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June 12, 2012

# Comments on the Justification for the Lower Churchill Transmission Project (Labrador-Island Transmission Link)

submitted to the  
Canadian Environmental Assessment Agency  
Comprehensive Study on the Lower Churchill  
Transmission Project

and to  
Government of Newfoundland and Labrador,  
Department of Environment and Conservation

on behalf of Grand Riverkeeper Labrador Inc.

by

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## 1. Mandate

### 1.1. *Mandate*

Grand Riverkeeper, Labrador Inc. has asked me to review the stated justification for the Labrador-Island Transmission Link (“the Project”), as presented in the Proponent’s Environmental Impact Statement, taking into account the report of the Public Utilities Board of Newfoundland and Labrador (PUB), as well as that prepared for the PUB by its consultant Manitoba Hydro International Inc. (MHI).

### 1.2. *Qualifications*

Cofounder of the Helios Centre, Philip Raphals has extensive experience in many aspects of sustainable energy policy, including least-cost energy planning, competitive market design, utility regulation (including transmission ratemaking) and green power certification. He is the author of numerous studies and reports and frequently appears as an expert witness in the regulatory arena. He has explored in detail the interaction between competition and regulation as well as the environmental implications of electricity trade.

Mr. Raphals is also an authority in the area of hydropower and the environment. From 1992 to 1994, he was Assistant Scientific Coordinator for the Support Office of the Environmental Assessment of the Great Whale hydro project, where he coauthored a study on the role of integrated resource planning in assessing the project’s justification.<sup>1</sup> In 2001, he authored a major study on the implications of electricity market restructuring for hydropower developments, entitled *Restructured Rivers: Hydropower in the Era of Competitive Energy Markets*. In 2005, he advised the Federal Review Commission studying the Eastmain 1A/Rupert Diversion hydro

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<sup>1</sup> J. Litchfield, L. Hemmingway, and P. Raphals. 1994. *Integrated resources planning and the Great Whale Public Review*. Background paper no. 7, Great Whale Public Review Support Office, 115 pp. (also published in French).

project with respect to project justification. Later, he drafted a submission to this same panel on behalf of the affected Cree communities of Nemaska, Waskaganish and Chisasibi.

Mr. Raphals chairs the advisory committee for renewable energies of the Low Impact Hydropower Institute (LIHI) in the United States, and has participated actively in the developing the low impact renewable electricity guideline for the Canadian Ecologo programme. Mr. Raphals is a frequent expert witness before the Quebec Energy Board (the Régie de l'énergie du Québec), notably with respect to transmission regulation.

Mr. Raphals has testified before the Joint Review Panel for Lower Churchill Generation Report, and before the Public Utilities Board of Newfoundland and Labrador, with respect to its review of the Muskrat Falls project.

He studied at Yale and at Boston University.

## **2. Project justification in the EIS**

The Proponent's stated justification for the proposed Project is presented in Chapter 2 of the EIS, entitled "Projet Rationale and Planning". In this chapter, after presenting the provincial energy plan (section 2.1), the Proponent describes the "Need, Purpose and Rationale" for the Project (section 2.2), its Justification in Energy Terms (section 2.3), and its Economic Analysis (section 2.4).

It then proceeds to discuss "Alternative Generation Sources" to the Muskrat Falls generation project (section 2.5, and the Development of Least-Cost Expansion Plans (section 2.6).

In section 2.7, it presents a Discussion of the Economic Analysis; in section 2.8, the project's Financial Benefits; and in section 2.9, its Environmental Benefits. Section 2.10 addresses Risk Management; section 2.11, Project Planning; and Section 2.12, Alternative Means of Carrying out the Project.

In section 4 of this report, we will comment on several of these elements.

### 3. Project rationale

In section 2.2 of the EIS, the Proponent clearly articulates its rationale for the Project:<sup>2</sup>

By constructing the Project, Nalcor will develop a long-term asset to meet this requirement for least-cost energy. The rationale for the Project is that its construction enables the transmission of energy from Muskrat Falls in Labrador: the least-cost option to meet long-term supply of power to the Island.

Thus, the Project is required to transmit the energy from the Muskrat Falls generation facility to the Island of Newfoundland. The stated justification for the Project is that, in combination with the closely related Muskrat Falls facility, it would constitute “the least-cost option to meet long-term supply of power to the Island.”

This same question has already been addressed by two public bodies: the Joint Review Panel for the Environmental Assessment of the Lower Churchill Generation Project, and the Public Utilities Board of Newfoundland and Labrador, in response to a reference from the provincial government.

Neither of these two bodies concluded that the proposed project is justified. The high-level conclusions of these two bodies are described in the following subsections.

#### ***3.1. Report of the Joint Review Panel***

Section 4.2 of the Report (Alternatives to the Project) concludes at page 34 as follows:

**The Panel concludes that Nalcor’s analysis that showed Muskrat Falls to be the best and least cost way to meet domestic demand requirements is inadequate and an independent analysis of economic, energy and broad-based environmental considerations of alternatives is required.** (bold in the original)

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<sup>2</sup> EIS, page 2-3.

Given that a Joint Review Panel, after several years of effort, found Nalcor's analysis showing Muskrat Falls to be the best and least cost way to meet domestic demand requirements to be **inadequate**, it is hard to see how the Responsible Authorities or the Agency, in a comprehensive study, could ever find the same analysis to be convincing.

That said, Nalcor has included in the LITL EIS certain information which it did not present to the Review Panel. It is thus relevant to ask whether the new information presented in the LITL EIS, which was not made available to the JRP, could be sufficient and adequate as a matter of fact to put to rest the concerns raised by the JRP? We will address this question from a factual perspective in our concluding chapter.<sup>3</sup>

### ***3.2. Reference to the Public Utilities Board***

On June 17, 2011, the government of Newfoundland and Labrador announced that it had mandated the provincial Public Utilities Board ("PUB") to conduct a review of the Muskrat Falls component of the Lower Churchill Generation Project and the Labrador-Island Link transmission line ("PUB Review of Muskrat Falls").

The Reference Question that the Province referred to the PUB is that "[t]he Board shall review and report to Government on whether the Projects represent the least-cost option for the supply of power to Island Interconnected Customers over the period of 2011-2067, as compared to the Isolated Island Option". This reference to the PUB is also mentioned by Nalcor in section 2.2 of the EIS.

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<sup>3</sup> I understand that several issues related to these questions are currently being argued before the Federal Court. I do not purport in any way to comment, in this document, on any matters of law in relation to that proceeding.

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Following a call for tenders, the PUB engaged Manitoba Hydro International as a consultant to assist it in the process. MHI produced a two-volume report entitled *Report on Two Generation Expansion Alternatives for the Island Interconnected Electrical System* in January 2012.<sup>4</sup>

In its report, MHI gave qualified support to Nalcor's conclusion that the Cumulative Present Worth (CPW) of the Infeed Option (including Muskrat Falls and the LITL) was lower than that of the Isolated Island Option as defined by Nalcor and as included in the PUB's Terms of Reference. It found Nalcor's analysis to be correct, given the inputs used, and it found these inputs to be "generally ... appropriate" (v. 1, p. 15). However, it identified a number of risks, related in particular to assumptions regarding load forecasts, capital cost estimates and fuel price, that could affect this outcome. And it found these risks to be substantial, given the 50+ year timeframe of the CPW analysis. MHI also raised a number of important concerns about design choices and reliability, where are summarized below.

In its report,<sup>5</sup> however, the Public Utilities Board of Newfoundland and Labrador did **not** make a determination as to the cost effectiveness of the Interconnected Option as compared to the Isolated Island Option, but rather concluded that the information provided to it was not adequate to support such a determination. On page iv, it wrote:

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

The Board based this conclusion in large part on the inadequacy of the information provided to the Board and its consultants.

In the final section of its report, the Board addressed in detail many of MHI's comments concerning planning criteria, AC integration studies, reliability assessment and adherence to

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<sup>4</sup> Available at <http://www.pub.nf.ca/applications/MuskratFalls2011/MHIreport.htm>.

<sup>5</sup> Available at [http://www.gov.nl.ca/lowerchurchillproject/muskrat\\_falls\\_pub\\_final\\_report.pdf](http://www.gov.nl.ca/lowerchurchillproject/muskrat_falls_pub_final_report.pdf).

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NERC standards. In particular, the Board rejected Nalcor's justification for the use of a 1:50 return period for the reliability assessment of the HVDC line.

Nalcor's reasoning for its rejection of this recommendation is not supported by the facts. Nalcor is relying on its own operational experience to support a design standard for a critical component of the Island's transmission infrastructure, even though it has no experience with the transmission line conditions in the alpine areas contemplated by the proposed route. **Nalcor proposed a "worst case" two-week scenario** to compare a prolonged HVdc bipole outage to a similar two-week outage on the existing system. **The Board agrees with MHI that this two-week period is not realistic and is not an industry accepted metric. Nalcor does not plan to add backup generation, such as combustion turbines, on the Island in the event of a major failure of the HVdc line** with or without the Maritime Link. The Board is of the view that Nalcor should address these significant gaps related to a major component of the Interconnected Option before proceeding to the next decision phase.<sup>6</sup> (emphasis added)

The Board also expressed concern about the possibility of load shedding on the Avalon and possibly the Burin Peninsula, in the event of an HVDC bipole outage (p. 85).

The Board considers that its statutory responsibility for reliability obliges it to consider these issues, even though Nalcor is exempted from the EPCA. It concludes:

In the Board's opinion, when considered together, **these gaps related to power system reliability raise serious concerns in relation to Nalcor's assessment of the interconnection of the significant generation associated with the Muskrat Falls generating facility to the Island Interconnected system.** These deficiencies should be addressed by Nalcor in a meaningful way should the Interconnected Option proceed to project sanction.<sup>7</sup> (emphasis added)

None of these deficiencies are addressed in the EIS.

As noted above, the PUB concluded that the information provided to it was not detailed enough, complete enough or current enough to support a determination as to the superiority of the Interconnected Option as compared to the Isolated Island Option. The information provided in the EIS with respect to project justification represents only a small subset of the information

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<sup>6</sup> Ibid., p. 99.

<sup>7</sup> Ibid., p. 100.



provided to the PUB, and it is neither more detailed, more complete nor more current.<sup>8</sup> The full body of information presented by Nalcor to the PUB was inadequate to convince the Board of the superiority of the Infeed Option, compared to the Isolated Island Scenario defined by Nalcor. One must therefore conclude that the PUB's review, like that of the Joint Review Panel, fails to support the project justification submitted by Nalcor in support of the LITL project.

## 4. Detailed Comments

In this section, I will comment on a number of specific elements raised by Nalcor in its chapter 2 of its EIS.

### 4.1. *Project planning and risk management*

#### 4.1.1. Planning process

In section 2.3 of the EIS, the Proponent explains its planning process has three basic functions:

- 1) The development of a long-term energy and capacity forecast.
- 2) An evaluation of whether existing supplies are adequate to meet forecasted requirements.
- 3) The development of expansion plans to meet the forecast.<sup>9</sup>

The Proponent asserts that the Isolated Island alternative presented in the EIS, which was developed using *Strategist* software, “represents the optimum portfolio of available generation

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<sup>8</sup> On page 2-2 of the EIS, Nalcor indicates that this chapter is largely based on Nalcor's submission to the PUB.

<sup>9</sup> EIS, p. 2-3.

sources without the Project.”<sup>10</sup> However, no demonstration is made of this assertion, either in the EIS or in other documents made public to date by Nalcor.

According to the *Electrical Power Control Act, 1994*, s. 3(b)(iii), the province’s power system should be managed and operated in a manner that would result in power being delivered to consumers in the province at the lowest possible cost consistent with reliable service.

Utilities across North America and abroad have put planning processes in place to determine the least-cost portfolio of resources to meet forecast demand. Such processes generally include several common features:

- Inclusion of supply-side (generation) and demand-side (demand management and conservation) resources;
- Evaluation of several alternative resource portfolios that meet projected demand; and
- Comparison of portfolios based on various parameters (cost, reliability, risk and, in many cases, environmental and social considerations).

There is no indication to the effect that any such process has been carried out by Nalcor or its subsidiary NLH in determining that the Isolation Island Scenario described in Table 2.6.1-1 actually represents the least-cost portfolio.

It is important to understand that planning programs like *Strategist* represent important inputs into a least-cost planning process, but can in no way substitute for such a process.

Back in 2007, the PUB found that “an IRP (Integrated Resource Plan) undertaken as part of a generic process as described in Order No. P.U. 14 (2004) is an important planning tool and would enhance the information available to the Board and other parties regarding future generation and supply options in the Province.”<sup>11</sup>

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<sup>10</sup> EIS, p. 2-66.

<sup>11</sup> Order P.U. 8 (2007), p. 60.

In that decision, the Board quotes P.U. 14 (2004) as follows:

*“...implementation of Integrated Resource Planning may present sound opportunities for coordinated planning and improved regulation involving both utilities. This process brings together strategic planning, future supply and demand, least cost analysis, demand side management options and environmental considerations.”*

According to Nalcor’s testimony before the Joint Review Panel for the Lower Churchill Generation Project, there has been no progress since that then with respect to integrated resource planning, either from the PUB or from the regulated utilities. This is unfortunate, because IRP is one important tool (among others) needed to properly compare the economic and environmental implications of alternate solutions to providing reliable electric power. Had Nalcor or its subsidiary NLH undertaken an integrated resource planning process *prior to* choosing a resource development strategy, the controversy surrounding the justification of and alternatives to the Muskrat Falls Generation and Transmission projects might well have been avoided.

While the restructuring of electric markets has resulted in limiting the application of IRP in many regions, it remains very relevant, *especially* for isolated electric systems. The Hawaiian Electric Company is a leader in this regard. The utility explains its planning process as follows:

How do we ensure that Hawaii’s energy needs will be met reliably and affordably for the years to come? It takes selecting the best mix of energy resources. That choice is not a matter of “either/or,” but rather an array of solutions, combining conservation and energy efficiency, renewables, distributed generation technologies as well as clean and efficient central power plants.

To find the right mix, Hawaiian Electric uses a process called Integrated Resource Planning (IRP). The Hawaii Public Utilities Commission (PUC) established IRP in 1992 for electric utilities to forecast energy demand and analyze the best ways to meet it. No other sector regulated by the PUC goes through such a thorough and far-reaching planning process.

In IRP, an outside advisory group representing business, government, energy regulators, consumers, environmentalists, and other interested stakeholders work closely with utility planners and engineers. They consider population growth, culture, lifestyle, the economy, the environment, available energy technology and other factors.

Hawaiian Electric, Maui Electric and Hawaii Electric Light companies each undertakes a separate IRP process for its service territory.

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Hawaiian Electric has begun its fourth IRP Process which is expected to result in a new 20-year plan being developed and filed with the PUC in mid-2008.<sup>12</sup>

Hawaii, like Newfoundland, is anxious to find ways to use indigenous renewable energy to replace fossil fuels. However, unlike Newfoundland and Labrador, it is approaching the question in a structured fashion designed to discover and compare all possible solutions, in order to choose the best one.

Furthermore, given that it excludes *demand*-side resources (as discussed below), many of which are clearly cost-effective, it is virtually impossible that the portfolio developed by *Strategist* is indeed the least-cost portfolio.

**For all these reasons, the Comprehensive Study Report should conclude that the Proponent has failed to demonstrate that the Muskrat Falls Transmission Project, in combination with the Muskrat Falls Generation Project, constitutes the least-cost option to meet long-term supply of power to Newfoundland Island.**

#### 4.1.2. Risk

Management of the risks and uncertainties related to the various resource options is an essential aspect of least-cost planning. In section 2.10, the Proponent addresses the question of Risks and Risk Management.

Unfortunately, this discussion remains entirely theoretical. It fails to address or specify in any way how the Proponent intends to address any of the specific risks related to the planning of its power system in general or the Muskrat Falls project in particular.

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<http://www.heco.com/portal/site/heco/menuitem.8e4610c1e23714340b4c0610c510b1ca/?vgnextoid=b71bf2b154da9010VgnVCM10000053011bacRCRD&vgnextfmt=default>

The Comprehensive Study Report should therefore conclude that the Proponent has failed to adequately address the risks and uncertainties related to the various resource options it considers.

## **4.2. Needs**

### **4.2.1. Load Forecast**

The first step in the Proponent's planning process, as described above, is to develop a long-term energy and capacity forecast. This is indeed a critical step.

In its report, MHI indicated:

“The amount of variability due to potential load changes is high and could materially impact the results of the cumulative present worth analysis” (v. 2, p. 39).

The implications are twofold: first, that the uncertainty with respect to the Proponent's load forecast is great, and second, that this uncertainty could invalidate the Cumulative Present Worth (CPW) analysis on which the Proponent's justification rests. It is thus important to look at the load forecast in detail.

The Proponent's load forecast projects “utility loads” (residential, commercial and institutional loads) increasing at 1.3% from 2009 to 2029, despite the fact that population is expected to decline gradually throughout this period (Table 2.3.1-2). The explanation is found on page 2-11, where Figure 2.3.1-4 shows that growth in the number of domestic customers has increased along with that of the population 25 and over, despite the decline in total population that began in 1993. The Proponent then explains that household and customer formation are most closely related to this age subset.

The EIS does not go deeper into the province's demographic projections, nor does it address load growth past 2029, despite the fact that planning period extends to 2067.

However, if the 25+ population has grown while the total population has declined, this inevitably means that the population under 25 has declined. Whether that is the result of an aging population that has fewer children, or of the emigration of young adults, we do not know. In either case, however, it suggests that the current pattern cannot sustain itself indefinitely. If current under-25 cohorts are smaller than the older cohorts, that could well suggest a long-term trend toward a significantly smaller population.

The MHI report points out that, for the last ten years, NLH's has consistently underforecast domestic energy consumption.<sup>13</sup> However, a systematic error in the past is no guarantee that future forecasts will err in the same direction. (The same issue arises with respect to fuel price forecasts, discussed below.)

Furthermore, MHI points out that the forecasting methodology used by Nalcor, based exclusively on econometric modeling, without any end-use modeling, does not represent best utility practice. Given that electric space heating is a key driver for electricity demand, end-use modeling is essential.

With respect to the industrial forecast, MHI shows that Nalcor and NLH's forecasts have dramatically overstated industrial demand over the years, as shown in the following table:<sup>14</sup>

Forecast Accuracy Measured in Percentage of Deviation from the Actual Load										
Years of History	1	2	3	4	5	6	7	8	9	10
Industrial	5%	14%	27%	37%	50%	67%	76%	92%	119%	124%

As noted above, MHI concluded that "The amount of variability due to potential load changes is high and could materially impact the results of the cumulative present worth analysis."<sup>15</sup> MHI

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<sup>13</sup> MHI, v. 2, p. 19, Table 4.

<sup>14</sup> MHI, vol. 2, p. 24.

also pointed out that Nalcor's industrial load forecast assumed no change in status for the Corner Brook Pulp and Paper Mill.<sup>16</sup> However, as of this writing, the closure of the Corner Brook Pulp and Paper Mill appears probable, as NL Natural Resources Minister Jerome Kennedy recently announced that it is 'on the verge of bankruptcy'.<sup>17</sup>

MHI concluded that the loss of a load of this magnitude would on its own result in a reduction of the perceived CPW benefit of the Interconnected Option from \$2.158 billion to \$408 million, a reduction of over 80%.

**I therefore conclude that the Proponent's load forecast does not provide a solid basis on which to base the conclusion that the Muskrat Falls option is preferable to the No Project option.**

#### 4.2.2. Conservation and demand management

In a one-and-a-half page section contained in s. 2.3.1.4 ("Key Forecast Assumptions and Drivers") of the EIS, the proponent describes the status and potential for Conservation and Efficiency in Newfoundland and Labrador. It indicates in the following section that "NLH has not explicitly incorporated these utility sponsored program savings targets into its PLF (Planning Load Forecast) due to the uncertainty of achieving dependable firm outcomes."<sup>18</sup>

The Proponent's exclusion of CDM from its planning process flies in the face of good utility practice. For example, MHI explains that, in the standard generation planning process, "Demand

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<sup>15</sup> Ibid., p. 39.

<sup>16</sup> MHI Report, v. 1, p. 85.

<sup>17</sup> <http://www.cbc.ca/news/canada/newfoundland-labrador/story/2012/06/08/nl-jerome-kennedy-mill-future-608.html>

<sup>18</sup> EIS, page 2-13.

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side management is treated as if it were generation, as it represents a reduction from the base load forecast. The economics of DSM programs should be evaluated to ensure that they make a positive contribution to the overall financial well-being of the province.”<sup>19</sup>

MHI criticized Nalcor for preparing its domestic forecast using only econometric modelling techniques which, it explains, are **not the best utility practices** in this area.<sup>20</sup> It points out that the domestic load forecast is primarily driven by electric space heat, and it emphasizes that developing an end-use forecasting model would have many benefits, including improving the design of CDM programs.

The forecasting methodology identified by MHI may be one of the reasons that Nalcor has failed to meet its own CDM objectives to date, and why its future CDM objectives are so weak.

CDM results to date, shown in the table 2.3.1-5 on page 2-13, demonstrate savings of only 5.3 GWh/year in 2010, or just 0.5% of the identified potential.

The Proponent states that “To date, the *response* to CDM programs and initiatives has been modest and lagging targets.”<sup>21</sup> (emphasis added) However, it fails to point out that the **programs and initiatives themselves** have also been modest and lagging targets.

The following chart, drawn from my April 13, 2011 submission to the Joint Review Panel,<sup>22</sup> demonstrates that CDM funding by NLH and by NP lagged far behind that which was projected in their Five-Year Joint CDM Plan.

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<sup>19</sup> MHI Report, vol. I, p. 31.

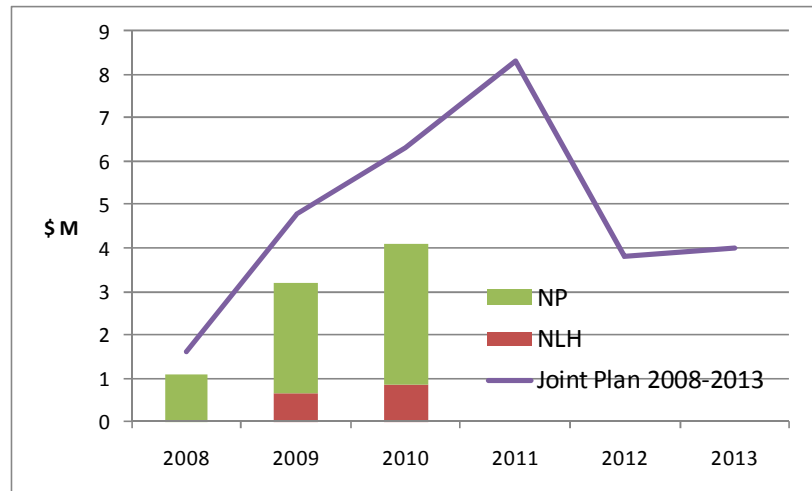
<sup>20</sup> Ibid., v. 2, pp. 20 and 39.

<sup>21</sup> P. 2-13.

<sup>22</sup> P. Raphals, “Comments on Proponent’s Response to the Panel’s Information Request of March 21, 2011,” submitted to the Joint Review Panel for the Lower Churchill Generation Project, April 13, 2011, p. 9. Available on CEAA website.



### CDM Program Funding



This is not particularly surprising: Most utilities perform very poorly when they first begin to pursue CDM savings. What is surprising is that, based on its admittedly poor performance in the first years of its CDM program, **NLH has chosen to exclude consideration of CDM savings as a resource in its 50-year power plan.** I am not aware of any other utility in North America that has so blatantly disregarded CDM as a resource.

The EIS also states: “As a *stand-alone option*, CDM is not a reliable alternative and cannot meet the long term electricity demands for electricity consumers in NL.” (emphasis added).

Obviously, CDM can never be a stand-alone option. This has not prevented it from being a major component of the least-cost resource plan of virtually every utility in North America.

Table 2.7.1-3 presents the results of five sensitivity analyses with respect to CDM, together with the resulting CPW preference for the Interconnected Island (Muskrat Falls) option. The results are as follows, expressed as a percentage reduction of the base case preference of \$2,158 million:

1. Moderate conservation (375 GWh/yr by 2031) — 21% reduction
2. Aggressive conservation (750 GWh/yr by 2031) — 41% reduction
3. Loss of 880 GWh/yr from 2013 on — 81% reduction

4. Loss of 1086 GWh/yr from 2013 on — 100% reduction
5. Low load growth (50% of projected load growth) — 65% reduction

Scenarios 3 and 4, which represent a sudden decrease of 11% or of 13% of total load, presumably model the sudden loss of an industrial load. While the relationship is not spelled out in the EIS,<sup>23</sup> Scenario 3 refers to the possible closing of the Corner Brook Pulp and Paper Mill. This possibility was invoked by MHI, at whose request this sensitivity analysis was carried out. The relevant passage of the MHI report reads as follows:

#### 7.5 Load Forecast Sensitivity

Another consideration which could have a significant impact on the resulting CPW relates to the assumption used for the load forecast. The assumption used for the Isolated Island Option was based on the same planning load forecast<sup>69</sup> (PLF) described in the 2010 Capital Budget Application to the Board, but extended to 2067. **However, the significance of a possible alternate future for the remaining pulp and paper mill was not considered as an additional Isolated Island scenario. The PLF makes the assumption that there is no change in status for the mill.** MHI requested Nalcor to perform a sensitivity analysis with a reduction in system consumption of 880 GWh per year, equivalent to the total electric energy requirement of the mill including purchases from Nalcor and their own generation. In Exhibit 43, revision 1, Nalcor indicated the CPW differential between the two Options would be reduced from \$2.158 billion in the base case to \$408 million in favour of the Infeed Option.<sup>24</sup> (emphasis added)

As noted above, the closure of the Corner Brook Pulp and Paper Mill appears probable. In other words, this Scenario 3, which now seems likely to occur, would on its own result in eliminating **four-fifths** of the perceived benefit of the Muskrat Falls scenario.

Scenarios 1 and 2 refer to “Moderate” and “Aggressive” conservation, with gains of 375 or 750 GWh/yr by 2031. However, it is important to note that, according to documents detailing these

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<sup>23</sup> See page 2-10.

<sup>24</sup> MHI Report, v. 1, p. 85.

scenarios filed with the PUB, the scenarios foresee no additional CDM gains between 2031 and 2067.

How “aggressive” is the Aggressive Conservation scenario? To answer this question, we need to refer to the study of the CDM potential in Newfoundland prepared by Marbek Resource Consultants in 2008.<sup>26</sup> It was filed in response to PUB Order PU 8 2007, which required NLH to file it and a five-year plan for implementation of CDM programs, starting in 2008.

The summary of the study findings, on page 9, identifies the Upper and Lower limits of Achievable Savings by the year 2026 as 951 and 556 GWh/yr, respectively. This table is reproduced on p. 2-12 of Nalcor’s EIS.

This 2008 Marbek report, which is mentioned on page 2-12 of the EIS, and which is apparently the only serious study of conservation and demand management (CDM) potentials ever undertaken by NLH, identifies an upper achievable limit of 951 TWh, or 15% of total base-year consumption, as shown in Table 2.3.1-4.

It fails, however, to mention two important aspects of this estimate of an “achievable upper limit”. First, it is based on a horizon of 2026.<sup>27</sup> Obviously, the achievable potential over the 50-year planning horizon for the Muskrat Falls project would be considerably greater.

Second, it is based on an avoided cost of just 9.8 cents/kWh.<sup>28</sup> In evaluating CDM potentials, a key parameter is the cost of energy the use of which could be avoided, since it is this cost which ultimately determines what CDM measures are cost effective. Given that, with or without the

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<sup>26</sup> Marbek Resource Consultants Ltd., CONSERVATION AND DEMAND MANAGEMENT (CDM) POTENTIAL, NEWFOUNDLAND and LABRADOR: Residential, Commercial and Industrial Sectors

– Summary Report, prepared for Newfoundland & Labrador Hydro and Newfoundland Power, Jan. 31, 2008.

<sup>27</sup> Ibid., p. 2.

<sup>28</sup> Ibid., p. 4.

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Muskrat Falls project, the cost of wholesale power for NLH, at the margin, is anticipated to be around 16¢ by 2017, a similar study done today would use that higher avoided cost figure. **As a result, it would inevitably result in higher potentials, since, in addition to the CDM measures which were already deemed cost-effective in 2008, based on a lower avoided cost, more expensive CDM measures would now also become cost-effective.** Thus, the 2008 Marbek study necessarily **underestimates** the real CDM potential.<sup>7</sup>

I conclude that the EIS **fails to properly take into consideration the impacts on load growth of a properly designed and executed portfolio of CDM programs over the planning period. Had it done so, the CPW advantage of the Infeed scenario would be greatly decreased, if not eliminated, even before considering other sensitivities.**

As noted above, the generation planning methodology used by Nalcor explicitly excludes two important elements: demand side management options and environmental considerations. Instead, they are based on just one criterion: the reduction of costs to the utility. Benefits relating to reduced ratepayer cost are excluded from the analysis. According to a document provided by Nalcor to the PUB:

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 percent.** There were no objectives tied together as only one objective function was used.<sup>29</sup> (emphasis added)

Energy efficiency programs are generally measured by a number of tests, the most important of which is the Total Resource Cost test, which measures the total cost to a society, not just the cost to the utility. Thus, unlike the “minimization of utility cost” function, it also takes into account reductions of **customer** costs, resulting from reduced electricity use.

A recent study by the Regulatory Assistance Project in the US explains this as follows:

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<sup>29</sup> PUB, MHI-Nalcor-41 Rev. 1.

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The goal of an IRP is to identify the least-cost resource mix for the utility and its consumers. *Least-cost* in this case means lowest total cost over the planning horizon, given the risks faced. The best resource mix is typically the one that remains cost-effective across a wide range of futures and sensitivity cases — the most *robust* alternative — and that also minimizes the adverse environmental consequences associated with its execution.<sup>30</sup>

As noted earlier, if Nalcor had undertaken an IRP process in the past, as suggested by the PUB in 2007, most of the issues addressed in this brief would have been resolved prior to the initiation of the environmental assessment process.

As for environmental considerations, which play an important role in IRP, they are excluded from the Proponent's generation expansion planning.

The PUB declined to order implementation of an IRP in 2007, in anticipation of the provincial Energy Plan. I am not aware of any progress in that direction in the meantime.

Once again, we must distinguish between a generation scenario optimized on the basis of cost only, on the one hand, and a robust integrated plan, on the other. The Isolated Island Scenario is an example of the former. It constitutes an important input in the development of a plan, but should not be confused with the result.

**The Comprehensive Study Report should therefore include the following findings:**

- that the Proponent has failed to present a coherent load forecast that properly accounts for the uncertainty of its forecast industrial loads, or the achievable levels of Conservation and Demand Management,**
- that the Proponent has also failed to otherwise account for achievable levels of CDM in its resource strategy;**

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<sup>30</sup> Electricity Regulation in the US: A Guide, RAP, [www.raponline.org](http://www.raponline.org), p. 73.

- that, as a result, the Proponent has failed to demonstrate that its Isolated Island Option constitutes the least-cost option in the absence of the Muskrat Falls Generation and Transmission projects; and
- that, in consequence, the Proponent has failed to demonstrate that the Muskrat Falls Transmission Project, in combination with the Muskrat Falls Generation Project, constitutes the least-cost option to meet long-term supply of power to Newfoundland Island.

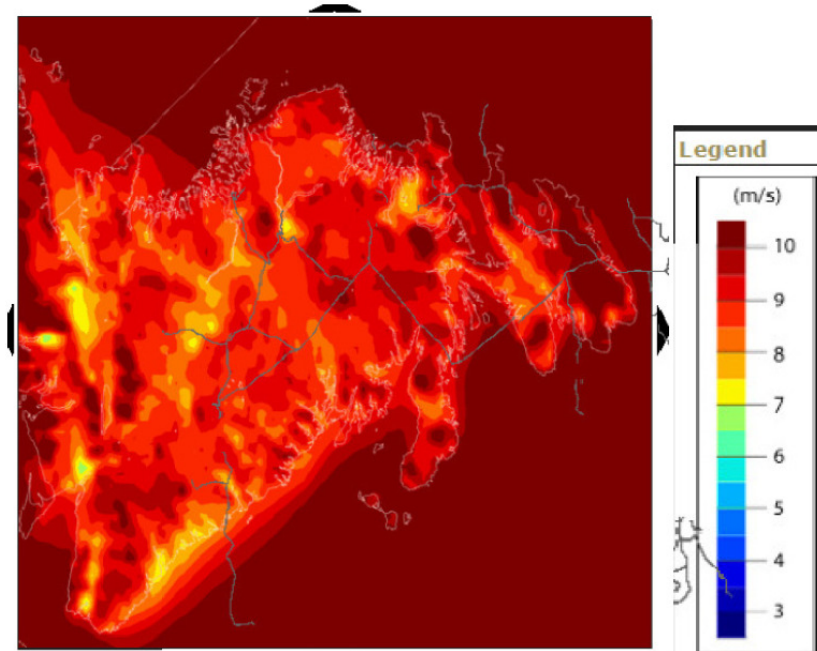
### **4.3. Alternatives**

The EIS devotes some 30 pages to purporting to review generation alternatives to Muskrat Falls, as part of setting out its views on the justification of the Labrador-Island Transmission Link. Many aspects of this review are deficient, as indicated in the following sections.

#### **4.3.1. Wind power**

In section 2.5.8, the Proponent provides a summary description of wind power technology, and describes its costs and limitations for the Island grid.

The EIS states that “Good wind sites are often located in remote locations, far from places where the electricity is needed.” This is indeed often the case, but it is most certainly **not** the case on the Island of Newfoundland. As the following image from the Canadian Wind Atlas demonstrates, average wind speeds are over 10 m/s across virtually all Newfoundland, including on the Avalon Peninsula, where most of the load is located.



As for the limitations on wind power, the EIS indicates that they were established in a 2004 NLH study (*An Assessment of Limitations for Non-Dispatchable Generation f the Newfoundland Island System*), which was provided to the PUB as Exhibit 61.<sup>31</sup> The EIS states that “The limits identified in the 2004 study are still applicable today.”<sup>32</sup> This statement is misleading and factually incorrect.

The EIS states that the study “established two limits regarding the possible level of wind generation integration on the Isolated Island system, an economic limit and a maximum technical limit.”<sup>33</sup> The economic limit is that, in excess of 80 MW, “there would be a significant increase in the risk of spill at the hydroelectric reservoirs.”<sup>34</sup> The study notes that an additional 20 MW of wind power could result in an increase in expected spill from 9 to 19 GWh/yr, with a cost of

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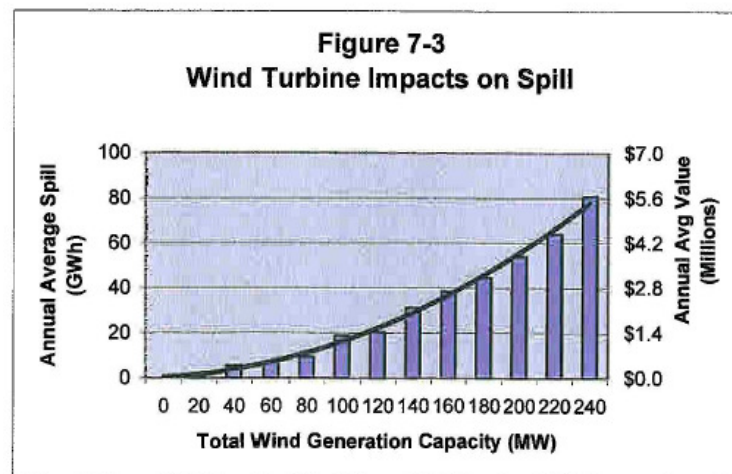
<sup>31</sup> A copy can be found at <http://www.pub.nf.ca/applications/MuskratFalls2011/files/exhibits/Exhibit61.pdf>

<sup>32</sup> Page 2-46.

<sup>33</sup> Page 2-45.

<sup>34</sup> Ibid.

\$1.3 million/yr.<sup>35</sup> The technical limit could require curtailment of wind down to 130 MW during periods of light load.<sup>36</sup> To avoid incurring these costs, NLH recommended limiting installed wind power to 80 MW.<sup>37</sup> The graph related installed wind generation to the economic impacts of spill is reproduced below.<sup>38</sup>



Obviously, hydro spillage and wind curtailment are to be avoided as much as possible. However, in an economic analysis, it is the bottom line that counts. So we need to look a little closer.

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<sup>35</sup> NLH, *An Assessment of Limitations for Non-Dispatchable Generation of the Newfoundland Island System*, p. 20-21 and 27. Available at <http://www.pub.nf.ca/applications/MuskratFalls2011/files/exhibits/Exhibit61.pdf>

<sup>36</sup> Ibid., p. 16.

<sup>37</sup> Ibid., p. 28.

<sup>38</sup> Ibid., p. 20.



First, let's start with the cost of wind power. The EIS relies on an unidentified publication of the Pembina Institute, an Alberta environmental NGO, to state the cost of onshore wind as 8-12 cents/kWh,<sup>39</sup> pointing out that good wind sites on the island are "at the lower end of this range." In fact, based on data from the Canadian Wind Atlas, we estimated that wind power costs on the Island would be much lower – as low as \$75/MWh, using conservative assumptions,<sup>40</sup> and as low as \$65/MWh, using escalation factors similar to those used for the Muskrat Falls project.<sup>41</sup> Given that these costs are roughly half the cost of Muskrat Falls power delivered to the Island, wind power clearly merits an in-depth evaluation, not a cursory dismissal based on a preliminary study that is almost 10 years old.

According to Canadian Wind Atlas data, Island wind power would have a capacity factor as high as 45%. This means that an additional 20 MW of installed wind capacity would produce 79 GWh a year, at a levelized annual cost of around \$5.2 million.

According to the 2004 NLH study, this additional 20 MW of wind power could result in increasing spillage by 10 GWh/yr, to a total of 19 GWh/yr, with a total value of \$1.3 million. Charging that cost that to the wind project results in net generation of 79 GWh for a total cost of \$6.5 million, or just \$82/MWh, net of spillage. Given that this cost is significantly less than the cost of either Muskrat Falls or continued operation of Holyrood, there is no justification for excluding this additional 20 MW of wind power from the least-cost plan.

As for the technical limit, the EIS states that:

“for wind generation above 130 MW it would not always be possible to maintain system stability particularly during periods of light load and during these periods

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<sup>39</sup> EIS, page 2-46.

<sup>40</sup> Philip Raphals, "Comments on Proponent's Response to the Panel's Information Request of March 21, 2011," page 14. (Available at <http://ceaa.gc.ca/050/documents/49714/49714E.pdf>)

<sup>41</sup> Philip Raphals, Final Presentation to Joint Review Panel, April 14, 2011 (Transcript of April 14, 2011, <http://ceaa.gc.ca/050/documents/49747/49747E.pdf>, page 17).

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wind generation would have to be curtailed, again, reducing the economic benefit of the additional wind generation.”<sup>42</sup>

In other words, since this technical limit can be resolved by wind curtailment during light load periods, it is in fact an economic limit as well. And since the economic parameters of the Island power system have changed so dramatically since 2004, economic limits based on 2004 avoided costs clearly cannot be relied on.

It goes without saying that wind generators don’t like curtailment any more than hydro operators like spillage. However, in areas with open wholesale markets, wind generators are now frequently required to curtail generation when so required. If new wind generation is economic, *taking into account the cost of curtailment*, there is no reason to exclude it.

Finally, it is important to mention that the 2004 study made it very clear that it was a preliminary investigation:

However, given the preliminary nature of this investigation, it would be prudent to further limit the initial quantities of wind generation into the system. Consideration should be given to a stepwise pattern of increased penetration levels over a number of years to gain direct operating experience with the technology and its integration into the Island system. This would allow Hydro to further define the opportunities and constraints associated with the resource without subjecting customers to undue expense or power quality issues. As well it would allow the industry to arrive at possible solutions which, along with the experience gained by Hydro, may permit penetration levels beyond those currently identified.<sup>43</sup>

Indeed, the Government of Newfoundland and Labrador seems to continue to be interested in the possibility of increasing wind penetration beyond the levels identified in the 2004 study. A Request for Proposals was issued last year by the provincial Department of Natural Resources

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<sup>42</sup> EIS, pp. 2-45 and 2-46.

<sup>43</sup> NLH, *An Assessment of Limitations for Non-Dispatchable Generation f the Newfoundland Island System*, op. cit., p. 28.

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concerning Onshore Wind, in Phase 2 of its Energy Innovation Roadmap process?<sup>44</sup> However, this reasonably foreseeable future activity is not considered in the EIS, and it should have been. A copy of this RFP is attached, as Appendix 1.

For Onshore Wind, one of the areas to be included in the Roadmap is identified as Grid Inflexibility/ Integration. The RFP states (p. 8):

The ability of the grid to absorb higher penetrations of intermittent wind energy is a function of the flexibility of other generation supply, interconnection, customer loads, and the availability of electricity storage facilities. This is particularly challenging for Newfoundland and Labrador given the absence of these features at the present time.

One of the work products requested is to:

“assess the flexibility of the existing generating capacity in Newfoundland and Labrador, particularly with respect to the integration of a significant amount of variable generation (e.g. wind power)”. (p. 9)

The consultant is also asked to:

- “recommend options and technologies that could improve the flexibility of the existing generating facilities;”
- “recommend options which could lead to the development of new concepts for the techno-economic integration of high wind penetration systems featuring hydro and gas (possibly) and storage facilities;” and
- **“recommend options for the development of power management strategies and system designs that are tolerant of high proportions of wind generated power and the consequent fluctuations in energy supply, by providing**

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<sup>44</sup> <http://www.nati.net/membership/requests-for-proposals/rfp-energy-and-innovation-roadmap.aspx>

mechanisms such as storage loads or wide area balancing that provide grid stability despite unpredictable supply characteristics.” (emphasis added)

Read together, the 2004 study and the 2011 RFP make very clear that the 80 MW limit is not only preliminary, but also that significant effort is underway to overcome it. While it may be prudent *today* to limit wind penetration to 80 MW, **it is not reasonable to assume that this limit will remain in place for the next decade, much less for the next 50 years.**

Thus, it is incorrect to conclude that the Isolated Island Scenario includes the economically optimal level of on-island wind generation.

Section 2.5.8 of the EIS concludes by stating that “Wind power has a place in the electricity generation mix on the Island and, due to its low environmental footprint, it will be incorporated whenever economically viable.”<sup>45</sup>

It is clear from the foregoing that neither of the two plans proposed for study by Nalcor (the Interconnected Island Option, based on the Muskrat Falls project, and its Isolated Island Option) come anywhere near approaching economically viable levels of wind power.

**The Comprehensive Study Report should therefore include the following findings:**

- **that the study the Proponent has invoked to justify its decision to limit wind power to 80 MW until 2067 in the Isolated Island Option is both preliminary and outdated,**
- **that the Proponent has failed to present a reasonable estimate of the economically optimal level of on-island wind generation, in the No Project scenario,**
- **that, as a result, the Proponent has failed to demonstrate that its Isolated Island Option constitutes the least-cost option in the absence of the Muskrat Falls Generation and Transmission projects; and**

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<sup>45</sup> P. 2-46.

- **that, in consequence, the Proponent has failed to demonstrate that the Muskrat Falls Transmission Project, in combination with the Muskrat Falls Generation Project, constitutes the least-cost option to meet long-term supply of power to Newfoundland Island.**

#### 4.3.2. Natural gas

In section 2.5.2, the Proponent explains its view that “‘landed’ Grand Banks gas is not a viable option to meet the Island’s electricity needs” (p. 2-37), identifying several barriers that have, to date, prevented the development of offshore gas for domestic needs. In particular, it is mentioned that “natural gas from White Rose is being stored in an adjacent reservoir for future use,” and that, “to date, no concrete plan for domestic natural gas development exists.”

Given the recent collapse of North American gas prices, and the widespread expectation that the shale gas phenomenon will keep gas prices low for decades, it seems unlikely that expensive infrastructure will be developed to land offshore gas for the continental market and in the foreseeable future. That said, it also seems reasonable to presume that, if NL government policy were to favour such a solution, offshore gas could indeed be brought to the Island for power generation purposes at some time in the coming decades.

What does *not* seem reasonable is the presumption that, for fifty years, NL will continue to buy oil on the world market to run Holyrood, despite its domestic gas reserves. And yet, it is this hypothesis that underlies the Proponent’s Isolated Island Alternative. Indeed, given the ever-increasing prices forecast for #6 fuel oil, which according to the PIRA forecast used by Nalcor increase to around \$200/barrel by 2043<sup>46</sup>, and to over \$300/barrel by 2067<sup>47</sup>, there is no doubt

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<sup>46</sup> PUB, Exhibit 4, Nalcor, « NLH Thermal Fuel Oil Price Forecast Reference Forecast, », January 2010.

<sup>47</sup> Increasing by 2%/year from 2043 to 2067. MHI, vol. 2, p. 204.

that, in the No Project alternative, pressure will increase, decade by decade, to replace oil as a fuel. In such a context, it is difficult to imagine that offshore gas will remain in the ground for the next fifty years.

It is important to recall that, since fuel costs represent 69% of all costs in the Isolated Island Alternative,<sup>48</sup> any new development that reduces or replaces part of these costs can be expected to have a significant effect on the CWP analysis.

**The Comprehensive Study Report should therefore include the finding that the Proponent has failed to adequately consider the possibility of refueling Holyrood with natural gas, sometime prior to 2067.**

#### 4.3.3. Electricity imports

In section 2.5.14, the EIS addresses the possibilities of regional power imports as a supply alternative. It judged these alternatives in terms of three considerations:

- Exposure to price volatility or significant price premiums,
- Security of supply, and
- Potential market structure/transmission impediments.<sup>49</sup>

The review was limited to two transmission paths (Churchill Falls to the Island, and Maritimes to the Island). The EIS states:

For purposes of the screening review, energy was assumed to be ultimately sourced from the New York and New England markets as both regions have competitive wholesale generation markets.<sup>50</sup>

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<sup>48</sup> Figure 2.6.1-1

<sup>49</sup> EIS, page 2-63.

<sup>50</sup> EIS, page 2-62.

It is surprising that the possibility of a power purchase from Hydro-Québec was not even mentioned in this section. It is well known that Hydro-Québec has a great deal of surplus power, and is actively seeking purchasers under long-term contracts.

Hydro-Québec's recent long-term contract with Vermont was priced lower than the cost of Muskrat Falls power. While such purchases may well turn out not to be the best solution, there is no basis for excluding them from consideration *a priori*.

**The Comprehensive Study Report should therefore include the finding that the Proponent has failed to adequately consider the possibility of regional imports from sources other than the New York and New England electricity markets, in particular the possibility of imports sourced from Hydro-Québec.**

#### **4.4. Reliability**

In section 2.3.5, the EIS addresses issues related to transmission reliability.

In this section, the Proponent states that the two options were judged against NLH's "accepted" transmission planning criteria which, it states, "adhere to industry accepted practice."

The MHI report examined the question of reliability at length, and found that **NLH's transmission planning criteria do not meet industry standards**. In its report, MHI addressed at length Nalcor's compliance, or lack thereof, with NERC reliability standards, which are mandatory in the US. MHI found that compliance with these standards is now an essential element of Good Utility Practice, and has been adopted by virtually all other jurisdictions in Canada. It was very critical of Nalcor's statement that "it does not plan to address a 3 phase fault at Bay d'Espoir as the present system fails to maintain angular stability following this

contingency under some operating conditions.”<sup>51</sup> As NERC reliability standards would inevitably apply to the Labrador operations of the Lower Churchill Project, if and when the Maritime Link is commissioned, MHI considers this non-compliance to be a serious issue.

**The Comprehensive Study Report should therefore include the finding that NLH’s failure to conform to NERC reliability standards is a significant departure from Good Utility Practice.**

#### 4.4.1. HVDC Converter Stations and Electrodes

MHI was also very critical of the lack of risk review of the HVDC converter stations and electrodes. It noted that there was no comprehensive HVDC system risk analysis review of operations and maintenance for the overall HVDC transmission system.<sup>52</sup>

There does not appear to be any risk analysis done for the HVDC converter stations or the operational aspects of the LIL HVDC system. Converter station outages could be lengthy and could be very costly to repair, particularly if lost revenues are considered. MHI recommends that this be completed prior to the development of the HVDC converter station specification so any additional requirements can be included.<sup>53</sup>

**The Comprehensive Study Report should therefore include the finding that NLH has failed to carry out a comprehensive review of the financial and reliability risks of the overall HVDC system.**

#### 4.4.2. HVDC Transmission Lines

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<sup>51</sup> MHI report, v. 2, p. 78.

<sup>52</sup> Ibid., p. 112.

<sup>53</sup> Ibid.



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MHI pointed out that transmission losses for the proposed HVDC link would be approximately 10%.<sup>54</sup> It analyzed in detail the choice of design criteria for the transmission line, and criticized Nalcor's choice to design to a 1:50 year reliability return period. It pointed out that the international and Canadian standards for a line without an alternate source of power supply is 1:500 years, and, when an alternate source of supply does exist, it is 1:150 years. "MHI considers this a major issue and strongly recommends that Nalcor adhere to these criteria."<sup>55</sup> There has been no indication that it intends to do so.

**The Comprehensive Study Report should therefore include the finding that the planning criteria used for the HVDC transmission lines is inadequate.**

#### 4.4.3. Strait of Belle Isle Marine Cable Crossing

MHI's review pointed out a number of risk factors with respect to the marine cable. Literature reviewed indicated cases of cable failures due both to external and internal causes. External causes include third-party mechanical damage (anchors, fishing trawlers, excavation activities). Lightning and of course icebergs – for which the risk is deemed significant -- represent other possible external causes of failure.

A number of HVDC failures over the last decade were attributed to internal causes, including two due to damage caused by installation difficulties. In other cases, the causes of failure are unknown.<sup>56</sup> Assuming that the cable will be problem-free, as Nalcor appears to do, would therefore be optimistic.

Based on historical data, MHI indicated that Nalcor should expect one cable failure every 10 years – though this figure does not take into account the particular characteristics of the Strait of

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<sup>54</sup> Ibid., p. 116.

<sup>55</sup> Ibid., p. 121.

<sup>56</sup> Ibid., p. 134.

Belle Isle.<sup>57</sup> The installation of a third cable will clearly alleviate the risk of a prolonged outage following a cable outage. However, a damaged cable must be repaired, and repairs can be expected to be costly and lengthy.<sup>58</sup>

**The Comprehensive Study Report should therefore include the finding that Strait of Belle Isle Marine Cable Crossing creates risks that have not been recognized in the Proponent's EIS.**

#### 4.4.4. AC transmission upgrades

In section 2.3.6 of the EIS, the Proponent refers to the Island Transmission System Outlook Report, which identifies several transmission constraints that may need to be addressed in the next 5 to 10 years, depending on generation choices. It states that:<sup>59</sup>

Following development of generation expansion plans through the generation planning process, the transmission system effects of the proposed generation sites can be more fully assessed and transmission system additions more fully defined.

It is important to note that MHI was very critical of Nalcor's failure to complete AC Integration Studies, which define the additional modifications to the Newfoundland transmission system that would be required in order to successfully integrate power from Muskrat Falls, prior to deciding to go ahead with Muskrat Falls. MHI states that these studies provided "do not adequately describe the facilities required to successfully operate the transmission system under the new configuration. As such, there may be unidentified risks in proceeding with this project at this time."<sup>60</sup>

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<sup>57</sup> Ibid., p. 135.

<sup>58</sup> Ibid.

<sup>59</sup> EIS, page 2-23.

<sup>60</sup> MHI report, vol. 2, page 75.

MHI states that “Good utility practice requires that these integration studies be completed as part of the project screening process (DG2); MHI considers this a **major gap** in Nalcor’s work to date.”<sup>61</sup> (emphasis added)

**The Comprehensive Study Report should therefore include the finding that the Proponent’s failure to fully assess the AC transmission upgrades required to integrate the Muskrat Falls project into its existing system is a major failing, and that this failing may create unidentified financial and reliability risks for the Island power system.**

#### **4.5. Fuel price forecasts**

In section 2.7.1.1 of the EIS, the Proponent presents a sensitivity analysis based on the price of fuel. The analysis demonstrates that the justification of the proposed Project is highly dependant on fuel price forecasts. Thus, Table 2.7.1-1 shows that, under PIRA’s Low World Oil Forecast, the preference for the Interconnected Island scenario, as compared to Nalcor’s Isolated Island scenario, almost completely disappears, dropping from \$2,158 million to just 120 million. In MHI’s words:

More interesting is the low price case, where **a near-term double-dip recession in the US might lead to fuel prices that are so low that the CPW gap almost disappears.**<sup>62</sup>

It is widely recognized that fuel price forecasts are highly uncertain and volatile. The recent drop in oil prices, which have fallen by almost 25% in the last month (from about \$105 a barrel at the beginning May 2012 to just over \$80 a barrel on June 4), only reminds us of this fact.

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<sup>61</sup> Ibid.

<sup>62</sup> MHI, vol. 2, p. 205.

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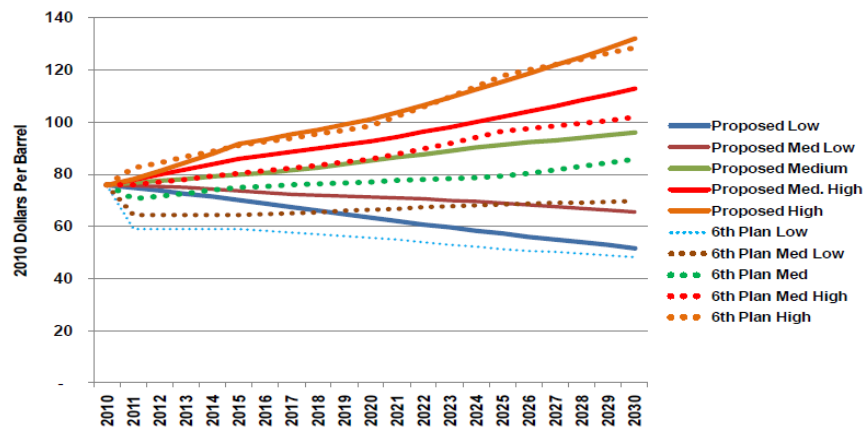
MHI pointed out this uncertainty as well, writing:

It is clear there is much uncertainty related to the pricing of fuel for thermal-based power generation. Different scenarios can and should be run and compared, but **the results related thereto often have a short shelf life.** While the prospect of raising the necessary capital to finance and construct the Infeed Option may be daunting, **the uncertainty associated with forecasting the price of fuel for thermal generation over the long term might be, and likely is, even more so.** (emphasis added)<sup>63</sup>

The PIRA high and low forecasts have not been made public, so to get an idea of the extent of the typical spreads between high and low oil price forecasts, I had to look to other sources. The following chart presents the oil price forecast from the Northwest Power Planning Council's 2009 Power Plan.

<sup>63</sup> Ibid.

### Comparison of Revised and Sixth Plan Oil Price Forecasts Refiners Acquisition Cost \$2010/barrel



The high scenario shows prices more than twice as great as the low scenario (about \$130 versus about \$50 per barrel, in 2030). As MHI wrote in their report, long-term fuel price forecasts have a short shelf life.

The following table, assembled by the US Energy Information Agency, assesses the accuracy of its own fuel price forecasts from 1982 to 2010.

Table 4. World Oil Prices, Projected vs. Actual  
(percent difference)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
AEO 1982	9.9	148.7	128.6	228.9	197.3	171.4					492.7															
AEO 1983	7.4	110.0	80.2	170.0	154.8	144.6					331.0															
AEO 1984	7.7	110.0	70.8	133.2	105.9	87.6																				
AEO 1985	0.0	84.7	36.9	78.9	64.2	55.1	97.7	122.7	165.8	202.5	189.6															
AEO 1986		4.1	-12.5	18.9	4.3	-5.2	19.0	39.4	84.3	124.7	132.9	117.3	168.3	351.0	241.7	132.5										
AEO 1987			-0.1	18.8	4.6	-8.4	11.8	19.6	48.7	77.3	86.9					108.4										
AEO 1988*				1.0	-17.4	-24.9	-5.1	5.2	34.3	62.5	68.7	61.3	104.1	252.7	168.6	80.4										
AEO 1989					-2.1	-19.6										66.7										
AEO 1990							1.1	32.4	40.6	63.9	76.3	65.5	42.6	64.8	166.0	98.6	33.2	81.1	82.8	69.9	42.0	13.0	0.6	-5.2	-27.1	21.2
AEO 1991								1.8	10.2	28.0	43.6	41.2	27.5	54.7	158.9	96.7	33.4	81.4	81.2	66.2	37.0	7.5	-5.3	-11.3	-31.8	13.9
AEO 1992									3.6	25.5	36.9	31.0	14.7	35.0	121.8	65.9	12.0	52.2	53.0	40.4	14.8	-10.7	-21.4	-25.1	-42.9	-3.9
AEO 1993										5.7	10.9	6.4	-5.9	11.4	83.7	37.7	-7.9	25.0	25.1	15.0	-5.3	-26.2	-35.0	-39.2	-53.3	-22.5
AEO 1994											-1.8	0.8	-11.7	4.0	69.4	25.1	-17.1	10.5	8.8	-1.6	-19.7	-37.8	-45.5	-49.4	-61.4	-35.8
AEO 1995												0.1	-14.0	0.3	63.8	21.5	-19.3	8.2	6.8	-3.6	-21.4	-38.9	-46.6	-50.6	-62.5	-38.1
AEO 1996													-3.1	4.8	62.4	16.3	-25.7	-1.5	-4.2	-14.3	-31.0	-47.1	-54.3	-58.1	-68.5	-48.7
AEO 1997														9.0	56.1	15.1	-24.4	-1.0	-5.0	-15.3	-32.2	-48.3	-55.9	-59.7	-69.8	-50.8
AEO 1998															3.8	-21.0	-47.0	-25.7	-34.6	-29.1	-41.1	-53.8	-59.0	-61.6	-71.4	-53.7
AEO 1999																0.5	-21.3	-4.6	-9.2	-20.4	-37.0	-52.5	-59.6	-63.4	-72.9	-56.3
AEO 2000																	1.8	13.0	-3.7	-19.3	-35.8	-51.6	-58.9	-62.9	-72.6	-56.0
AEO 2001																		4.5	-7.3	-13.4	-30.8	-47.5	-55.1	-59.2	-69.6	-50.9
AEO 2002																			-0.3	-2.9	-28.4	-48.0	-55.8	-60.1	-70.5	-52.6
AEO 2003																				-0.2	-31.7	-50.0	-57.4	-61.4	-71.3	-53.5
AEO 2004																					-0.4	-27.5	-46.2	-56.0	-69.0	-52.0
AEO 2005																						4.3	-4.4	-18.3	-42.7	-12.9
AEO 2006																							7.8	-4.5	-23.8	6.1
AEO 2007																								-9.0	-18.1	22.7
AEO 2008																									6.3	-32.4
AEO 2009																										-3.1
AEO 2010																										
Average Absolute Percent Difference (All AEOs)	6.3	91.5	54.8	93.0	68.8	57.5	28.0	34.5	57.0	70.7	115.5	33.1	44.7	126.3	67.4	42.1	25.7	24.0	22.3	27.2	35.6	39.3	41.9	53.4	34.0	

The results are surprising. The forecasts produced from 1982 to 1985 were far too high – 133% too high, on average. From 1986 to 1995, the forecasts were still too high – by 35%, on average. But for the next 10 years, from 1996 to 2005, forecasts were all too low -- 32% on average.

This is particularly interesting, not just because it shows the inaccuracy of the forecasts, but because the errors are so systematic. We don't see random variation – we see that forecasters were systematically wrong, in the same direction, for years on end. From 1982 through 1994, they *consistently* over-forecast oil prices. And from 1995 until today, they have consistently under-forecast prices. What does that tell us about today's forecasts? That there is a very substantial chance that they will be wrong, and significantly so. We just don't know in which direction.

A forecast with this much uncertainty has little if any predictive value. Basing decision-making on calculations based on the median value is methodologically unsound. As Nalcor's CPW calculations depend heavily on such values, the conclusions drawn from them cannot be relied upon, as the PUB very correctly noted.

**The Comprehensive Study Report should therefore include the findings:**

- **that the Proponent's fuel price forecasts include a very high degree of uncertainty, and thus have little predictive value, and,**
- **that economic analyses based on a single value extracted from these forecasts, such as the Proponent's CPW calculations for the Isolated Island Option, also have little predictive value.**

#### **4.6. *Power purchase expense***

In section 2.4.1.1 of the EIS (pages 2-30 to 2-31), the Proponent explains the power purchase agreement that would define the price paid to Nalcor by NLH for Muskrat Falls power. It begins

the section by saying: “The price that NLH pays for power and energy from Muskrat Falls on behalf of Island ratepayers is a cornerstone for the Lower Churchill Project.”<sup>64</sup>

It is noteworthy that, even though the price paid is a “cornerstone” of the Lower Churchill Project, most of the information provided in this section was not presented to the Joint Review Panel for the Lower Churchill Generation Project.

In this section, the Proponent explains that its proposed PPA was developed in order to address the fact that, under cost-of-service (COS) price setting, the price of Muskrat Falls power would be a significant burden for ratepayers in the early years:<sup>65</sup>

Under a regulated Cost of Service (COS) price setting environment, the annual revenue requirement for a utility asset would be comprised of:

COS = Operating and Maintenance Costs + Power Purchases+ Fuel + Depreciation + Return on Rate Base

Where Return on Rate Base would be comprised of a cost component for lenders (cost of debt) and a profit component for shareholders (return on equity) for a prescribed debt-equity capital structure. This annual COS would then be divided by the output produced and sold from the asset in question to derive an average selling price or rate (such as cents per kilowatt hour (kWh), or equivalent dollars per megawatt hour (MWh). An important feature of this pricing methodology is that under COS price setting, the unit rate revenue paid by ratepayers for a given asset is highest in the first year. This is because as a new regulated asset goes into rate base, the undepreciated cost of the asset is at its maximum and return on rate base is driven by undepreciated net book value. Another feature of this pricing framework is that as the equity investor earns its regulated return each year, the return in dollars is also highest in the first and initial years. This is not necessarily prudent for the Muskrat Falls development in that the Island ratepayer energy requirements at the time of plant commissioning is projected to be only about 40%, or 2 terawatt hours (TWh), of the plant’s average annual production of 4.9 TWh. While the Island’s energy requirements increase over time in line with economic growth, the early-year COS rate for Muskrat Falls power would be a significant burden for ratepayers in those years. The required COS revenue for Muskrat Falls would be at its maximum and the power required by ratepayers at a minimum. In an effort to address this issue, an alternative approach to Muskrat Falls power pricing was developed that affords a number of advantages for ratepayers.

However, the EIS fails to mention the advantages for consumers of COS pricing in later years, or the corresponding drawbacks of the proposed PPA approach.

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<sup>64</sup> EIS, p. 2-30. It is interesting to note that this issue was not addressed in the EIS of the Lower Churchill Generation Project.

<sup>65</sup> Ibid.

Traditionally, hydro projects have been developed as ratebase projects under COS principles, which implies higher costs in the first few years, that decrease dramatically over time. That's why the costs of many existing hydro projects such as Bay D'Espoir are so low. If they had been built under a PPA, instead of COS, it would cost consumers far more today.

In my comments to the PUB, I demonstrated why, under the proposed PPA, Muskrat Falls will probably never be a low-cost resource. The table presented in Appendix 2 is based on data provided by Nalcor to the PUB.<sup>66</sup> All the columns in white are from Nalcor's document; my additions are presented in yellow.

Nalcor's column 5 shows the nominal annual cost, in \$/MWh, of the whole Lower Churchill Project (generation and transmission). This cost remains relatively constant, varying between \$190 and \$260/MWh over the life of the project.

My new columns 5a and 5b break down the nominal annual cost between MF and LITL, by dividing the incremental costs of each (columns 2 and 3) by the total energy (column 1). We see that, while the nominal annual cost of LITL falls (from \$147/MWh at the beginning to \$13 at the end), the annual cost of MF increases, from \$92 to \$247/kWh.

These combined costs are then levelized, on a nominal basis, in column 6, resulting in a fixed nominal dollar cost of \$208/MWh. Again, I have broken this down into MF and LITL components, using the same methodology described in Nalcor's note 2. The levelized nominal LUEC for MF is \$126/MWh, and that for LITL is \$83/MWh.

In column 7, I have only changed the title. While Nalcor calls it an "escalating real LUEC", I find this confusing, since the figures are actually in nominal dollars, not real ones. I find it clearer to refer to it as a "Real LUEC expressed in nominal dollars". In other words, we have converted the nominal LUEC to real dollars, and then re-translated it back into nominal dollars, as a price that escalates with inflation. These are thus the actual prices, in current dollars, that

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<sup>66</sup> CAKPL-Nalcor-27 rev. 1



will be charged to consumers for Muskrat power (delivered to the Island and blended, of course, with other sources), which starts at \$152/MWh in 2017 and increases to \$409/MWh in 2067. (Nalcor's figures, from col. 7.)

In column 7a, I have indicated the total annual payments (MF plus LITL), in current dollars. (That's the energy from column 1 times the current dollar prices, in column 7.) In column 7b, I have subtracted from that the LITL payments in column 3, to show the current dollar payments under the MF PPA. Then, in column 7c, I have calculated the current dollar unit cost for Muskrat Falls power (without transmission), by dividing by current dollar payments in column 7b by the amount of energy, from column 1.

Column 7c shows that the actual price paid to Nalcor for Muskrat Falls power starts at \$5/MWh in 2017, and rises to \$396/MWh in 2067. This result – more extreme than the blended result shown by Nalcor in column 7, results from mixing PPA and COS costs, and from the fact that customers must pay the full cost of LITL, under COS, but only for the energy they actually consume, under the PPA. But in either case, the price to be paid for Muskrat Falls power under the PPA in 2067 comes to around \$400/MWh, or 40 cents/kWh.

The costs of Muskrat Falls power under a COS regime have not been produced by the Proponent. However, the information in this table allows us to estimate that as well.

Making the simplifying assumption that the capital structure and depreciation of MF are similar to that of LITL, we can simply inflate the LITL payments in column 3 to correspond to the MF CPW of \$2.682 billion (column 2). The result, shown in column 8a, shows the annual current dollar payments that would be required to cover the costs of Muskrat Falls under a COS regime identical to one applied to LITL. These costs start at \$407 million in 2017, and fall to \$90 million by 2067. Column 8b then shows this amount divided by the total energy each year, giving the unit cost in \$/MWh for Muskrat Falls energy under COS. It starts at \$225/MWh in 2017, and then fall to \$20/MWh by 2067. Of course, if consumers were credited with the revenues of third party sales, which would be normal in COS, the early-year costs would be lower.

This exercise shows the real difference between COS and PPA pricing. With the PPA, Muskrat Falls prices are much lower at first, but 20 times higher in 2067.

In other words, if Muskrat Falls were subject to COS regulation, in 50 years its power would be almost as cheap as any other low-cost old hydro project.

And what happens after 2067? Under COS, the unit cost from MF would remain stable, somewhere around \$20/MWh or lower, like it does for other COS hydro projects.

Under the escalating price scenario, however, NF consumers would be paying \$396/MWh for MF power in 2067. How much would Nalcor charge in 2068? Would it suddenly cut the price to \$20/MWh, pointing out that, since all its costs incurred 50 years ago had now been paid, it had no reason to charge more? Or, more likely, would it keep on charging \$400/MWh? Doing so would of course produce a windfall profit for Nalcor and its shareholder – paid from the pockets of Newfoundland consumers.

At Churchill Falls, Hydro-Quebec enjoys pricing very similar to COS pricing, and Newfoundland and Labrador certainly wishes that the pricing were more like the PPA proposed here. But in the case of Muskrat Falls, it is Newfoundland consumers who will be paying the escalating prices.

Thus, while the PPA is advantageous, compared to COS pricing for consumers in the project's first decade, it is very disadvantageous to consumers later on. This intergenerational equity issue is not addressed in the EIS.

**The Comprehensive Study Report should therefore include the finding that the Proponent has failed to present the long-term disadvantages for Newfoundland consumers of its proposed PPA for Muskrat Falls power.**

## **5. Conclusions and recommendations**

As we have seen, the stated justification for the LITL is that **the Muskrat Falls generation project** represents “the least-cost option to meet long-term supply of power to the Island.” From a justification perspective, the two projects are inseparable.

The previous (albeit partial) reviews of the justification of the Muskrat Falls project are thus entirely relevant to the assessment of the LITL. As we have seen, the Joint Review Panel for the Lower Churchill Generation Project was unable to resolve a number of key questions related to the project’s justification, in particular with respect to alternatives to the project.

A great deal of new information has been made public since the issuance of the JRP report, in the process carried out by the PUB and in the EIS for the LITL. However, as we have shown above, the fundamental questions raised by the JRP still have not been resolved. **In my opinion, Nalcor’s analysis showing Muskrat Falls to be the best and least cost way to meet domestic demand requirements is still inadequate.**

That is, the Proponent’s attempt to demonstrate that Muskrat Falls represents the least-cost option to meet long-term supply of power to the Island fails, because it depends on the comparison with an Isolated Island Scenario which is in no way optimal, because it:

- is not the fruit of a true planning process, but is simply the output of a planning program.
- is based on a load forecast:
  - in which the forecast residential growth rate is inadequately substantiated, and
  - which fails to account for the potential closure of Corner Brook Pulp and Paper, which in itself would eliminate 80% of the CPW reduction under the Muskrat Falls scenario;
- fails to include **any** Conservation and Demand Management savings in the base plan, and the CDM scenarios explored in the sensitivity analyses remain modest, with no gains foreseen after 2031;
- ignores the phenomenal wind power potential near load centers on the Island based on a preliminary 2004 study, the underlying parameters of which are no longer valid;

- fails to address the possibility of purchases from Hydro-Québec;
- Relies on a CPW analysis that depends heavily on long-term fuel price forecasts, which are known to have a “very short shelf life” and which have so much uncertainty as to be of little or no predictive value;
- assumes that Holyrood will continue to burn oil until 2067, making the unjustified assumption that, in the absence of the Muskrat Falls project, offshore gas will remain untapped for the next 50 years.

**Given these many and substantial flaws, the analysis comparing the Muskrat Falls Interconnected Island Scenario to the Isolated Island Scenario prepared by Nalcor should be judged, once again, inadequate.**

**I recommend that the Agency find that the rationale presented in the EIS for the proposed Labrador-Island Transmission Link is factually unsupported, for the reasons set out above. More specifically, it should find that said rationale is based upon unsupported assumptions and deficient analyses.**

**For all these reasons, the Comprehensive Study Report should conclude that the Proponent has failed to demonstrate that the Muskrat Falls Transmission Project, in combination with the Muskrat Falls Generation Project, constitutes the least-cost option to meet long-term supply of power to Newfoundland Island.**

## **APPENDIX 1**

# **NL DEPARTMENT OF NATURAL RESOURCES REQUEST FOR PROPOSALS ONSHORE WIND PHASE 2 — ENERGY INNOVATION ROADMAP**



## **Request for Proposals**

### **Phase 2 Energy Innovation Roadmap Onshore Wind/Transmission in Harsh Environments**

**Department of Natural Resources  
Government of Newfoundland and Labrador  
St. John's, Newfoundland and Labrador  
Canada**

**December 2011**

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**1.0 Introduction**

The Department of Natural Resources (NR), Government of Newfoundland and Labrador, is in the process of developing Energy Innovation Roadmaps to identify opportunities, set priorities and plan for new investments in the energy sector in Newfoundland and Labrador (NL). This process requires independent consultancy advice and expertise to assist the Department in this important and strategic planning exercise.

**2.0 Background**

In September 2007, the Government of Newfoundland and Labrador released its Energy Plan, *Focusing Our Energy* (<http://www.nr.gov.nl.ca/energyplan>). In the Plan, Government identified NL's abundant energy resource warehouse which includes oil, natural gas, hydroelectricity and wind, along with a number of other potential sources such as ocean energy, hydrogen, uranium and biomass. NL's energy industry is a key economic driver in our economy and innovation, coupled with resource development, has significant potential to contribute to future growth in our economy. However, the goals of sustainable development and a long term viable energy industry can not be achieved without strategies to identify opportunities, establish priorities and overcome challenges.

The Government of Newfoundland and Labrador recognizes the importance of energy innovation in improving the way energy is produced, transported and utilized. In an ever changing world, innovation is critical to ensure that the province's energy sector remains adaptable and sustainable in the long term.

The Energy Plan committed to invest in the planning, implementation and financing of energy innovation in the province, including the creation of an Energy Innovation Roadmap. The Plan further committed to:

- pursue a strategic, coordinated approach to energy innovation focusing on areas of competitive advantage;
- identify and work with various groups to focus on key opportunity areas;
- leverage existing strengths and energy expertise at Centres of Excellence and elsewhere by encouraging a common, coordinated approach to executing energy research; and
- address the lack of venture capital and other funding necessary to move ideas ahead into implementation.

The Government of Newfoundland and Labrador views the development of Energy Innovation Roadmaps (EIR) as an important step in the process of planning for energy innovation and development. The EIR will be a strategic planning tool for future investments in innovative energy technologies, from R&D through to technology demonstration and commercial deployment.

The EIR project is being undertaken in two phases:



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- Phase 1: Priorities Identification – this Phase, which has been completed, consisted of an analysis of NL's energy sources and innovation opportunities based on various screening criteria to determine the priority areas to focus development of energy innovation roadmaps;
- Phase 2: Roadmapping – this Phase will involve the development of energy innovation roadmaps for the priority areas that were identified in Phase 1.

Through a public, competitive process, NR retained consultants to undertake Phase 1. All energy sources relevant to NL were considered including crude oil, natural gas, wind, hydro, ocean, biomass, hydrogen, uranium, peat, geothermal and solar, as well as power transmission and energy efficiency & conservation.

The four main energy sources (crude oil, natural gas, wind, hydro) in the Energy Plan were earmarked for detailed evaluation from project start. However, the remaining other energy sources went through a filtering process to determine which ones may warrant further assessment. The filtering approach included the following screening criteria for the various energy types:

- Does NL have (or could NL have) sufficient local resources?
- Is the energy type consistent with the Energy Plan?
- Is technical innovation required i) locally, and ii) elsewhere external to NL?
- Is it feasible that NL has, or could have, appropriate capabilities to meet the challenge considering existing capability (e.g. university, industrial base) and international competitiveness?

Once this process narrowed the source types under consideration, a further analysis was undertaken which included an examination of:

- barriers to determine where innovation may be required;
- innovation opportunities to determine how valuable innovation would be and whether the innovation is well advanced outside Newfoundland and Labrador;
- innovator competitiveness to determine whether Newfoundland and Labrador has a basis to be competitive for the required innovation; and
- innovation priorities to determine the extent innovation may be a priority for local and/or external markets.

As a result of the above analysis, nine priority themes across four energy areas were recommended for Phase 2 roadmapping:

- **Oil & Gas** – given the complexity of the issues and the number of stakeholders that are involved in this sector, separate Roadmaps were recommended to address the following six priority areas: harsh

environment, Arctic conditions, subsea protection, enhanced recovery,

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far offshore logistics and onshore seismic.

- **Onshore Wind** – one Roadmap for this sector was recommended which would address barriers impacting onshore wind innovation in the province, particularly related to icing, cold conditions, grid inflexibility and resource mapping.
- **Transmission** – one Roadmap was recommended to focus on innovations that would enhance power line de-icing capabilities (e.g. prediction, monitoring, control strategies, de-icing technologies) with a specific focus on Labrador conditions.
- **Remote Energy** – one Roadmap was recommended to address remote location power systems technologies that could be applied to smaller scale, off-grid settings such as outports (e.g. Ramea). This roadmap will be broad-based and provide considerable flexibility given the early stage and uncertain development path that that some of these technologies (e.g. small scale generation, energy storage, control systems) may take.

Four reports for Phase 1 have been completed: (1) *Analysis Document: 'Energy Warehouse' Areas (Onshore Wind Energy, Hydroelectricity, Transmission, Upstream Oil & Gas, Midstream Gas)*; (2) *Screening Document: Other Energy Types*; (3) *Analysis Document: Other Energy Themes (Remote Energy Systems, Marine Energy Technologies, Energy Efficiency)*; and (4) *Recommendations for Innovation Priorities*. These reports are available online at <http://www.nr.gov.nl.ca>.

In light of the Cougar helicopter crash and the BP oil spill in the Gulf of Mexico, the results of Phase 1 were reviewed to determine if there were any prioritization implications from a health, safety and environment (HSE) perspective in relation to the development of the oil and gas innovation roadmaps. This review indicated that the high level priorities for innovation within the oil and gas sector have not been fundamentally altered as a result of the two incidents. However, the relative importance of innovation areas within the general priorities has changed. An example is the heightened significance of oil spill-related innovation within the previously defined category of "Arctic conditions". The report noted that the province has strength in areas such as oil spill detection and tracking in ice environments, and safety response and evacuation simulation. Other areas of provincial knowledge and capabilities that are relevant to innovation-need include the testing of flight suits and Arctic weather work-wear and support for oil spill clean-up in cold water environments. The results of this analysis are contained in a report *Oil and Gas HSE Addendum* which is also available online at <http://www.nr.gov.nl.ca>.

### **3.0 Scope of Work**

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Through this Request for Proposals, NR invites proposals from consulting firms that are interested in undertaking and completing the development of an Energy Innovation Roadmap for specific technology issues related to Onshore Wind and Energy Transmission in Harsh Environments. Requests for Proposals to cover development of Energy Innovation Roadmaps for other priority areas will be issued separately.

The work undertaken for this initiative will be directed by a project Steering Committee comprised of officials from the Department of Natural Resources (lead), Department of Innovation, Business and Rural Development, Department of Business, the Newfoundland and Labrador Research & Development Corporation, and Nalcor Energy. An Executive Steering Committee, comprised of the Deputy Ministers, Chief Executive Officer and Vice-President(s) of the above departments/organizations will also direct the work and meet with the consultants during the course of the project.

As noted above, this Request for Proposals covers the preparation of an Energy Innovation Roadmap for Onshore Wind and Transmission. The Roadmap should address only innovation/technology issues and opportunities such as those outlined in this Scope of Work. It should be emphasized that the Roadmap itself should not try to solve each specific innovation/technology issue that will be considered (e.g. identify a specific solution for operating turbines at -40 °C or actually produce a provincial wind and ice map). Rather, the intent is to develop and recommend options for how to address these issues specifically within the Newfoundland and Labrador context, along with estimated timelines, costs, etc. Issues that are company, market or regulatory related will be considered through mechanisms outside of this roadmapping initiative.

### **3.1 Onshore Wind**

The Energy Plan estimates that there are more than 5,000 Megawatts (MW) of potential wind energy available within the province, with much of the province having average wind speeds of between seven and ten metres per second at 50 metres above the ground.

There are two wind farms (Fermeuse and St. Lawrence) operating in the province which together generate up to 54 MW of wind energy. Both farms each generate 27 MW using nine, Vestas V90, 3 MW turbines. Nalcor Energy is also in the process of commissioning 390 kilowatts (six 65kw) of wind power as part of its Wind-Hydrogen-Diesel energy project in Ramea, on the southwest coast of the island.

Newfoundland and Labrador has a number of options for future engagement in innovation in the onshore wind sector, either as a wind turbine manufacturer, component manufacturer, test facility or research institute. These include establishing new entities or partnering with third parties with the relevant innovation capabilities. These options will be explored further as part of the roadmapping process.

For Onshore Wind, four areas were identified in Phase 1 which require innovation specific to Newfoundland and Labrador, particularly as it relates the operation of

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turbines in harsh environments. The four areas to be included in the Roadmap, as outlined below, are: Icing; Cold Conditions, Grid Inflexibility/Integration; and Resource Mapping.

**3.1.1 Icing:**

Build-up of ice on turbine blades can unbalance and damage turbines. Ice can also be thrown from the blades. Turbine energy production can be improved with the use of anti-icing or de-icing techniques. Anti-icing prevents the formation of ice, while de-icing removes ice when a predetermined amount has accumulated. The methods use to prevent and remove ice from wind turbine rotors can be mechanical, passive or active.

There is a considerable amount of existing and ongoing research related to anti-icing, de-icing and ice detection solutions for medium and severe icing conditions. While various applications have been developed in recent years, challenges still remain and reliable, commercial solutions need to be improved and/or developed.

The following work will be required with respect to turbine icing:

- review the existing research/literature and current practices in other jurisdictions (e.g. Yukon, Manitoba, Finland, Sweden, Norway) related to anti- and de-icing technologies and/or techniques to determine applicability and/or adaptation to Newfoundland and Labrador's circumstances. Examples of literature to review, but not limited to, include:
  - **Recommendations for Wind Energy Projects in Cold Climates**, Technical Research Centre of Finland, Working Paper 151, 2009;
  - **State-of-the-Art of Wind Energy in Cold Climates**, Technical Research Centre of Finland, Working Paper 152, 2010;
  - **Analysis and Mitigation of Icing Effects on Wind Turbines**, Wind Energy Research Laboratory, Université du Québec à Rimouski;
  - **Systems for Prediction and Monitoring of Ice Shedding, Anti-Icing and De-Icing for Overhead Power Line Conductors and Ground Wires**, CIGRE (International Council on Large Electric Systems) Working Group B2.29, July 2010;
  - **Guidelines for Meteorological Icing Models, Statistical Methods and Topographical Effects**, CIGRE (International Council on Large Electric Systems) Working Group B2.16, April 2006;
  - Relevant presentations from previous wind related conferences (e.g. **Wind Energy Development in Harsh Environments**, St. John's, 2010; **Winterwind**, Sweden, 2008, 2011).
- recommend anti- and/or de-icing technologies and techniques (e.g. icephobic coatings that are designed specifically for harsh environments) that could be adapted or developed and tested for future implementation in the province, with particular reference to Labrador;
- recommend options to undertake long term research-grade observations of wind (using ice-free anemometers) and icing conditions through the lower

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boundary at heights up to 300-400 m above ground in particularly ice-prone areas;

- recommend options to implement research and demonstration sites to collect detailed icing impacts data that could lead to more effective anti-/de-icing measures;

**3.1.2 Cold Conditions:**

Although the cold climate turbine market is still relatively small, it is growing in countries such as Canada, China, US, Sweden, Norway and Finland. Task 19 of the International Energy Agency estimates that 5-10% of the total installations in Canada, US, Europe and China are cold climate installations.\*

Similar to the issues related to icing, operation of wind turbines in cold conditions, such as in Labrador, is extremely challenging. For example, existing cold climate packages for turbines are normally rated for -30 °C. However, turbines operating in Labrador need to be able to operate at temperatures of -40 °C.

The following work will be required with respect to the operation of wind turbines in cold conditions:

- review the existing research/literature (see above) and current practices in other jurisdictions (e.g. Yukon, Manitoba, Finland, Sweden, Norway) related to the operation of wind turbines in cold climates to determine applicability and/or adaptation to Newfoundland and Labrador's circumstances;
- recommend options for the development and testing of more reliable turbines capable of working in cold conditions (e.g. -40 °C);
- recommend new concepts for the operation and maintenance of wind turbines in cold conditions (e.g. the development of equipment and operational processes that allow wind-based systems to be operated over higher duty cycles and serviced in harsher environmental conditions).

**3.1.3 Grid Inflexibility/Integration:**

The ability of the grid to absorb higher penetrations of intermittent wind energy is a function of the flexibility of other generation supply, interconnection, customer loads, and the availability of electricity storage facilities. This is particularly challenging for Newfoundland and Labrador given the absence of these features at the present time.

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\* ***Wind Energy in Cold Climates IEA Task 19***, Presentation to Winterwind 2011, Sweden.

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The following work will be required with respect to grid inflexibility/integration:

- review the existing research/literature and experiences in other jurisdictions (e.g. Manitoba, Ontario, British Columbia, United States, Finland) related to issues of grid integration and assess the applicability and/or adaptation to Newfoundland and Labrador's circumstances. Examples of literature to review, but not limited to, include:
  - **Integration of Wind Generation with Power Systems in Canada Overview of Technical and Economic Impact**, Natural Resources Canada, February 2006.
  - **The Hydroelectricity Industry's Role in Integrating Wind Energy**, Summary Report, CEATI Project No. T102700-0371.
  - **Impacts of Large Amounts of Wind Power on Design and Operation of Power Systems, results of IEA Collaboration**, 2009.
  - **Wind Farm Integrated into Hydroelectric Power System/Washington State, USA**, Natural Resources Canada.
  - **BPA Wind Integration Services**, Bonneville Power Administration, March 2004.
  - Relevant presentations from previous wind/energy related conferences (e.g. **Wind Energy Development in Harsh Environments**, St. John's; 2010; **Winterwind**, Sweden, 2008, 2011; **RETECH**, United States, 2011);
- compare existing grid codes that are applied in Newfoundland and Labrador regarding wind turbine generator unit design and utilization with other developments in Canada and elsewhere. Particular attention should be given to recognizing grid codes and practices in island power systems around the world that are host to significant amounts of variable renewable generation;
- assess the flexibility of the existing generating capacity in Newfoundland and Labrador, particularly with respect to the integration of a significant amount of variable generation (e.g. wind power);
- recommend options and technologies that could improve the flexibility of the existing generating facilities;
- recommend options which could lead to the development of new concepts for the techno-economic integration of high wind penetration systems featuring hydro and gas (possibly) and storage facilities;
- given that large-scale wind development in Labrador could involve the addition of a HVDC transmission link and associated AC transmission in the province and beyond, recommend options for cost effective HVDC transmission, control development especially in weak networks, HVDC cable reliability, multi-terminal effects, voltage source converters and real-time or faster than real-time simulation.
- recommend options for the development of power management strategies and system designs that are tolerant of high proportions of wind generated power and the consequent fluctuations in energy supply, by providing

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mechanisms such as storage loads or wide area balancing that provide grid stability despite unpredictable supply characteristics.

#### **3.1.4 Resource Mapping**

Although resource mapping is well advanced as a discipline, the combined effects of wind and ice for wind energy are not well understood or mapped. This is needed for Labrador wind development.

Nalcor Energy is undertaking a three-year Wind Monitoring Program in four communities in coastal Labrador – Nain, Hopedale, Makkovik and Cartwright. The scope of the work will include site visits for wind prospecting, the evaluation of transmission requirements, constructability, and other desirable qualities of a wind development site, as well as the collection and validation of the wind data from each site.

Without duplicating work that will be undertaken as part of the Wind Monitoring Program noted above or ongoing work of Natural Resources Canada and/or Environment Canada, options should be identified to:

- improve, verify and operationally implement meso-scale modelling approaches to predict the occurrence and amount of icing conditions;
- develop a provincial and regional atlas which would include the frequency and duration of icing conditions and distribution of ice amounts at high resolution (e.g. 1 km, and from 10-400 m above ground), particularly for potential wind energy and transmission line sites in Labrador and on the island;
- develop a long term predictability methodology for the creation of high-resolution wind and ice digital databases involving the creation of synthetic time series (using a mesoscale atmospheric model) of meteorological variables (e.g. winds, temperature, humidity, freezing rain, cloud liquid water content) at a horizontal resolution of 1 km over Newfoundland and Labrador, with a time sampling of every ten minutes;
- develop improved numerical forecasting of short term (0 to 48 hours) energy production;
- develop a methodology for the study of historical weather extremes (e.g. cold, icing conditions, precipitation) and their future trends in a changing climate.

#### **3.2 Transmission**

For the purpose of this RFP, transmission is defined as the establishment and operation of infrastructure for transmitting electricity at high and medium voltages. The Transmission industry is mature and well developed. However, similar to the icing issues related to onshore wind development, icing of above ground power lines is a hazard faced in many parts of the world and can bring down lines over long

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distances. It is a key factor for some parts of Labrador energy development since there is unlikely to be alternative routes to provide redundancy.

The following work is required with respect to transmission:

- recommend options to enhance power line de-icing capabilities (prediction, monitoring, control, de-icing technologies) with a focus on Labrador conditions.

### **3.3 General**

In addition to the above, the following work is required:

- compile an inventory of existing onshore wind-related innovation capabilities and infrastructure in Newfoundland and Labrador;
- review the **Wind Technology Road Map** prepared for the Government of Canada (2009) to determine areas of potential fit with Newfoundland and Labrador's Innovation Roadmap for Onshore Wind;
- define, evaluate and recommend options for engagement including establishing new entities or partnering with third parties (e.g. research/test facilities, turbine/component manufacturers, etc.) taking into consideration key factors such as, but not necessarily limited to, cost to implement, time to implement, ease of implementation;
- evaluate and make recommendations on the potential to export the capabilities and expertise that will reside in the province as a result of developing and implementing the specific innovations that are recommended in the Roadmap for Onshore Wind/Transmission.

### **3.4 Energy Innovation Roadmap Structure**

The Roadmap should cover a multi-year planning horizon and include the following components:

- **Overview** - this component should include an overview of the onshore wind and electrical transmission landscape in Newfoundland and Labrador, the challenges and opportunities that the environment poses to development, recent technological innovations that have occurred in these areas which have particular relevance to this province, recent and current research in the province that is related to onshore wind and transmission in harsh environments, and Canadian and NL company onshore wind and transmission expertise/capabilities.
- **Vision** – this component should identify the vision that will guide the objectives and actions that will be required to achieve it.
- **Innovation/Technology Objectives** – this component should identify innovation/technology objectives consistent with the vision.



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- **Actions Required** – this component should identify specific, detailed actions that are required to achieve the vision and objectives outlined in the previous section.
- **Ownership for Action** – this component should identify an organization(s) that could take a lead role in implementing the recommended action. An organization could be government (provincial or federal), university, institute, or individual companies. As outlined above, options for the type and level of engagement should be explored and recommendations developed. This could include, among other things, collaborative options for engagement with wind turbine companies (manufacturers), universities/institutes, testing centres, electric power utilities, and/or technology solution providers.
- **Key Milestones** – this component should identify key milestones over the planning period for the commencement and completion of the specific actions that will be required to fulfill the vision and innovation/technology objectives.
- **Resource/Cost Estimates** – this component should identify estimated costs of implementing the specific actions that will be required to fulfill the vision and objectives.
- **Performance Indicators (PIs)** – this component should identify specific performance indicators that can be used to evaluate the progress of achieving the vision and each objective.
- **Executive Summary (Report and Presentation formats)** – this component should provide a concise, visual presentation of the objectives, specific actions that are required to fulfill the objectives, and time frames for commencement and completion of the actions.

### **3.5 Methodology**

Stakeholder interviews, focus groups and/or specific workshops will be required to obtain information and input to inform development of the Roadmap. It may be necessary to undertake meetings and site visits in other Canadian provinces and international, in order to complete the due diligence required. A stakeholder engagement strategy/approach should be proposed and costed in detail by the consultant as part of its proposal submission, including potential meetings and/or focus groups and proposed locations. The final strategy/approach and stakeholder/consultation list to be approved by the Department prior to implementation. A potential stakeholder/consultation list is attached as Appendix A.

The consultant will be expected to complete and deliver a final presentation to the Steering Committee, as well as a final written Roadmap report, no later than September 30, 2012. As well, the consultant should expect to complete and submit two (2) interim reports and/or presentations during the contract period, the content and timing of which will be agreed to by the Department. The consultant will be expected to meet in-person with the Steering Committee at the beginning of the project and in-person monthly thereafter until project completion, as well as

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participate in weekly teleconferences. Other shorter oral and/or written updates may also be required, at the discretion of the Department, from time to time.

The final report should include an Executive Summary, the format of which will be subject to final approval of the Department. The consultant will deliver the report in an electronic software format agreed by NR and the consultant. The consultant will also deliver any related and supporting work, reports, presentations and documentation from the completion of this work. The consultant should be aware that any work undertaken and completed by the Government of Newfoundland and Labrador, including that done by consultants on its behalf, is subject to possible public release. Any confidential information provided should be clearly identified.

#### **4.0 Proposal Submission**

Interested consultants are asked to review this Request for Proposals, available reports, studies and other documentation and submit proposals to complete an Energy Innovation Roadmap for the Onshore Wind and Transmission sectors. As referenced in Section 3, Requests for Proposals to cover development of Energy Innovation Roadmaps for other energy areas will be issued separately. The Government of Newfoundland and Labrador is not obligated to engage the consultant selected to complete the Onshore Wind and Transmission Energy Innovation Roadmap to develop any other Roadmap(s) that may be undertaken in the future.

Each submitted proposal must detail how the consultant will address the areas of local Newfoundland and Labrador knowledge, energy sector expertise and experience, and outline whether the consultant plans to subcontract work to local consultants with specific expertise in particular areas. The consultant's approach to addressing these requirements will form part of the overall evaluation of the consultant's proposal submission.

Proposals should include:

- project approach, summary/overview of work, and anticipated Energy Innovation Roadmap outline;
- project work schedule, including work schedule of the consultant's team members;
- key milestone check points to facilitate the Committee's review of progress towards completing the Roadmap;
- details as to how the consultant will address the areas of local Newfoundland and Labrador knowledge;
- the percentage of work under the contract to be undertaken in Newfoundland and Labrador;
- detailed budget including daily rates and total cost of each of the consultant's team members, including costs to travel to/from the province, within the province and to other proposed locations. Cost estimates for out-of-province consultations should be included separately as options;
- company prospectus, services offered and details on the experience of the firm, including previous experience in undertaking similar work;
- anticipated role/contribution and previous experience/curriculum vitae

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- for each of the consultant's team members, particularly with respect to their knowledge, experience and expertise related to energy innovation and innovation/technology Roadmaps;
- names of former clients and associates for whom similar or relevant work has been performed presented as references, including a description of the work completed (minimum of three (3) references required); and
- any additional information the consultant deems relevant to its proposal submission.

All proposals submitted in response to this Request for Proposals must be delivered in a sealed package and clearly marked with the title "Energy Innovation Roadmap – Phase 2: Onshore Wind/Transmission in Harsh Environments" to the Government Purchasing Agency, 30 Strawberry Marsh Road, St. John's, Newfoundland and Labrador, Canada, A1B 4R4 no later than the closing date of Friday, January 13, 2012 at 4:00 pm (NST). A proposal package shall include one (1) signed original and eight (8) complete paper copies and one (1) complete electronic copy in Adobe Reader format. Facsimile or electronic only proposals are not acceptable and will not be considered.

All proposals must remain valid and open for acceptance for not less than ninety (90) calendar days from the closing date of this Request for Proposals.

Consultants are solely responsible, and without recourse for any expenses they incur in preparing and submitting a proposal and for their participation in the Request for Proposals process including, but not limited to, attending any interviews or presentations requested by the Department of Natural Resources and providing any additional information that may be requested. The Department of Natural Resources shall not defray nor be liable for any reason for any expenses incurred by the consultant in responding to this Request for Proposals.

All proposals and accompanying documentation submitted under this Request for Proposals are considered to be the property of the Department of Natural Resources and will not be returned.

All proposals must address the content of this Request for Proposals. Proposals are those that clearly demonstrate a thorough understanding of this Request for Proposals, and its stated requirements and criteria. The Department of Natural Resources will disqualify proposals that do not demonstrate this understanding and do not include the information that is requested in this Request for Proposals.

## **5.0 Proposal Acceptance**

The Department of Natural Resources reserves the unfettered right to reject any or all responses received in response to this Request for Proposals and is not bound to accept the highest ranking or any response. The Department of Natural Resources may elect to cancel this Request for Proposals at any time with or without cause and no liability shall accrue to the Department nor the Government of Newfoundland and Labrador as a result of its exercise of its discretion in this regard.

Should the Department of Natural Resources decide not to accept any proposal

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received, all proponents will be given written notice of such decision.

The proposal of the successful proponent will form part of any resulting agreement by attachment and incorporation by reference. Claims made in the proposal will constitute contractual commitments. Any provision in the proposal may be included in the resultant agreement as a direct provision thereof.

Any agreement resulting from this Request for Proposals shall be governed by the laws of the Province of Newfoundland and Labrador. An agreement issued pursuant to this Request for Proposals shall be issued in the name of the proponent exactly as that proponent's personal or corporate name is stated in the Request for Proposals document. Funds payable (CDN\$) for materials delivered pursuant to this agreement shall be paid only to the proponent who is listed as party to this agreement.

All documents and other records in the custody of, or under the control of some or all of the Department of Natural resources, or its representatives, shall remain confidential.

## **6.0 Proposal Evaluation**

Proposals will be evaluated for completeness, conciseness and general suitability. Additional information may be requested from the consultant, if necessary, to validate and support proposals submitted in response to this Request for Proposals. Any such additional information will be provided at the consultant's expense.

Only proposals that have been deemed by the Department of Natural Resources to have met all mandatory requirements as identified within this Request for Proposals document will be evaluated.

Interviews or presentations may be requested of proponents, if necessary, to validate responses. Any presentations made on site will be at the proponent's expense.

Proposals should identify project costs by category, including the per diem rates and number of days for each person on the project team. All costs should be quoted in Canadian dollars, exclusive of applicable taxes.

The proposals will be scored out of 100 as follows:

<b>Evaluation Criteria</b>	<b>Maximum Number of Points</b>	<b>Minimum Number of Points</b>
Consultant Proposal Bid Price (CDN\$, exclusive of applicable taxes)	25	15
Consultant Profile, Proposed Team, Project Role, Expertise and Experience (including energy sector and innovation/technology roadmapping related experience)	30	15

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Local (NL) Knowledge, Energy Sector Expertise and Experience	10	5
Work Plan, Work Schedule, Approach and Proposed Methodology for Evaluating Opportunities and Developing the Roadmap	35	15
<b>Total</b>	<b>100</b>	<b>50</b>

Proposals which receive a score below the minimum threshold in any of the above categories will be removed from further consideration.

## **7.0 General Terms and Conditions**

The successful proponent must be in good standing with the Workplace Health, Safety and Compensation Commission (WHSCC) or its equivalent in the jurisdiction where the proponent organization is located and provide a certification letter to this effect prior to receiving any payments for this contract.

If the proponent is a corporation, the organization must be licensed to conduct business in its own jurisdiction and shall be in good standing in that jurisdiction.

Any contract resulting from this Request for Proposals will be governed by the laws of the province of Newfoundland and Labrador.

The Department of Natural Resources will retain copyright of any programs, systems or other intellectual property developed as part of this project. The proponent will, upon either completion or termination of the project, immediately transfer to the Department of Natural Resources all materials including, but not restricted to, all research reports, papers, tapes, slides, CDs, films, photographs, audio-visual materials, electronic data or other information submitted to the proponent or developed by the proponent in the performance of the assignment, whether in draft or completed form.

## **8.0 Inquiries and Communication**

Inquiries and questions related to this Request for Proposals are to be submitted to the Department of Natural Resources no later than Friday, January 6, 2012 at 4:00 pm (NST). Inquiries and requests received after this date will not be addressed.

Please forward all inquiries to:

Paul Morris  
Assistant Deputy Minister  
Energy Innovation Roadmap  
Department of Natural Resources

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Government of Newfoundland and Labrador  
7<sup>th</sup> Floor, Natural Resources Building  
50 Elizabeth Avenue  
P.O. Box 8700, St. John's, NL A1B 4J6  
Tel: (709) 729-3547  
Fax: (709) 729-2871  
Email: [pmorris@gov.nl.ca](mailto:pmorris@gov.nl.ca)

All inquiries are to be submitted in writing or by e-mail and the Request for Proposals title "Energy Innovation Roadmap – Phase 2: Onshore Wind/Transmission" should be quoted on all correspondence. The Government Purchasing Agency shall provide to all bidders who have registered to receive amendments, any relevant information in response to inquiries received in writing without revealing the source of those inquiries. Bidders are cautioned that it is their responsibility to ensure that they receive all information relevant to this Request for Proposals. The Government of Newfoundland and Labrador shall not be responsible for bidders who fail to inform themselves regarding the scope and nature of the work. The Government Purchasing Agency shall publish all amendments to the procurement website at [www.gpa.gov.nl.ca](http://www.gpa.gov.nl.ca). Bidders may register on the procurement website to receive amendments automatically by fax. Bidders not registered to receive amendments are solely responsible for ensuring they are aware of and have complied with all amendments by closing time.

Verbal information or representations shall not be binding upon the Department of Natural Resources. Only written changes, alterations, modifications or clarifications approved by the Department of Natural Resources are binding. In order to be valid, all such changes, alterations, modifications or clarifications shall be issued in the form of addenda and all such addenda shall become part of this Request for Proposals.

Information pertaining to the Department of Natural Resources obtained by the proponent as a result of this Request for Proposals is confidential and must not be disclosed by the proponent, except as authorized by the Department of Natural Resources.

The Department of Natural Resources may, during the assessment period, request a meeting with a proponent to clarify points in the proposal. Demonstrations of any or all proposed solutions may also be requested. No changes or amendments by the proponent will be permitted to its proposal after the Request for Proposals closing date. The proponent shall be responsible for any expenses incurred related to this requirement.

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**Appendix A  
Potential Stakeholder/Consultation List**

- Memorial University
  - Associate VP Research
  - Dean, Engineering & Applied Science
  - Associate Dean Research, Engineering & Applied Sciences
  - Various Faculty Members, Engineering & Applied Science
  - Genesis Research
- Government of Newfoundland and Labrador
  - Department of Natural Resources
  - Department of Innovation Trade & Rural Development
  - Department of Business
  - Department of Labrador and Aboriginal Affairs
  - Department of Environment & Conservation
  - Research & Development Corporation
  - Rural Secretariat
  - Women's Policy Office
- Government of Canada
  - Atlantic Canada Energy Office
  - Atlantic Canada Opportunities Agency
  - Industry Canada
  - Natural Resources Canada – (Ottawa, ON)
  - National Research Council of Canada (Ottawa, ON)
  - Environment Canada (Ottawa, ON; Montreal, QC)
- Newfoundland and Labrador Environmental Industries Association
- Newfoundland and Labrador Association of Technology Industries
- Canadian Manufacturers Association - NL
- Newfoundland and Labrador Organization for Women Entrepreneurs
- SafetyNet – Centre for Occupational Health & Safety Research
- College of the North Atlantic, Office of Applied Research
- Natural Sciences and Engineering Research Council of Canada
- Women in Science and Engineering Newfoundland and Labrador
- Women in Resource Development Corporation
- Professional Engineers & Geoscientists of Newfoundland and Labrador
- Newfoundland and Labrador Federation of Labour
- Canadian Wind Energy Association (Ottawa, ON)
- Canadian Electricity Association (Ottawa, ON)
- Electric Power Research Institute (Palo Alto, California)
- Wind Energy Institute of Canada (North Cape, PEI)
- Sustainable Development Technology Canada (Ottawa & Toronto, ON)
- Vestas (Toronto, ON; Houston, Texas; Denmark)
- Frontier Power Systems (Alberton, PEI)
- National Renewable Energy Centre – CENER (Sarriguren, Spain)
- CIGRE (International Council on Large Electric Systems), Montreal, QC; Paris France
- Bonneville Power Administration (Portland, Oregon)
- Wind Energy Strategic Network
- Wind Energy TechnoCentre (Gaspé, QC)

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- CEATI International Inc. (Centre for Energy Advancement through Technological Innovation, Montreal, QC)
- Electric Reliability Council of Texas, Inc. (Austin, Tx)
- National Renewable Energy Laboratory (Washington, DC)
- National Wind Technology Center (Boulder, Co)
- Finnish Meteorological Institute (Helsinki, Finland)
- Mount Washington Observatory (White Mountains, NH)
- Leading Edge Projects Inc. (Whitehorse, Yukon)
- WindREN (Färentuna, Sweden)
- GL Garrad Hassan (Ottawa, ON)
- Hatch (Mississauga, ON)
- VTT Technical Research Centre of Finland
- GE Energy (Canada, USA)
- Manitoba Hydro
- University of Alberta
- University of Windsor
- University of Manitoba
- University of Saskatchewan
- Compusult (Mount Pearl, NL)



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## **APPENDIX 2**

**Exhibit GRK-3, as filed before the PUB  
February 23, 2012**

Source: CAKPL-Nalcor-27 rev. 1  
Columns in yellow: P. Raphals

(1)	(2)	(3)	(4)	(5)	(5a)	(5b)	(6)	(6a)	(6b)	(7)	(7a)	(7b)	(7c)	(8a)	(8b)
Incremental Costs: Muskrat Falls (MF) + Labrador-Island Transmission Link (LIL)															
Reference	Energy at Soldier's Pd GWh	MF Purchases \$000	LITL \$000	Total Incremental \$000	Total	Nominal Annual Cost \$/MWh		Nominal LUEC \$/MWh	Nominal LUEC MF \$/MWh	Nominal LUEC LITL \$/MWh	Real LUEC in nominal dollars \$/MWh (incl. losses)	Total annual payments \$000	Total MF payments \$000	MF payments \$/MWh	MF (COS) \$000 \$/MWh
	(MHI-49.2)	(MHI-49.2)	(Note 1)	(2+3)	(4) / (1)	(2) / (1)	(3) / (1)	(Note 2)			(Note 3)	(1 * 7)	(7a - 3)	(7b / 1)	(3) * CPW(MF)/CPW(LITL)
CPW	21 303	2 682 308	1 758 655	4 440 963				208	126	83	132				2 682 308
Real	33 608														
2010	0	0	0	0	0						132				
2011	0	0	0	0	0						135				
2012	0	0	0	0	0						137				
2013	0	0	0	0	0						140				
2014	0	0	0	0	0						143				
2015	0	0	0	0	0						146				
2016	0	0	0	0	0						149				
2017	1 811	166 064	267 033	433 097	239	92	147	208	126	83	152	275 272	8 239	5	407 280
2018	1 878	175 566	263 292	438 858	234	93	140	208	126	83	155	291 090	27 798	15	401 574
2019	1 953	186 252	265 058	451 310	231	95	136	208	126	83	158	308 574	43 516	22	404 268
2020	2 019	196 415	255 835	452 251	224	97	127	208	126	83	161	325 059	69 224	34	390 201
2021	2 115	209 849	258 160	468 009	221	99	122	208	126	83	164	346 860	88 700	42	393 747
2022	2 212	223 883	248 415	472 298	214	101	112	208	126	83	168	371 616	123 201	56	378 884
2023	2 378	245 531	244 719	490 250	206	103	103	208	126	83	171	406 638	161 919	68	373 246
2024	2 447	257 705	241 032	498 737	204	105	99	208	126	83	174	425 778	184 746	75	367 623
2025	2 505	269 099	237 356	506 455	202	107	95	208	126	83	178	445 890	208 534	83	362 016
2026	2 587	283 493	241 393	524 887	203	110	93	208	126	83	181	468 247	226 854	88	368 174
2027	2 676	299 074	231 230	530 304	198	112	86	208	126	83	185	495 060	263 830	99	352 673
2028	2 809	320 236	227 615	547 851	195	114	81	208	126	83	189	530 901	303 286	108	347 159
2029	3 025	351 695	224 011	575 706	190	116	74	208	126	83	193	583 825	359 814	119	341 663
2030	3 103	367 950	220 420	588 370	190	119	71	208	126	83	196	608 188	387 768	125	336 186
2031	3 181	384 734	224 237	608 970	191	121	70	208	126	83	200	636 200	411 963	130	342 007
2032	3 258	402 008	213 274	615 282	189	123	65	208	126	83	204	664 632	451 358	139	345 286
2033	3 336	419 822	209 721	629 543	189	126	63	208	126	83	208	693 888	484 167	145	319 867
2034	3 414	438 197	206 181	644 378	189	128	60	208	126	83	213	727 182	521 001	153	314 468
2035	3 483	456 106	202 654	658 760	189	131	58	208	126	83	217	755 811	553 157	159	309 089
2036	3 545	473 458	207 510	680 968	192	134	59	208	126	83	221	783 445	575 935	162	316 495
2037	3 482	474 395	195 644	670 039	192	136	56	208	126	83	226	786 932	591 288	170	298 397
2038	3 548	493 064	192 160	685 225	193	139	54	208	126	83	230	816 040	623 880	176	293 083
2039	3 618	512 787	188 692	701 478	194	142	52	208	126	83	235	850 230	661 538	183	287 794
2040	3 680	532 031	185 239	717 270	195	145	50	208	126	83	239	879 520	694 281	189	282 527
2041	3 742	551 758	191 269	743 027	199	147	51	208	126	83	244	913 048	721 779	193	291 724
2042	3 804	572 087	178 380	750 468	197	150	47	208	126	83	249	947 196	768 816	202	272 066
2043	3 865	592 988	175 426	768 414	199	153	45	208	126	83	254	981 710	806 284	209	267 560
2044	3 927	614 549	171 588	786 137	200	156	44	208	126	83	259	1 017 093	845 505	215	261 707
2045	3 989	636 677	168 218	804 896	202	160	42	208	126	83	264	1 053 096	884 878	222	256 567
2046	4 051	659 468	175 578	835 046	206	163	43	208	126	83	270	1 093 770	918 192	227	267 792
2047	4 112	682 807	161 533	844 340	205	166	39	208	126	83	275	1 130 800	969 267	236	246 371
2048	4 174	706 915	158 218	865 133	207	169	38	208	126	83	280	1 168 720	1 010 502	242	241 315
2049	4 235	731 704	154 922	886 625	209	173	37	208	126	83	286	1 211 210	1 056 288	249	236 288
2050	4 289	755 830	151 646	907 475	212	176	35	208	126	83	292	1 252 388	1 100 742	257	231 291
2051	4 343	780 595	160 509	941 104	217	180	37	208	126	83	298	1 294 214	1 133 705	261	244 809
2052	4 396	806 039	145 155	951 194	216	183	33	208	126	83	304	1 336 384	1 191 229	271	221 391
2053	4 450	832 197	141 941	974 138	219	187	32	208	126	83	310	1 379 500	1 237 559	278	216 489
2054	4 500	858 354	138 749	997 103	222	191	31	208	126	83	316	1 422 000	1 283 251	285	211 621
2055	4 550	885 209	135 579	1 020 789	224	195	30	208	126	83	322	1 465 100	1 329 521	292	206 786
2056	4 600	912 830	146 144	1 058 974	230	198	32	208	126	83	329	1 513 400	1 367 256	297	222 899
2057	4 629	937 105	129 309	1 066 414	230	202	28	208	126	83	335	1 550 715	1 421 406	307	197 223
2058	4 629	955 847	126 210	1 082 057	234	206	27	208	126	83	342	1 583 118	1 456 908	315	192 496
2059	4 629	974 964	123 135	1 098 099	237	211	27	208	126	83	349	1 615 521	1 492 386	322	187 806
2060	4 629	994 463	120 086	1 114 549	241	215	26	208	126	83	356	1 647 924	1 527 838	330	183 156
2061	4 629	1 014 353	132 576	1 146 928	248	219	29	208	126	83	363	1 680 327	1 547 751	334	202 205
2062	4 629	1 034 640	114 066	1 148 705	248	224	25	208	126	83	370	1 712 730	1 598 664	345	173 974
2063	4 629	1 055 332	111 096	1 166 428	252	228	24	208	126	83	377	1 745 133	1 634 037	353	169 444
2064	4 629	1 076 439	108 154	1 184 593	256	233	23	208	126	83	385	1 782 165	1 674 011	362	164 957
2065	4 629	1 097 968	105 241	1 203 209	260	237	23	208	126	83	393	1 819 197	1 713 956	370	160 514
2066	4 629	1 119 927	111 025	1 230 953	266	242	24	208	126	83	401	1 856 229	1 745 204	377	169 336
2067	4 629	1 142 326	59 364	1 201 689	260	247	13	208	126	83	409	1 893 261	1 833 897	396	90 542