, and, of course, a hydro project has no fuel costs. With respect to the Hydroelectric Projects, it should be noted that there is not an expected average costs since there is no "standard" hydro project, i.e., each hydro project is unique. As such, the \$7,110/kW for the Round Pond Development initially appeared high to Navigant. However, on further review, when the very long service life and zero fuel cost are reflected, the project appears to be an economic choice.

In addition to the foregoing cost estimates, with respect to the Isolated Island case, Navigant also reviewed the projected costs for the Holyrood life extension upgrades and pollution control investments (electrostatic precipitators, scrubbers, low NOx burners) that total over \$800 million (nominal in-service dollars) as per Nalcor documents. The pollution control equipment represents about 70 percent of the total cost. Most of the pollution control equipment and life extension upgrades would be installed in the 2015 to 2019 time frame and would be retired with the Holyrood facility in 2036. Navigant understands that if the Holyrood plant is to remain in service, the pollution control investments are required to conform with the Province's energy policy as discussed in the Environmental Restrictions section.

The pollution control upgrades proposed for Holyrood would typically result in a reduction of the plant's efficiency primarily because of increased station service requirements, which has been factored into the economic analysis. More importantly, both the pollution control equipment and the life extension upgrades would only be in service for a relatively short period of time (compared to power plant service life expectations) since the plan is to retire Holyrood in 2033/2036 and replace the facility with cleaner and more efficient combined cycle units. In

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light of the relatively short service life for the capital intensive Holyrood pollution control equipment and life extension upgrades, replacing Holyrood with combined cycle units in the 2015 to 2019 period rather than installing the short-lived upgrades, and then ultimately installing the combined cycle units, warranted consideration. Navigant understands that Nalcor reviewed this option and determined that the lower fuel costs associated with operating Holyrood on two percent sulphur oil (See section 4.2.8.4.2.8 Environmental Restrictions on page 42) until 2033/2036 would offset the costs associated with the higher cost fuel required by the combined cycle units. Continuing operation of the Holyrood units beyond 2036, without spending significant life extension capital, would not be practical as the plant would be in excess of 60 years old at that point.

**14. Nalcor's estimated capital costs for the various supply expansion alternatives considered in the two cases ~~was~~ were reasonable.**

#### 4.2.2 Project Risk Assessment

##### Muskrat Falls Generation Facility and Labrador – Island Transmission Link

Nalcor undertook a detailed risk analysis of these two projects. The analysis entailed the development of a Time Risk Assessment, a Tactical Risk Assessment and a Strategic Risk Assessment.

The primary project timing risk factors are: the Generation Project release from EA; Powerhouse Excavation and Primary Powerhouse Concreting; and the awarding of the Engineering, Procurement and Construction Management (EPCM) contract. Nalcor has placed significant effort in its Time Risk Assessment on developing and implementing a de-risking strategy for the delivery schedule. Mitigation activities have included preparing to issue a Bulk Excavation Contract Package to advance the start of Powerhouse Excavation, and late 2010 award of contracts for Turbine Model Testing in order to de-risk the overall turbine delivery schedule to support the Powerhouse concrete program.

The Tactical Risk Assessment concerns the impact of definition and performance risk on the project capital cost estimate. The Strategic Risk Assessment focuses solely on capital expenditure issues. A total of 34 strategic risks were considered in the analysis. These 34 items were apportioned among organizational risks, financial risks, interface risks, commercial risks, health, safety and environmental risks, engineering/technical risks, environmental approvals and permitting risks, stakeholder risks, Muskrat Falls construction risks, turbine supplier risks, de-escalation/inflation risks, transmission risks, environmental assessment risks, enterprise risks and technology risks. For each of the strategic risks, the assessment includes recommendations for mitigating the related risk. For example, with respect to the risks associated with the limited number of HVdc specialty suppliers and installers, the recommendations include: (i) optimizing packaging strategy of HVdc specialties equipment and services to entice key players; and (ii) select and engage early to ensure availability. Since the assessment has been completed, Nalcor

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has already taken actions to mitigate certain identified risks, e.g., reverting back to traditional LCC HVdc technology to alleviate the risk of failure of application of VSC HVdc technology for the Island Link.

The results of the foregoing risk assessments have been employed by Nalcor to develop the contingencies incorporated in the Muskrat Falls and Labrador-Island Link capital cost. On an individual project basis, the assessments have considered the key risks and potential benefits.

**15. Nalcor's focus on time, tactical and strategic risks for the Muskrat Falls and Labrador-Island Link was critical to ensure that the projects' ultimate project capital costs falls as close to the estimates as possible. In particular, the emphasis on the 34 major strategic risks that were identified in the analysis constitutes a key element in the overall risk assessment and risk mitigation.**

**16. Nalcor's risk assessment analysis for Muskrat Falls and the Labrador-Island Link project was thorough and comprehensive.**

#### *Isolated Island*

Given the nature of the various projects in the Isolated Island case, it was not necessary for Nalcor to undertake as detailed a risk assessment for the Isolated Island case as was undertaken for the Interconnected Island case. Nalcor has significant past experience with projects very similar to most of the projects in the Isolated Island case.

Whereas the primary risks for the Interconnected Island case are largely capital-cost related; the Isolated Island's primary risks are associated with fuel costs and environmental regulations, both of which were addressed through sensitivity analysis.

The CPW of the Isolated Island case is very dependent on fuel costs. As indicated in **Error! Reference source not found.** Table 13, the CPW difference between the two cases could increase to almost \$5.5 billion using the PIRA high fuel price forecast.

New environmental legislation and regulations pose a very significant threat to the isolated Island case. Potential CO<sub>2</sub> federal legislation that could preclude using any fossil fuel but natural gas as discussed in Section ~~4.2.84.2.8~~ *Environmental Restrictions* on page 42. The introduction of some form of carbon pricing through legislation or regulation is another example of an environmental legislation / regulation risk. This risk has been explored through the CPW sensitivity analysis as shown in **Error! Reference source not found.** Table 13.

Another potential risk entails the planned electrostatic precipitators and/or the flue gas desulphurization system not producing the expected emission reductions, which could require Holyrood to continue to burn one percent sulphur oil, leading to higher fuel costs while still

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incurring the capital costs associated with the environmental equipment. The capital cost of the precipitators and scrubbers and or the operating costs of those new facilities ultimately being substantially higher than projected are additional risks that could occur in the Isolated Island case. While these risks have not been explicitly addressed in sensitivity analysis, Navigant notes that the possibility of these risks for the Isolated Island case would increase the preference for the Interconnected Island case.

Commented [AW56]: Discuss deletion

#### 4.2.3 Heat Rates

The following table sets forth the range of heat rates employed in the analysis for existing and proposed generating units.

**Table 6: Heat Rates Used in Nalcor Supply Decision**

| Heat Rates                | Fuel Oil | Max<br>MBTU/MWh | Min<br>MBTU/MWh |
|---------------------------|----------|-----------------|-----------------|
| <b>Existing</b>           |          |                 |                 |
| Holyrood - Units 1,2, & 3 | #6       | 9.78            | 10.39           |
| CTs                       | #2       | 12.26           | 12.26           |
| Diesels                   | #2       | 10.97           | 10.97           |
| <b>Future</b>             |          |                 |                 |
| CT - 50 MW                | #2       | 9.43            | 9.43            |
| CCCT - 170 MW             | #2       | 7.64            | 8.63            |

Commented [AW57]: Update with revised exhibit filed with PUB

Navigant has reviewed the foregoing heat rate ranges and considers them reasonable. However, the heat rate review raised an issue with respect to the combined cycle units that would replace the Holyrood plant in 2033/2036. Specifically, the plan entails using three 170 MW combined cycle units capable of burning No. 2 fuel. From a state-of-the-art combined cycle generating perspective, these units are not the most efficient. Rather than installing the three units totaling 510 MW, a similarly sized Frame facility (typically 2x1, i.e., two combustion turbines and one steam turbine) would be expected to have a heat rate of less than 7.00 MBTU/MWh. However, the No. 2 fuel that Nalcor intends to use for the new units is typically outside the allowed fuel specifications for the larger units which typically call for higher cost kerosene. Navigant understands that Nalcor has previously considered this matter and determined that the higher fuel cost does not offset the lower efficiency of the smaller combined cycle plants. In addition, Nalcor advises that it elected the three 170 MW units because the largest single contingency that its system can accommodate without potentially becoming unstable is 175 MW.<sup>27</sup> Accordingly,

Commented [AW58]: To discuss further with Nalcor

Commented [AW59]: Consider insertion of conclusion

<sup>27</sup> While the 900 MW Labrador-Island Link exceeds this level, the forced outage rates for cable projects is substantially lower than that for thermal projects as shown in Table 11.



Nalcor's choice of the 170 MW combined cycle units is reasonable under the circumstances because of potential system stability concerns with larger (higher capacity) units.

The use of more efficient combined cycle facilities should be considered in the event that natural gas becomes available as a generator fuel. In addition, if natural gas were to become available, the combined cycle facilities could be installed with duct burners which could obviate the need for the 50 MW simple cycle combustion turbines in both options.

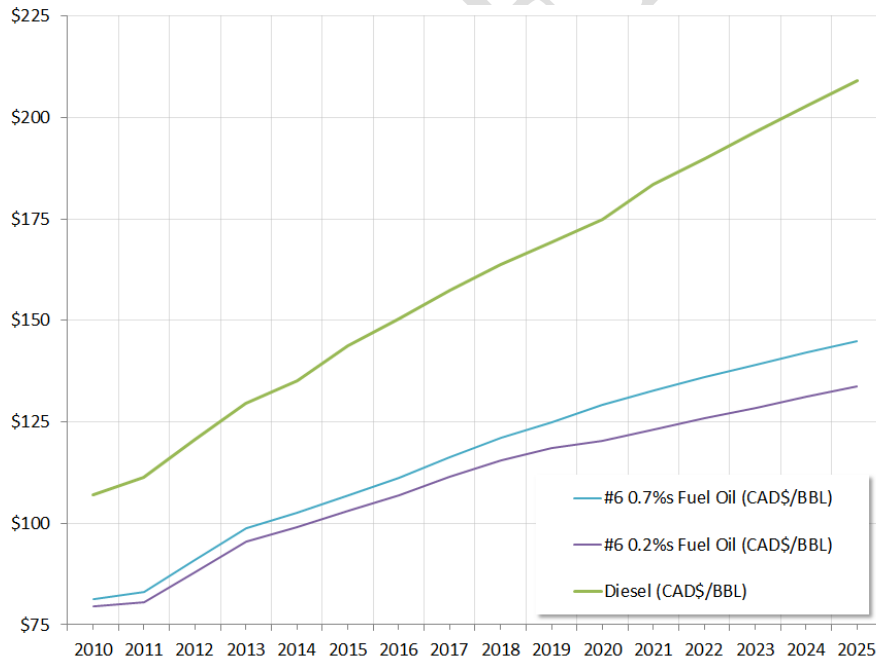
Commented [AW60]: Discuss rationale

#### 4.2.4 Fuel Cost Forecasts

PIRA Energy Group of New York, a leading international supplier for energy market analysis and forecasts, and oil market intelligence in particular, supplies the fuel price data, which is updated for long term projections at the beginning of each expansion analysis. Such fuel oil market based price forecasts are used in production costing for the existing Holyrood and combustion turbine (CT) thermal plants, plus for any new combined cycle and simple cycle combustion turbines. Annual fuel cost projections are set forth in the following Table 7.

Commented [AW61]: To discuss – Nalcor takes PIRA forecast and applies supplier discounts and foreign currency exchange out to 2025 to derive CAD landed prices. Beyond that prices increase at the rate of CPI. Reference should be made to date forecast was prepared.

**Table 7: Fuel Cost Forecast**



Source: PIRA Energy Group and Nalcor Energy at January 2010

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While the estimated fuel costs appear reasonable, Navigant compared those results with the fuel cost projections issued by the United States Federal Energy Information (“EIA”) Administration. EIA’s annual price change projections were slightly higher than those used in the analysis, but were close enough for the projections used by Nalcor to be considered reasonable. The prices in both forecasts are similar in the earlier years of the review period, but the EIA prices escalate at a higher rate in the later years. Of course, higher fuel costs have the effect of improving the economics for the Interconnected Island case.

#### 4.2.5 O&M

Table 8 below sets forth the projected fixed and variable Operating and Maintenance costs in \$2010 (except where noted) that were applied by Nalcor. Navigant has reviewed these projections and considers them reasonable based on prior experience including the fixed O&M components included in Power Purchase Agreements. While the fixed O&M costs pertaining to the existing Holyrood plant may seem high, these levels are consistent with industry experience as steam plants require relatively high staffing levels compared to combined cycle/combustion turbine facilities. In addition, with respect to LIL, it would be expected that the O&M for the most part would be fixed and blended with the capital recovery component in the Transmission Service Agreement resulting in a single monthly charge.

**Table 8: Projected Operating and Maintenance Costs<sup>28</sup>**

| Facility                        | Fixed Annual Cost<br>(\$/kW - 2010\$) | Variable O&M<br>(\$/MWh 2010\$) |
|---------------------------------|---------------------------------------|---------------------------------|
| Island Pond                     | 15.79                                 | N/A                             |
| Portland Creek                  | 17.97                                 | N/A                             |
| Round Pond                      | 20.66                                 | N/A                             |
| Wind (new)                      | 28.89                                 | \$5.90                          |
| Holyrood CCCT                   | 9.22                                  | \$5.32                          |
| Greenfield CCCT – Unit 1        | 10.49                                 | \$5.32                          |
| Greenfield CCCT – Unit 2        | 9.22                                  | \$5.32                          |
| Holyrood (existing steam units) | 41.39                                 | \$1.28                          |
| Holyrood (ESP and FGD)          | \$11M (2015) to \$24M (2033) nominal  | N/A                             |
| Muskrat Falls                   | \$13M (2018) to \$44M (2066) nominal  | N/A                             |

<sup>28</sup> Fuel costs not included.

**Commented [AW63]:** Consider deletion as confusion with escalating OM costs.

**Commented [AW64]:** Discuss as this is new concept

**Commented [AW65]:** Reference to Source  
Nalcor to confirm with Strategist data  
Consider insertion of (excluding fuel costs, where applicable)  
To discuss formatting (fixed / variable)



| Facility          | Fixed Annual Cost<br>(\$/kW - 2010\$) | Variable O&M<br>(\$/MWh 2010\$) |
|-------------------|---------------------------------------|---------------------------------|
| LIL               | \$14M (2017) to \$50M (2067) nominal  | N/A                             |
| GTs (SVL and HWD) | 9.11                                  | N/A                             |
| GTs (Greenfield)  | 10.49                                 | \$5.32                          |

N/A = Not Applicable

**17. The heat rates, fuel prices and operating and maintenance costs used by Nalcor in its analysis were reasonable.**

#### 4.2.6 Projected Retirements

The following two tables set forth the retirement years that the Nalcor analysis assumed for existing generating units for the two options and the anticipated service lives assumed by Nalcor for the different categories of facilities.

**Table 9: Retirements - Existing Units<sup>29</sup>**

|                      | Isolated Island Case | Interconnected Island Case |
|----------------------|----------------------|----------------------------|
| Holyrood Units 1 & 2 | 2033                 | 2021                       |
| Holyrood 3           | 2036                 | 2021                       |
| Hardwoods CT         | 2022                 | 2022                       |
| Stephenville CT      | 2024                 | 2024                       |

**Table 10: Operating Life - Future Units**

|                | Years               |
|----------------|---------------------|
| Wind Farms     | 20                  |
| CTs            | 25                  |
| CCCTs          | 30                  |
| Hydro-electric | Beyond Study Period |
| HVdc Link      | 50                  |

<sup>29</sup> Existing hydro plants, both Hydro-owned and owned by others, are assumed to never retire. Existing Hydro diesel units and thermal units owned by others, primarily used in a stand-by mode, are assumed to never retire.





The projected retirement years for each of the two options are consistent with the underlying assumptions of those options and reflect the life extension proposals for Holyrood. For the Isolated Island case, the Holyrood retirement age would be in excess of 60 years which is longer than the typical average service life for similar units. However, as indicated in the “Holyrood Thermal Generation Station Condition Assessment and Life Extension Study” because of the historical seasonal based lightly loaded service experienced by those units, a service life longer than the average for such facilities would be expected.

The projected operating lives for the different categories of new facilities are consistent with general industry standards.

#### 4.2.7 Outages

##### *Scheduled*

According to information provided by Nalcor, it is assumed that the three Holyrood units experience scheduled maintenance eight weeks per year. Nalcor assumes that scheduled maintenance for the other thermal units would be two weeks per year. With respect to the hydro and wind units and the Labrador-Island Link, it was assumed that scheduled maintenance would be performed in the off-peak months. It is Navigant’s view that that Nalcor’s schedule for maintenance outages is reasonable and conforms with standard utility practices pertaining to generation and transmission maintenance. Virtually all utilities schedule major generation maintenance during off-peak periods.

##### *Forced Outage Rates*

A forced outage is an unplanned outage that requires all or a portion of a project to be removed from service. The following table sets forth the forced outage rates employed by Nalcor in its analyses.

**Table 11: Forced Outage Rates**

| Category       | Forced Outage Rate (%) |
|----------------|------------------------|
| Existing Hydro | 0.90                   |
| Future Hydro   | 0.90                   |
| Gas Turbine    | 10.62                  |
| Holyrood       | 9.64                   |
| Diesel         | 1.18                   |
| Combined Cycle | 5.00                   |
| LIL            | 0.89                   |

Commented [AW66]: ?



Hydro Purchases

3.19/2.26

The forced outage rates for the existing facilities are predicated on actual experience and, as such, are appropriate to use for the analysis. The forced outage rates employed by Nalcor for the future units appear to be reasonable with one exception. Based on Navigant's experience, it would be expected that the forced outage rate applicable to the new 50 MW combustion turbines, such as a GE LM6000, would be more in line with the 5.00 percent rate applicable to the new combined cycle plants rather than the 10.62 percent shown above. Nalcor acknowledges that the 5.00 percent forced outage rate may be more appropriate for simple cycle combustion turbines and will consider using this rate in future analyses.

Commented [AW67]: To discuss basis of 5%

#### 4.2.8 Environmental Restrictions

In 2004, the Provincial government passed into law strict environmental regulations to limit source emissions from the burning of fossil fuels, specifically the Newfoundland and Labrador Regulation 39/04 Air Pollution Control Regulations ("Regulations"). To comply with the Regulations, the Holyrood station is required to burn 1% sulphur fuel, but now actually burns 0.7% sulphur fuel. This is necessary because the boilers at Holyrood do not have environmental equipment for controlling sulphur dioxide (SO<sub>2</sub>) or particulate emissions.

In addition to the Regulations, Newfoundland and Labrador's 2007 Energy Plan requires that in the event that the Lower Churchill Project does not proceed, scrubbers and precipitators must be installed at Holyrood. As such, to comply with the Energy Plan, Nalcor would install electrostatic precipitators that would be expected to remove 95 percent of the particulate from the flue gas emissions and a flue gas desulphurization system that would remove 95 percent of the sulphur dioxide (SO<sub>2</sub>) emissions. These changes would allow Holyrood to burn lower cost 2% sulphur oil. Since the projected cost of the pollution control system is approximately \$600 million (nominal) and this equipment would be retired after a relatively short service period, Navigant suggested considering maintaining the use of 1% (or 0.7%) sulphur fuel and foregoing the installation of the environmental equipment since Holyrood is currently in compliance with the Regulations. This is not an alternative, as government has committed in 2007 and recently reiterated its requirement that pollution. Nalcor advised it is not the Regulations, but rather a matter of Public Policy pursuant to the Energy Plan that the pollution control systems must be installed on the Holyrood station in the event that the Lower Churchill Project does not proceed.

Commented [AW68]: To discuss – as Regulations may only apply to new facilities; energy policy is requiring scrubbers / precipitators not regulations

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While the installation of the precipitators and flue gas desulphurization system would be expected to remove virtually all of the particulate and SO<sub>2</sub> as described above, that equipment will actually result in a slight increase (about 19,000 Tonnes per year or one percent) in the amount of Carbon Dioxide (CO<sub>2</sub>) emitted from Holyrood. CO<sub>2</sub> is a greenhouse gas that contributes to global warming and other climate effects.



One potential concern associated with incurring more than \$600 million of pollution control upgrades (along with more than \$200 million of life extension improvements) for Holyrood is the possibility that the federal government may impose restrictions on CO<sub>2</sub> emissions for existing power plants in the future. A federal regulation was recently proposed that would establish a regime for the reduction of CO<sub>2</sub> emissions that result from the production of electricity by using coal as a fuel<sup>30</sup>. Specifically, the regulation would limit the intensity of CO<sub>2</sub> emissions to 375 tonnes per GWh of electricity produced from fossil fuel during the calendar year. This is an extremely low CO<sub>2</sub> emissions target that, for the most part, could only be met by a very efficient combined cycle generator fuelled by natural gas.

**Commented [AW69]:** To discuss concept of upgrades versus pollution control

Following are the estimated CO<sub>2</sub> intensity levels for the existing and future Nalcor units as well as a new gas fired combined cycle facility.

**Table 12: GHG Intensity by Generation Type**

| Generating Facility  | CO <sub>2</sub> Intensity (Tonnes/GWh) |
|----------------------|--|
| Holyrood (No. 6)     | 734                                    |
| Existing CTs (No. 2) | 907                                    |
| New CCCTs (No. 2)    | 565                                    |
| New CTs (No. 2)      | 697                                    |
| New Gas CCCT (Gas)   | 340                                    |

As indicated above, even the relatively efficient new CCCT fueled by No. 2 oil would have a GHG emission intensity well in excess of the 375 Tonnes/GWh limit. Clearly, in the event that legislation similar to that described above were to apply to all fossil-fired generating stations, the Isolated Island option would be at risk since oil fired CCCTs, even the most efficient models fuelled by kerosene which has a lower CO<sub>2</sub> intensity, could not meet the threshold requirement. It should be noted that unlike previous legislation in which a facility that could not meet the requirements could buy credits from others, such is not the case with respect to the recently proposed federal legislation. That legislation provides that a facility that cannot meet the requirements is at risk of being permanently shut down.

**Commented [AW70]:** Consider insertion of conclusion. To discuss CO<sub>2</sub> permit market?

While the foregoing legislation is directed at coal plants, there have been indications that similar legislation may be proposed for oil fired generation. In the event that such legislation were to be enacted, the environmental improvements and life extension upgrades for Holyrood would

<sup>30</sup> Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations. The consultation version of the proposed regulation is available at: [http://www.ec.gc.ca/Content/2/E/5/2E5D45F6-E0A4-45C4-A49D-A3514E740296/E\\_Consultation.pdf](http://www.ec.gc.ca/Content/2/E/5/2E5D45F6-E0A4-45C4-A49D-A3514E740296/E_Consultation.pdf)



essentially be rendered moot and prospects for the \$400 million (CPW) potential cost exposure (backup to be provided by Nalcor) discussed in Section 4.2.1 would be substantially increased.

**18. Nalcor did not consider all of the potential risks associated with environmental legislation that could impact the Isolated Island case, such as limits on the unit emission rates for new fossil-fuel fired generation. Given this, the risk (and possibly CPW) for the Isolated Island case may be higher than assumed by Nalcor in its DG2 decision.**

#### 4.2.9 Power Purchases from Muskrat Falls

Just as the power from Muskrat Falls is a critical supply component in the Interconnected Island case, the cost of power purchases for Muskrat Falls is a critical driver of the economics of the Interconnected Island case.

Based on information provided by Nalcor, Navigant understands that the cost of power purchases for Muskrat Falls would cover a 50 year term. Nalcor's development of the Muskrat Falls power purchase price was based on the following framework:

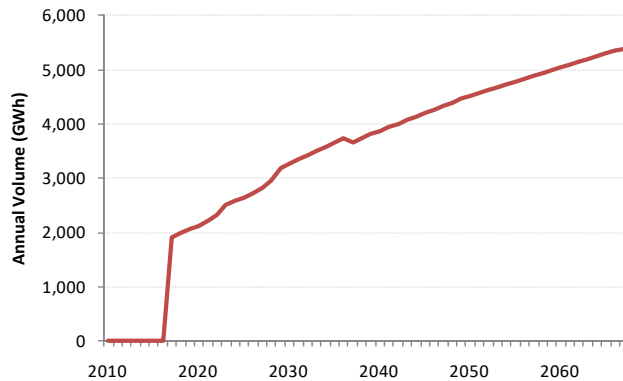
1. Assuming the firm output of the Muskrat Falls facility is sold at a selling price that escalates at inflation, estimate the starting (first year) price that yields an 11% target return to capital for the project.

Given the assumptions at the time of the DG2 decision, this price was determined to be approximately \$76 (\$2010) per MWh.

2. Recognizing that NL Hydro's requirements for Muskrat Falls power are, in the early years, substantially less than the firm output of Muskrat Falls, but grow over time as shown in [Figure 13](#)~~Figure 11~~, calculate the return to capital that the price from step 1 above would provide as applied to NL Hydro's annual requirement for Muskrat Falls power.



**Figure 13: Muskrat Falls PPA Projected Volumes**



Commented [AW71]: Change title / data to MF data

Commented [AW72]: To correct

Given NL Hydro's volume requirements (and the starting price of \$76 per MWh from step 1 above), this yields an 8.4% return to capital. This estimate does not attribute any value to potential MF output that is not purchased by NL Hydro.

Navigant believes this is a reasonable approach for setting the Muskrat Falls power purchase price because the unit price remains constant in real dollar terms over the term which provides electricity ratepayers on the Island with a significant degree of rate certainty for this component of their supply. Navigant also believes that the 8.4% return to capital Nalcor expects given the power purchase price and NL Hydro volume requirements is reasonable.

**19. The Muskrat Falls pricing approach used by Nalcor was appropriate and sufficiently well defined for the purposes of 1) estimating the Muskrat Falls power purchase price, and 2) informing the DG2 decision.**

Nalcor will be undertaking further work leading up the DG3 decision to further define the factors affecting the power purchase price and the degree of volumetric flexibility to ensure the proper treatment of any new information or sensitivity analysis affecting the price in the DG3 decision. These factors would likely include:

- Refinements to the annual volume based on refinements to the load forecast and/or supply from other on-Island generation.
- Daily, weekly, monthly "shaping" ability and notification period (lead time) for such shaping.
- NL Hydro's access to the storage capabilities of Muskrat Falls which could enable transfers of volume from one season to the next and possibly from one year to the next, etc.



- “Re-marketing” provisions related to any volume commitments in excess of NL Hydro’s needs. Any sensitivity analysis regarding annual volumes delivered to the Island should reflect some expected value through either “re-marketing” of any excess and/or consideration of utilizing the excess to increase the level of hydro storage on the Island for use at other times. Note that Nalcor’s sensitivity analysis for the DG2 decision did not include the impact of any such re-marketing provisions and, as such, likely overstate the CPW for the Interconnected Island under the various low load growth sensitivity analyses conducted.
- Access to incremental power beyond the annual commitment to meet unexpected load growth or to address an extended outage at an Island generator.

May need to mention selling to New England via the Maritime Link as new information subsequent to DG2

### 4.3 Anticipated Legislative Mandates that Can Impact the Plan

Nalcor did not explicitly consider potential future provincial or federal legislative mandates in its supply decision. While it is difficult to know what any government will do in the future, Navigant believes that some form of greenhouse gas (GHG) emission mitigation legislation is possible in the 50 year analysis period and that Nalcor should have considered the potential impact of this potential legislation in its supply decision.

While the specific mechanism promulgated by any such legislation cannot be known, it would be reasonable to model the impact of such legislation through some form of allowance pricing on CO2 or GHG emissions.

**20. Nalcor could have considered the introduction of some form of carbon pricing regime in its analysis. Any such regime would increase the preference for the Interconnected Island case given the significantly higher GHG emissions under the Isolated Island case.**

To this end, Navigant has estimated the potential impact of projected carbon pricing on the supply decision based on a reputable third party forecast of carbon pricing. This potential cost impact is shown in Section 5.4.65.4.4 Impact of Carbon Pricing on page 58 and, not surprisingly, increases the preference for the Interconnected Island case given the relatively high level of carbon emissions in the Isolated Island case.

### 4.4 Nalcor Inflation and Escalation Forecast

Nalcor developed weighted cost indices for capital assets and used projections on various producer price indices from Global Insight to drive each weighted index. For O&M expenses,

Commented [AW73]: Blend with 4.2.8?

Commented [AW74]: Explain why Nalcor did not include

Commented [AW75]: Consider reference to source

Commented [AW76]: Move capex escalation to 4.1(?) with LCP capex



Nalcor used, as applicable, specific rates for five categories: (i) More Material, Less labour; (ii) Same Material, Same Labour; (iii) More Labour, Less Material; (iv) Labour Only; and (v) Support Activities. With respect to general inflation, Nalcor used a Conference Board of Canada estimate of the GDP implicit deflator for 2009. General inflation post 2010 is a composite of inflation forecasts provided by the Conference Board of Canada

Figure 12 presents key considerations used in the escalation for construction costs and Figure 15 shows general inflation and O&M escalation indices. Figure 15 presents escalation indices for different types of resources, and Table 13 presents practices used by Nalcor in the escalation. Figure 15 shows the sensitivity of the general inflation and operating and maintenance cost forecasts to the mix of labour and material.

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**Figure 14: Nalcor Construction Escalation Indices at January 2010**

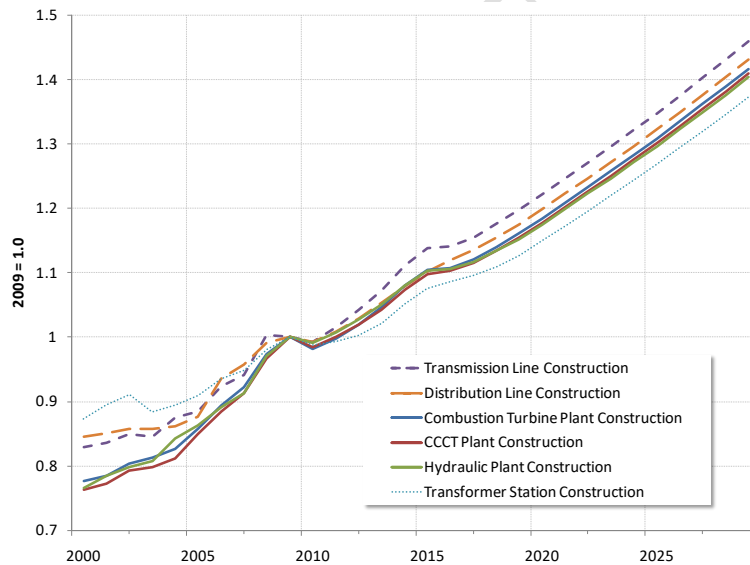




Figure 15: Nalcor General Inflation and O&M Escalation Indices at January 2010

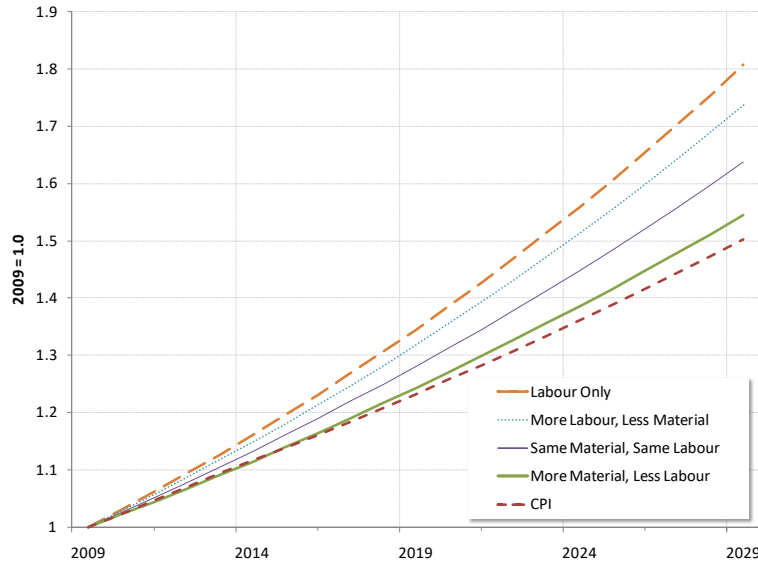


Table 13: Practices Used in Nalcor Escalation Modelling

| Best Practice as Recommended by Validation Estimating                                  | Included in NE-LCP Escalation Model            |
|--|--|
| Differentiate between escalation, currency and contingency                             | Yes  |
| Use indices that address differential price trends between accounts                    | Yes  |
| Use indices that address levels of detail for various estimate classes                 | Yes  |
| Leverage procurement/contracting specialist's knowledge of markets                     | Yes  |
| Leverage economist's knowledge (i.e., based on macroeconomics)                         | Yes  |
| Ensure that a consistent approach is applied in a model that facilitates best practice | Yes  |
| Calibrate data with historical data  | Yes  |
| Use probabilistic methods  | To be determined pending further investigation |
| Use the same economic scenarios for business and capital planning                      | Yes  |
| Include as a part of an integrated project/cost management process                     | Yes  |
| Facilitate estimation of appropriate spending or cash flow profile                     | Yes  |

Source: Nalcor. "Synopsis Of 2010 Generation Expansion Decision" Exhibit 3 Part 2. July 2011

The escalation projections presented in the following table are unique to the LCP projects. Briefly, based on a number of best practices for cost escalation, Nalcor developed a





methodology for estimating escalation that links the capital cost estimate with the project scheduling activities, resulting in a model that provides time-phased escalation projections on commodity, project component and aggregate levels. The following table sets forth the cumulative escalation factors resulting from the application of the model.

**Table 14: Escalation Projections for Muskrat Falls and LIL**

| Component                           | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|-------------------------------------|------|------|------|------|------|------|------|------|------|
| Muskrat Falls                       | 1.00 | 1.02 | 1.05 | 1.11 | 1.16 | 1.20 | 1.23 | 1.26 | 1.30 |
| Labrador – Island Transmission Link | 1.00 | 1.02 | 1.04 | 1.08 | 1.12 | 1.16 | 1.20 | 1.24 | 1.29 |

Source: Nalcor. "Synopsis Of 2010 Generation Expansion Decision" Exhibit 3 Part 2. July 2011

For a capital intensive project that will take years to construct, such as Muskrat Falls/LIL, it is imperative that a solid methodology that recognized project scheduling activities be employed. In recognition of the lengthy construction period and the lag between the development of the estimated capital cost and the commencement of the construction process, understanding the effects of cost escalation is essential to the projection of the additional costs that will likely be incurred during the construction period. The model developed by Nalcor incorporates these factors and, as such, the resulting capital costs escalation factors are quite reasonable.

**21. The processes used by Nalcor to develop the various escalation estimates were rigorous and indices resulting thereof are reasonable.**

**Commented [AW77]:** Consider deletion as previously covered?

**Commented [AW78]:** Need to reference Fig 14 and Table 13



## 5 THE PROCESS FOLLOWED TO SCREEN THE SUPPLY OPTIONS

### 5.1 Strategist

Nalcor uses Ventyx's Strategist software. Strategist is an integrated strategic planning computer program that allows modeling of the current and future electric power 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 Ventyx Strategist modules used to derive the CPW were:

1. Load Forecast Adjustment (LFA)
2. Generation and Fuel (GAF)
3. Capital Expenditure and Recovery (CER)
4. PROVIEW (PRV)

### 5.2 Modeling Inputs in Strategist

Nalcor incorporated the inputs described in Section 4 into the analysis and ran the model over the 2010 to 2067 period. The analysis involved considering the CPW of different combinations of resources. The factors reflected in the CPW calculation included:

- capital cost of new facilities
- fuel cost
- line losses
- outage factors
- required environmental improvements
- operations and maintenance cost
- heat rates
- expected generation output
- discount rates

NL Hydro used the Strategist planning model to enumerate the different combinations and identify the least cost ones. The process resulted produced two alternative cases: the Isolated Island and the Interconnected Island expansion plans.

Navigant reviewed Nalcor's implementation of Strategist, with a focus on the major resources (Muskrat Falls, Labrador-Island Link, and Holyrood pollution abatement upgrades and life

**Commented [AW79]:** Consider further development with description of CPW results from the 2 expansion plans



extension projects). Inputs in the model were consistent with those presented by Nalcor in exhibits presented to the Public Utilities Board.<sup>31</sup>

### 5.3 Constraints Used in the Modeling

The chosen resource plans (generation expansion plans) were selected on the minimization of revenue requirement, modeled as the “minimization of utility cost” objective function. As there was only one objective function used, its weighting was 100 per cent. There were no objectives tied together as only one objective function was used.

Nalcor constrained the entrance for the main resources in the resource plans: the Muskrat Falls project and LIL in the Interconnected Island case and the Holyrood environmental upgrade in the Isolated Island case. The timing on these potential entrances was based on the provincial requirement for the Holyrood pollution abatement upgrade.

Nalcor constrained the entrance of wind in the Isolated Island case to 25 MW in 2014, with a renewal of 50 MW of existing wind in 2029. Nalcor wanted to limit the total amount of wind added to 80 MW, based on the 2004 study which found that higher amounts would likely result in spilling at the hydro facilities.<sup>32</sup> As noted previously, the study found that amounts up to 130 MW could be incorporated in total without causing substantial operational problems. Further Navigant believes that, provided any such operational problems could be overcome, Nalcor could have explored the addition of a additional 100 MW of wind generation in 2025 and another 100 MW of wind generation to displace fossil output.

Nalcor conducted a preliminary optimization for twenty years, rather than attempting to optimize through 2067. Optimizing plans over the entire time horizon would have taken excessive amounts of clock time to complete, due to the astronomical number of combinations that the PROVIEW module of Strategist would create. Nalcor identified specific units, such as the three hydro options in the isolated Island case, that were part of the least cost plans in this preliminary analysis. Nalcor then locked in those options and allowed Strategist to optimize over the remaining portion of the time horizon and determine the appropriate mix of combined cycle and combustion turbines.

**Commented [FS80]:** Do calculations of the impact of adding 50 MW more of wind.

**Commented [AW81]:** To discuss process followed

<sup>31</sup> Nalcor. Letter from Geoffrey Young to Board of Commissioners of Public Utilities. July 6, 2011..

<sup>32</sup> Newfoundland and Labrador Hydro. “An Assessment of the Limitations for Non-Dispatchable Generation on the Newfoundland Island System. 2004.



22. Nalcor's use of the Strategist model in developing the two cases was appropriate and reasonable, and its process for constraining the potential combinations of resources in the Strategist model was a reasonable means of managing the complexity of the optimization problem.

## 5.4 Uncertainty and Risk Analysis

This could be a new, standalone section 7 to be moved just before Key Findings and Conclusions

Nalcor estimates that developing the Interconnected Island case will result in present value of lower costs to customers of just less than \$2.2B for the time period of 2010 through 2067 based on the difference between the Cumulative Present Worth (CPW) of the two generation expansion alternatives based on the assumptions to the analysis described in the previous sections.

Commented [AW82]: Consider 4.2.2 moved to under here?

### 5.4.1 Indifference Analysis

To estimate the conditions under which the two cases would yield an equivalent CPW – for which Nalcor would presumably be indifferent to the decision all other things being equal – two sensitivities were run. One sensitivity reduced fuel costs for each year of the analysis period by a fixed percentage necessary to yield equivalent CPWs for the two cases. The other sensitivity reduced load – starting in 2013 – by a fixed amount each year to yield equivalent CPWs and assuming the total purchase cost for Muskrat Falls is essentially fixed.

Holding all other assumptions unchanged, the CPWs of the two case would be equivalent if:

1. Fuel costs are 44% lower than Nalcor base forecast in each year of the forecast
2. Island load drops by 880 GWh starting in 2013 and continuing through the remaining analysis period. This would represent a step reduction in Nalcor's load of more than 10% in a single year.

It is important to note that neither Nalcor nor Navigant believe either of these two sensitivities are likely; the purpose of this analysis was simply to identify the point of indifference based on varying fuel prices or load. Additionally, a 44% reduction in fuel price is less than the PIRA Low forecast. The PIRA Low forecast has 1) a relatively low probability of occurring, and 2) a similar probability of occurring as the PIRA High forecast (in which the CPW difference is more than \$5 B, (as discussed in the following section)). In essence, while it is possible that fuel prices could be sufficiently low to render both cases being equivalent (in CPW terms), it is equally probable that fuel prices could be sufficiently high for the Interconnected Island case to have a \$5 B CPW advantage over the Isolated Island case. Also, a more recent long-term PIRA fuel



price forecast (as of May 2011) would yield a \$2.8 B CPW difference (roughly \$600 M more than the PIRA forecast used for the October 2010 base case).

#### 5.4.2 Sensitivity Analysis

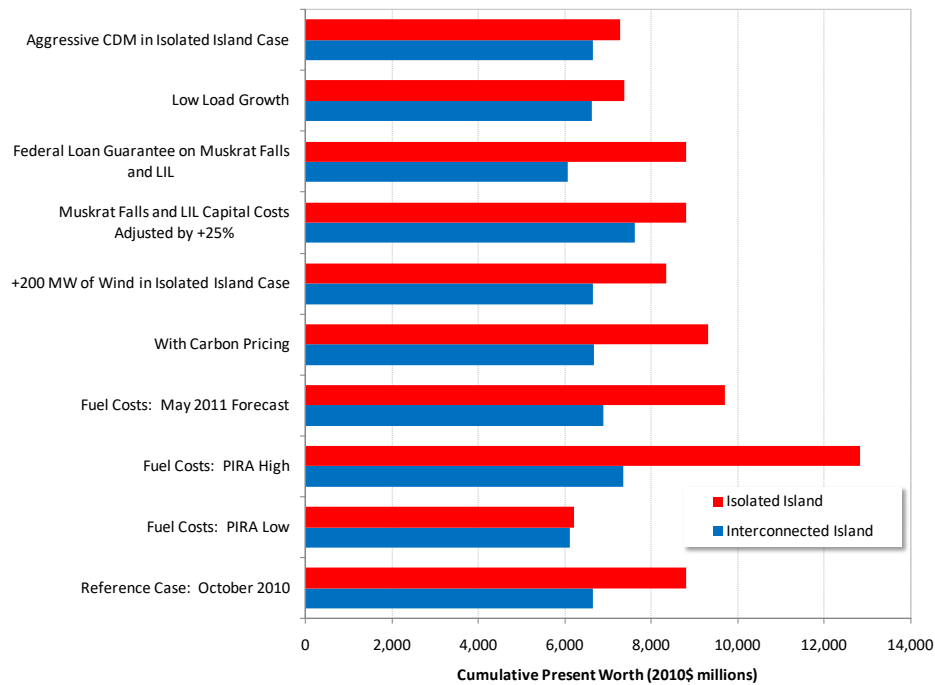
To explore the sensitivity of this result to the key uncertainties and risks in the assumptions, Navigant and Nalcor ran a number of sensitivities on capital costs, fuel costs, load growth and environmental legislation/regulation. These sensitivities were run outside the Strategist modelling environment and reflect risks and uncertainties that are largely outside Nalcor's control. Further sensitivities were run to explore the impact of higher CDM and increased wind generation in the Isolated Island case – two possible refinements to the input assumptions noted by Navigant in previous sections. Finally, the impact of the proposed federal government loan guarantees for Muskrat Falls and the Labrador-Island Link on the CPW for the Interconnected Island case was estimated.

The resultant CPW estimates for these sensitivity analyses are presented in Figure 16 along with the October 2010 DG2 input reference case. The difference between these various CPW estimates for the two cases are shown in [Source: Nalcor. MHI-Nalcor 41. August 11, 2011 and Navigant.](#)

[Figure 17](#)[Figure 17.](#)

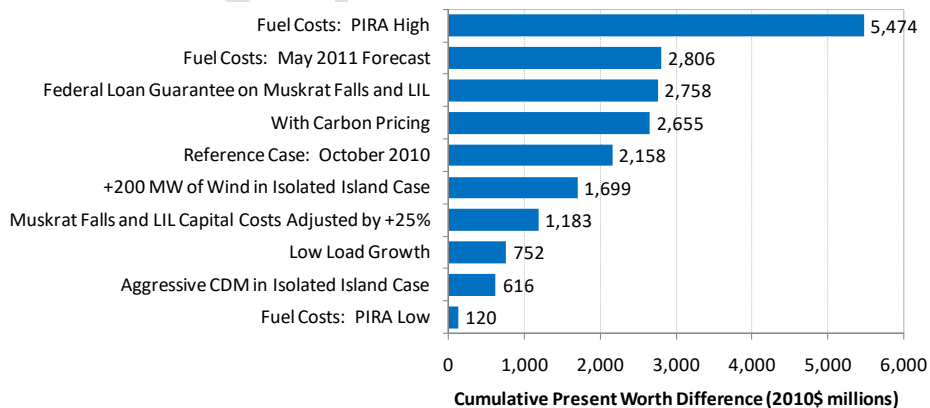


**Figure 16: Sensitivity Results: Interconnected Island and Isolated Island CPW**



Source: Nalcor. MHI-Nalcor 41. August 11, 2011 and Navigant.

**Figure 17: Sensitivity Results: CPW Difference between Cases**



Source: Nalcor. MHI-Nalcor 41. August 11, 2011 and Navigant.



It is particularly noteworthy that all of the sensitivities resulted in a CPW advantage for the Interconnected Island case. This clearly indicates that the DG2 decision preference for the Interconnected Island case was robust given the underlying risk and uncertainty in key assumptions as well as possible refinements to the Isolated Island case as identified by Navigant. Further, currently available information – specifically, the updated May 2011 PIRA fuel forecast and recent federal load guarantee commitment – increases the preference for the Interconnected Island case.

The fuel cost sensitivities reflect difference PIRA forecasts. Details of the other sensitivities are provided below.

#### 5.4.3 Low Load Growth Scenario

The sensitivity reflects a 50% reduction in the rate of annual load growth starting in 2015, after Vale's Long Harbour operation reaches full production. The resultant CPW difference is \$752 million in favour of the Interconnected Island case, as shown in Figure 17.

The lower load growth in this scenario was assumed not to affect the total annual power purchase payments for energy from Muskrat Falls. Hence, any benefits derived through sales of excess energy are not reflected in the results. To the extent that NL Hydro would be able to “re-market” any excess energy from Muskrat Falls in a low load growth scenario, the CPW preference for the Interconnected Island case would increase.

The low load growth is assumed not to affect annual demand and thus the timing of generation additions was not revised. To the degree that demand would be affected under a low load growth scenario, it is likely that CTs planned in both cases for the latter years of the analysis period could be deferred or avoided resulting in slightly lower CPWs for both cases.

**Commented [AW83]:** Consider achievability of high CDM similar to prior section  
Consider reference in prior sections to sensitivities

**23. Navigant believes that the sensitivities modeled appropriately capture the key elements of uncertainty associated with the supply decision, and the results support the preference for the Interconnected Island case.**

**24. All of the sensitivities modeled resulted in a CPW advantage for the Interconnected Island case. This clearly indicates that the DG2 decision preference for the Interconnected Island case was robust given the underlying risk and uncertainty in key assumptions as well as possible refinements to the Isolated Island case as identified by Navigant.**



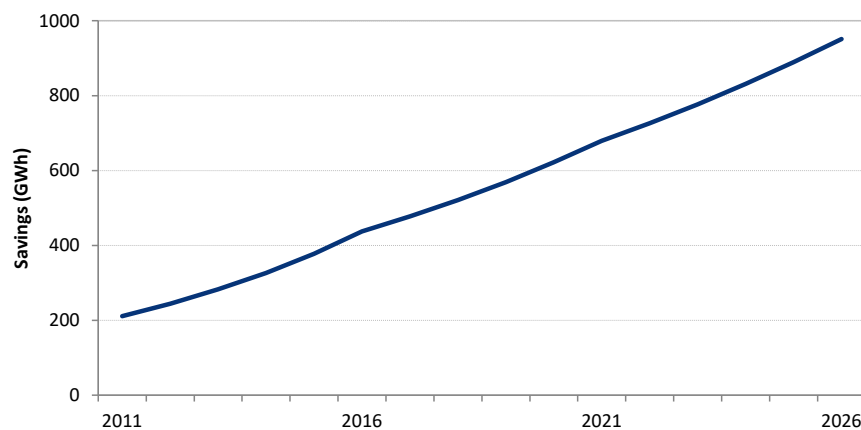
25. Currently available information – specifically, the updated May 2011 PIRA fuel forecast and recent federal load guarantee commitment – increases the preference for the Interconnected Island case

#### 5.4.4 Aggressive CDM Scenario

The aggressive CDM scenario reflects the impact of implementing aggressive CDM programs in the Isolated Island cases, as was discussed in the *Potential Effect on the Forecast of Aggressive CDM* section starting on page 30. Figure 17 presents the cumulative reduction in annual energy consumption under this scenario.

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**Figure 18. Load Reduction Under Aggressive CDM Scenario**



CDM programs are not free – there are typically incentive costs, marketing costs, administrative costs and evaluation costs associated with these programs. To estimate what these costs would be, Navigant assumed that the costs of implementing the program were 50 percent of the benefits, i.e., the benefit-cost ratio was 2.0. The benefits from the CDM programs are the avoided costs, which NERA estimated at \$0.0980/kWh for the Isolated Island case.<sup>33</sup>

The CPW of the resulting estimate of program costs is \$557 million to achieve the level of CDM savings assumed in the Aggressive CDM scenario. In addition, one other adjustment would be

<sup>33</sup> NERA Economic Consulting. "Newfoundland and Labrador Hydro. Marginal Costs of Generation and Transmission." May 2006





appropriate in the Isolated Island case to account for the potential reduction in the need for new capacity if CDM were pursued aggressively. This reduction could be estimated through a Strategist optimization. As an approximation, Navigant calculated the value of avoiding a combustion turbine, or fractional part thereof, based on Nalcor's assumptions for capital cost, fixed O&M, lifetime, escalation rate, and discount rate. This value would be \$185 million for upper CDM for the Isolated Island case. These adjustments result in a CPW value for the high CDM case that is \$616 million higher than the Interconnected Island case, as shown in Figure 17.

**Commented [AW84]:** Consider achievability of high CDM similar to prior section  
Consider reference in prior sections to sensitivities

#### 5.4.5 200 MW Increase in Wind Generation by 2035

In this scenario, the Isolated Island case adds an additional 100 MW of wind in 2025 and a further 100 MW of wind in 2035. The wind projects are not started earlier because, as described in section 3.3.13.3.1 Wind on page 17, additional wind output will not be expected to displace fossil output most of the time until 2025. Prior to 2025, Nalcor expects that additional wind would only result in partial displacement of fossil output and could trigger additional spill from the existing hydro facilities. Alternatively, additional wind prior to 2025 could be subject to curtailment to mitigate spill from existing hydro, but this would increase the effective cost of wind power.

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Wind projects typically have a life of 20 years. Therefore, Navigant modeled two sets of wind projects. The first set of projects – assumed to be 100 MW in total and generating 350 GWh annually – comprise a wind farm coming into service in 2025 operating through 2044, with a replacement wind farm coming into service in 2045 and continuing to operate through 2064. The second set of projects are the same size and output as the first, but start in 2035 with the replacement wind farm starting in 2055 and continuing to operate through the end of the analysis period.

The assumed prices for the wind projects (in nominal \$ for the starting year and escalating during the remainder of their contract period at 25% of inflation) are as follows:

**Table 15: Additional Wind Project Parameters**

| Wind Project          | Start Year | Initial Contract Price<br>(\$ per MWh) |
|-----------------------|------------|--|
| Project 1             | 2025       | 112                                    |
| Project 2             | 2035       | 132                                    |
| Project 1 Replacement | 2045       | 156                                    |
| Project 2 Replacement | 2055       | 182                                    |



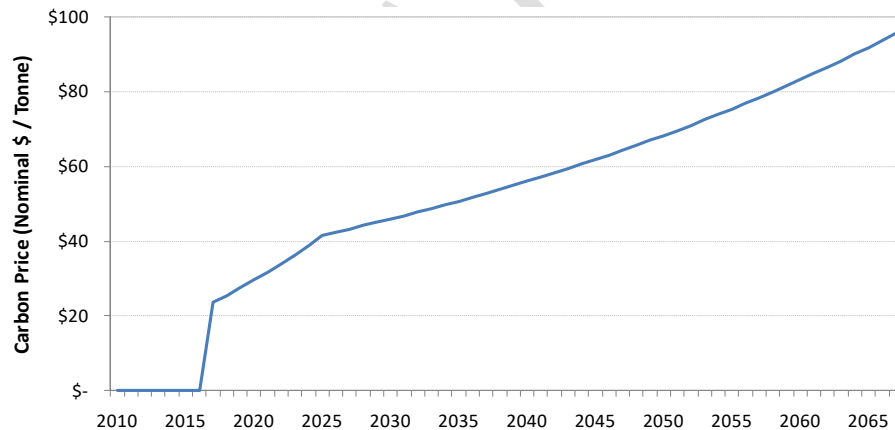
This incremental wind would displace fossil fuel consumption and, net of the cost of the wind power, the resultant CPW difference is \$1,699 million in favour of the Interconnected Island case as shown in Figure 17.

#### 5.4.6 Impact of Carbon Pricing

As discussed in Section 4.3 *Anticipated Legislative Mandates that Can Impact the Plan*, Nalcor did not explicitly consider potential future provincial or federal legislative mandates in its supply decision. Navigant believes that some form of greenhouse gas (GHG) emission mitigation legislation is possible over the supply decision horizon and that Nalcor should consider the potential impact of this potential legislation in its supply decision.

To address this possibility, Navigant has estimated the potential impact of projected carbon pricing coming into effect in 2017<sup>34</sup> using carbon price projections developed by the US-DOE as an analysis of the Waxman-Markey Legislation. The carbon price forecast is shown in **Figure 19**.

**Figure 19: Projected Carbon Prices**



Given the level of GHG emissions in the Isolated Island case, as shown in Figure 20, the introduction of any form of carbon pricing would likely have a significant impact on the CPW for the Isolated Island case. Post 2017, the GHG emissions in the Interconnected Island case are essentially zero until the latter parts of the analysis period when relatively limited GHG emissions from CTs operating infrequently to serve peak demand are expected.

<sup>34</sup> If carbon pricing was introduced prior to 2017, it would increase the CPW of both cases by roughly the same amount given the similar levels of GHG emissions for both cases through the end of 2016.

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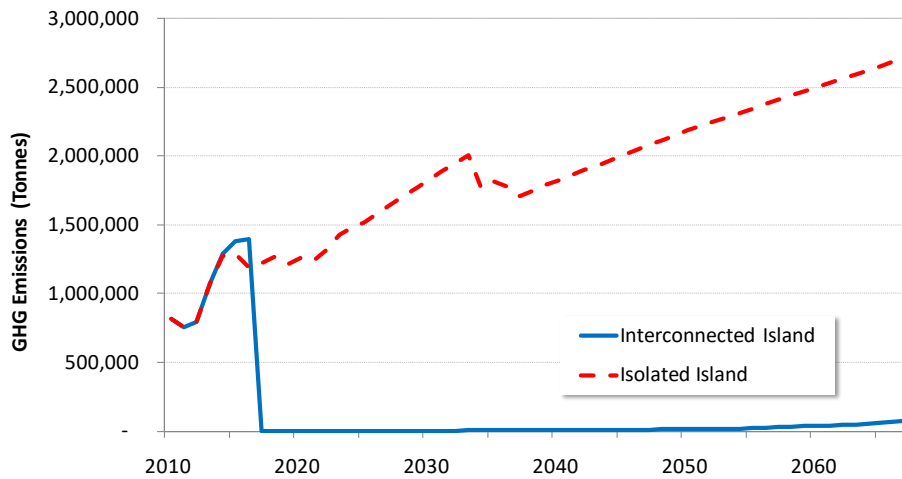
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**Figure 20: GHG Emissions: Interconnected Island and Isolated Island Cases**



The resultant CPW difference under the Carbon Pricing scenario is \$2,655 million in favour of the Interconnected Island case as shown in Figure 17.

#### 5.4.7 Impact of Federal Loan Guarantee

In August 2011, the federal government committed to provide a federal loan guarantee for the Muskrat Falls, Labrador-Island Link (and Maritime Link to Nova Scotia) **need caveats from press release re: Financial Study**.

The loan guarantee would have the effect of lowering the interest rate on the debt for Muskrat Falls, Labrador-Island Link to a level approximately equal to that on federal government debt. The resultant CPW difference under with the federal loan guarantee is **\$2,758** million in favour of the Interconnected Island case as shown in Figure 17.



## 6 REVIEW OF THE RATE IMPACT ANALYSIS

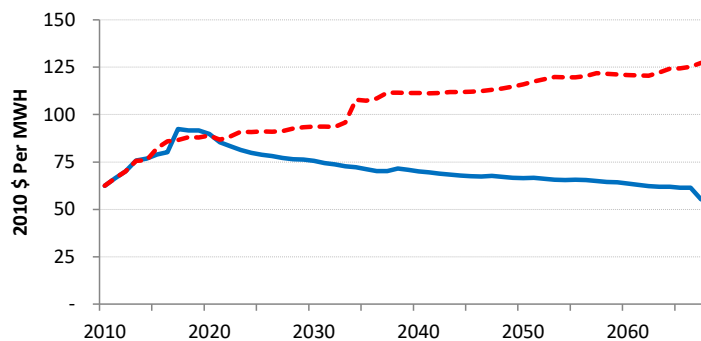
Estimates of the overall wholesale costs impacts associated with developing the Interconnected Island case versus the Isolated Island case were prepared by Nalcor. These costs are subsequently recovered from NL Hydro's customers (i.e. Newfoundland Power and industrial customers). Nalcor estimates that developing the Interconnected Island case will result in present value of lower costs to customers of just less than \$2.2B for the time period of 2010 through 2067 based on the difference between the Cumulative Present Worth (CPW) of the two generation expansion alternatives.

The scope of the wholesale rate impact analysis is with respect to the bulk generation and transmission grid of the Island and includes all cost of service components such as operating costs, depreciation and return on rate base. This entails combining the existing rate base and its associated revenue requirements with the incremental annual revenue requirements derived from the Strategist generation expansion plans. The revenue requirement associated with retail distribution is assumed to be identical in both the Isolated Island and Interconnected Island alternatives.

### 6.1.1 Estimated Rate Impacts

Figure 21 illustrates the projected rate impacts of the Isolated Island case versus Interconnected Island in Nalcor base case analysis.

**Figure 21 – Average Real Rate per MWh**



Short-term increases in the real average tariff occur in both cases for the next several years. However, a gradual decrease in real average rates occurs for the Interconnected Island case over time and long-term tariff prices are projected to decrease to existing levels by 2067.

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## 6.2 Approach Used to Quantify Rate Impacts

Nalcor used a traditional revenue requirement approach in evaluating the rate impacts associated with various supply alternatives. A revenue requirement was estimated annually for each supply alternative scenario. The revenue requirement is defined in the following equation:

$$\begin{aligned} \text{Revenue Requirement} = & \text{Operating and Maintenance Expenses} + \\ & \text{Power Purchases} + \\ & \text{Fuel Costs} + \\ & \text{Depreciation} + \\ & \text{Interest} + \\ & \text{Return on Equity} \end{aligned}$$

The overall approach to calculating the revenue requirement is consistent with what has been used by the PUB for regulatory filings in the past and consistent with the approach commonly used in other jurisdictions.

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## 6.3 Review of Assumptions used in Calculating the Revenue Requirement

A number of assumptions were used by Nalcor for estimating the rate impacts associated with the development of the Isolated Island and Interconnected Island alternatives. Navigant reviewed these assumptions which are discussed below.

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### 6.3.1 Capital Structure

NL Hydro's capital structure is composed of:

- Equity;
- Regulated Debt; and
- Liabilities associated with the company's post-retirement benefits which they are obligated to provided to employees.

#### Return on Equity (ROE)

The company's ROE is projected to increase from a currently approved 4.47% to a long-term rate in the range of 9% to 10%. The explanation for the increase in the ROE is a directive by the Province where Nalcor is to be afforded a ROE which is equal to that of Newfoundland Power<sup>35</sup>.

#### Regulated Debt

<sup>35</sup> Press Release from the Government of Newfoundland and Labrador dated June 17, 2009.



The projections of the cost of new debt range from a current projection of 8.80% decreasing to approximately 7.5% in the long-term. The projected cost of debt is based upon the cost of borrowing for the Province which is correlated to the projections of the cost of debt produced by the Conference Board of Canada.

#### **Liabilities Associated with Post-Retirement Benefits**

The liabilities associated with benefits due to the company's retirees are included in the capital structure as source of funds at no cost to ratepayers. The liabilities associated with post-retirement benefits are paid as needed by the company. Therefore, these liabilities reduce the weighted average cost of debt.

#### **Capital Structure**

The projected capital structure is expected to slightly de-leverage in the long-run which is attributable to a decrease in Nalcor's liability to retirees. Nalcor has used the same projections for the post-retirement liabilities in all scenarios. It is Navigant's opinion that the assumption assuming the same post-retirement benefits liability for each scenario on the basis that an Isolated Island Scenario would likely require a slightly larger workforce which would therefore trigger a larger unfunded liability on the balance sheet of the company. However, given that the workforce to support 2 major combined-cycle combustion turbine generating units (GE 7FA CCCTs with an operating capability of 500MW) would normally be less than 50 people the simplifying assumption is not expected to significantly bias the result of the analyses.

#### **6.3.2 Operations & Maintenance Expenses**

Operating, Administrative and Maintenance (OAM) Expenses are separated into two broad categories. The first category is non-Holyrood OAM and the second is OAM associated with Holyrood. These costs are projected based upon individual forecasts based upon the specific cases and forecasts developed for specific categories of expenses.

#### **6.3.3 Fuel Expense**

Nalcor incurs fuel expense for the Holyrood Steam Units, a number of combustion turbines and several diesel generating units which serve the rural areas of the Island. Almost 75% (just over \$6 billion) of the CPW for the Isolated Island case is associated with fuel expense, whereas fuel expense accounts for less than 20% (approximately \$1.2 billion) of the CPW for the Interconnected Island case.



#### 6.3.4 Purchased Power Expense

##### Non-Utility Generators

NL Hydro purchases the output of a number of Non-Utility Generators (NUG) located on-Island. These generators include a number of hydroelectric units and wind turbine units. The forecasted cost of purchased power expense for these units was determined based upon the commercial terms of their contracts.

#### 6.3.5 Muskrat Falls & Labrador-Island Link

The expense for purchased power from Muskrat Falls was consistent with the pricing framework as described in section 4.2.9 *Power Purchases from Muskrat Falls* on page 44. The cost of the Labrador-Island Link reflected a traditional cost of service approach as typically used by NL Hydro in the past.

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#### 6.3.6 Depreciation Expense

The following lives were used to determine Depreciation Expense for various classes of assets.

**Table 16 – Depreciation Lives for Various Classes of Assets**

| Technology                        | Depreciation Life (Years) |
|-----------------------------------|---------------------------|
| Gas Turbines                      | 25                        |
| Hydraulic Generation              | 60                        |
| Combined-Cycle Combustion Turbine | 30                        |
| Wind                              | 20                        |
| Labrador Island Transmission Link | 50                        |

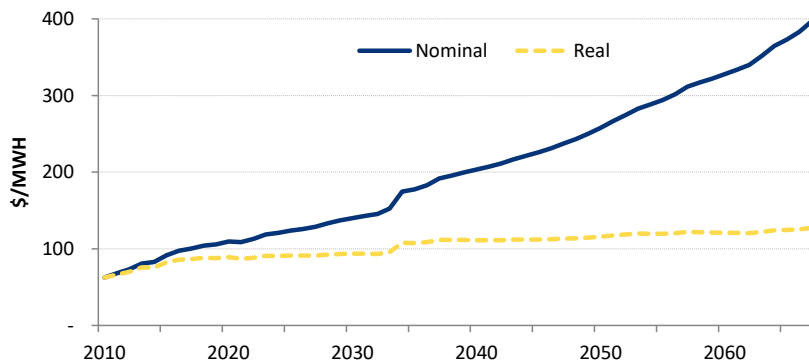
### 6.4 Analysis of Results

#### 6.4.1 Isolated Island Case

The base Isolated Island case has Newfoundland remaining electrically isolated from the system. *Figure 22* below illustrates the revenue requirement on a nominal and real basis for the time period 2011-2067.

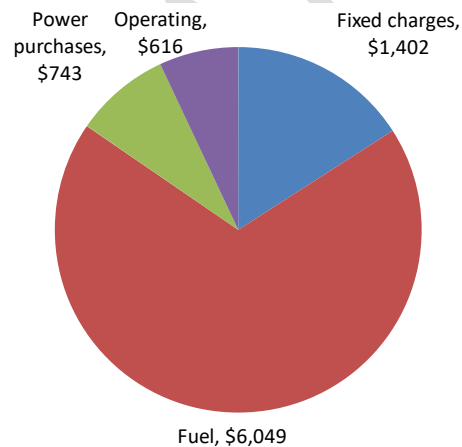


**Figure 22 – Average Revenue Requirement of the Isolated Island Case**



The composition of the revenue requirement for the Isolated Island Case is shown in [Figure 23](#).

**Figure 23 – Composition of the Isolated Island CPW**



It is interesting to note that almost 75% of the CPW for the Isolated Island case is due to fuel expenses for thermal power plants. Fuel costs are highly volatile and therefore the revenue requirement associated with the Isolated Island case can be expected to experience significant fluctuations from year-to-year. This also reinforces the relatively high sensitivity of the Isolated Island case to fuel cost – the sensitivity analysis conducted by Nalcor and Navigant showed the CPW for the Isolated Island case going from an amount is only \$120 M more than the



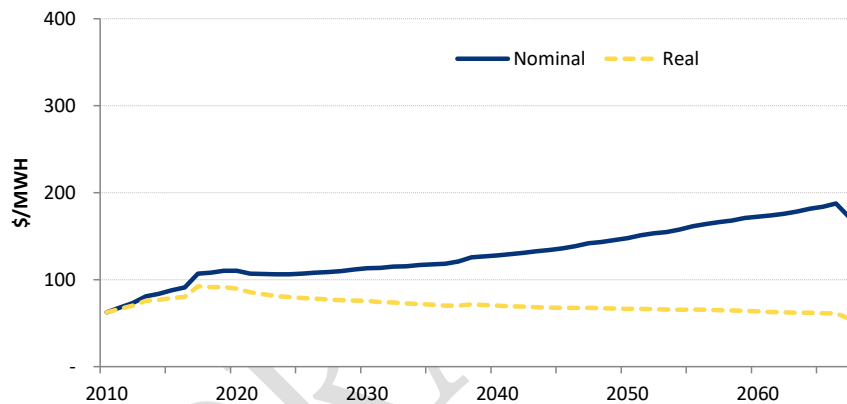


Interconnected Island case under the PIRA Low Fuel Price forecast to more than \$5 B higher than the Interconnected Island case under the PIRA High Fuel Price forecast.

#### 6.4.2 Interconnected Island Case

The base Interconnected Island case assumes 1) an interconnection of Newfoundland to the mainland through the Labrador-Island Link and 2) provision of power from Muskrat Falls under a PPA. [Figure 24](#) below illustrates the revenue requirement on a nominal and real basis for the time period 2011-2067.

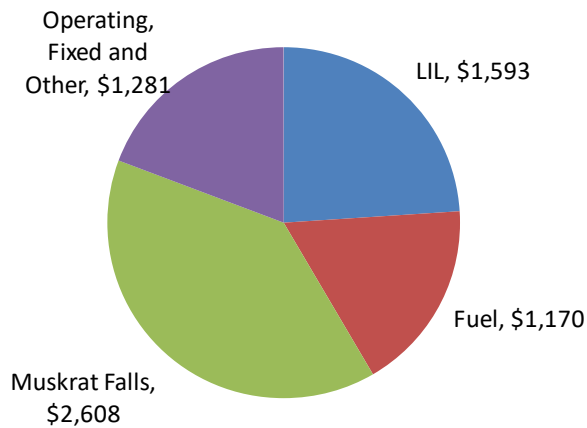
**Figure 24 – Average Revenue Requirement of the Interconnected Island Case**



The composition of the revenue requirement for the Interconnected Island case is shown below in [Figure 25](#).



Figure 25 – Composition of the Revenue Requirement of the Interconnected Island Case



In contrast to the Isolated Island Case the Interconnected Island Case has much lower fuel costs. Not surprisingly, the cost of purchased power from Muskrat Falls is approximately 39% of the CPW for the Interconnected Island case and the Labrador-Island Link contributes approximately 24% of the CPW for the Interconnected Island case.

## 6.5 Summary of Results

In summary, Navigant's key findings with respect to Nalcor's rate impact analysis are:

26. Except for a brief period at the end of this decade, the real (i.e. changes in the tariff stated in dollars per MWh in excess of inflation) costs incurred by NL Hydro are lower in the Interconnected Island case than the Isolated Island case.

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27. Nalcor's overall wholesale rate impact analysis accurately reflects the expected rate impacts of the two cases under the assumptions provided and provides a reasonable basis for assessing unit cost trends with respect to the two cases.

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## 7 KEY FINDINGS AND CONCLUSIONS

Navigant assessed the following aspects of Nalcor's recent Decision Gate (DG) 2 decision with respect to long-term electricity supply for the Island of Newfoundland:

- The reasonableness of the long-term Island supply options considered by Nalcor;
- The reasonableness of Nalcor's assumptions associated with Island supply options;
- The reasonableness of the process followed to screen and evaluate the supply options; and
- The accuracy of Nalcor's revenue requirements / rate analysis.

Navigant's key findings related to these four aspects of the decision are provided below followed by Navigant's assessment as to whether the Interconnected Island case represents the least cost option that also fulfills the additional criteria requirements of security of supply and reliability, environmental responsibility, and risk and uncertainty within the context of the DG2 decision.

### 7.1 Key Findings

1. Nalcor's Gateway process is a deliberate means of providing quality assurance for key decisions at crucial points in a project's lifecycle and is consistent with best practices.
2. Within the context of Nalcor's Gateway process, the level and accuracy of the information used in Nalcor's DG2 Island Supply Decision was appropriate for the decision stage.
3. Using the same pricing framework as used to determine the \$76 (2010\$) per MWh initial price of purchased power from Muskrat Falls, the initial price of purchased power from Gull Island would be significantly higher at \$122 (2010\$) per MWh. Given this higher price, it was reasonable for Nalcor not to include Gull Island in the Interconnected Island case.
4. **Churchill Falls conclusion**
5. Given that the expected cost of power from other potential hydro facilities would be substantially higher than wind power, it was reasonable for Nalcor not to include other potential hydro facilities in either system expansion case.
6. The transmission options considered by Nalcor in both system expansion cases were reasonable.



7. Wind power is expected to be the lowest cost of the other renewable electricity supply options on the Island and Nalcor's inclusion of wind power in the Isolated Island case was reasonable.
8. Nalcor's Isolated Island case could have considered additional wind power - 100 MW in 20205 and a further 100 MW in 2035 – when such power would be expected to displace fossil fuel-fired generation most of the time.
9. The ability of the isolated system to integrate an additional 200 MW of wind power while still maintaining stable system operations would require more study. Integrating more than 200 MW of wind power would likely create system instability problems due to the limited ability of the Island's fossil and other generation facilities to moderate supply given the variability of wind power.
10. An additional 200 MW of wind power – which does not provide firm capacity during periods of peak demand – would not obviate the need for the firm capacity provided by the Holyrood facility.
11. Nalcor's consideration of oil-fired generation, and exclusion of natural gas, LNG and coal as fossil fuel sources for electricity generation in both system expansion cases, was reasonable given the size, electricity consumption and location of Newfoundland and the unfavourable attributes of these other fossil fuels relative to oil in the context of the Island supply decision. **Could expand or provide a conclusion for each fuel**
12. Nalcor's base forecast for demand and energy growth is reasonable.
13. Aggressive pursuit of CDM would not make the Isolated Island case more economic than the Interconnected Island case.
14. Nalcor's estimated capital costs for the various supply expansion alternatives considered in the two cases was reasonable.
15. Nalcor's focus on time, tactical and strategic risks for the Muskrat Falls and Labrador-Island Link was critical to ensure that the projects' ultimate project capital costs falls as close to the estimates as possible. In particular, the emphasis on the 34 major strategic risks that were identified in the analysis constitutes a key element in the overall risk assessment and risk mitigation.
16. Nalcor's risk assessment analysis for Muskrat Falls and the Labrador-Island Link project was thorough and comprehensive.
17. The heat rates, fuel prices and operating and maintenance costs used by Nalcor in its analysis were reasonable.



18. Nalcor did not consider all of the potential risks associated with environmental legislation that could impact the Isolated Island case, such as limits on the unit emission rates for new fossil-fuel fired generation. Given this, the risk (and possibly CPW) for the Isolated Island case may be higher than assumed by Nalcor in its DG2 decision.
19. The Muskrat Falls pricing approach used by Nalcor was appropriate and sufficiently well defined for the purposes of 1) estimating the Muskrat Falls power purchase price, and 2) informing the DG2 decision.
20. Nalcor could have considered the introduction of some form of carbon pricing regime in its analysis. Any such regime would increase the preference for the Interconnected Island case given the significantly higher GHG emissions under the Isolated Island case.
21. The processes used by Nalcor to develop the various escalation estimates were rigorous and indices resulting thereof are reasonable.
22. Nalcor's use of the Strategist model in developing the two cases was appropriate and reasonable, and its process for constraining the potential combinations of resources in the Strategist model was a reasonable means of managing the complexity of the optimization problem.
23. Navigant believes that the sensitivities modeled appropriately capture the key elements of uncertainty associated with the supply decision, and the results support the preference for the Interconnected Island case.
24. All of the sensitivities modeled resulted in a CPW advantage for the Interconnected Island case. This clearly indicates that the DG2 decision preference for the Interconnected Island case was robust given the underlying risk and uncertainty in key assumptions as well as possible refinements to the Isolated Island case as identified by Navigant.
25. Currently available information – specifically, the updated May 2011 PIRA fuel forecast and recent federal load guarantee commitment – increases the preference for the Interconnected Island case
26. Except for a brief period at the end of this decade, the real (i.e. changes in the tariff stated in dollars per MWh in excess of inflation) costs incurred by NL Hydro are lower in the Interconnected Island case than the Isolated Island case.
27. Nalcor's overall wholesale rate impact analysis accurately reflects the expected rate impacts of the two cases under the assumptions provided and provides a reasonable basis for assessing unit cost trends with respect to the two cases.



On balance, Navigant believes that the \$2.2 billion difference in the reference case used for the DG2 decision case represents a reasonable estimate of the expected difference between the two cases, given the results of the sensitivity analysis undertaken by Nalcor and Navigant.

#### **7.4.17.2 Is the Interconnected Island the Least Cost Supply Option for Newfoundland?**

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Based on its analysis, Navigant's conclusion is that the Interconnected Island case is the least cost option for the Island of Newfoundland within the context of the DG2 decision. Short-term increases in the real average tariff would occur over the next few years under either case. However, a gradual decrease in real average rates occurs for the Interconnected Island case brings these rates back to current levels by 2067.

Relative to the Isolated Island case, the Interconnected Island case is also expected to provide similar levels of security and reliability (need to confirm), significantly reduced GHG emissions and, based on the sensitivity results presented above, significantly less risk and uncertainty.

Navigant recognizes that further analysis will be undertaken by Nalcor in the period leading up to the DG3 decision. In order to provide a more robust decision, Navigant recommends that Nalcor undertake a more holistic, integrated approach in its development of options for and analysis for DG3 that would include:

- Additional renewables, CDM and transmission expansions/upgrades, with a primary focus on their application in the Isolated Island case.
- Explicit consideration of the impact of potential GHG legislation on costs.
- Explicit identification and consideration of scenarios (plausible combinations of key assumptions) in its analysis with re-optimized expansion plans for each of the scenarios.
- Monte Carlo analysis of assumptions to more fully explore the variability in costs in the alternative cases being considered.