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Comments on the Proposed Maritime Link Project

submitted to the
Nova Scotia UARB

In the Matter of the Maritime Link Act
Matter #M05419

on behalf of CanWEA

by

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1. Mandate

The Helios Centre was engaged by the Canadian Wind Energy Association (CanWEA) to assist it in its participation in the Maritime Link hearings before the Nova Scotia Utility and Review Board. In the context of this mandate, I have assisted CanWEA in the preparation of Information Requests on the Application, and submit the present report.

In section 2, I will review the regulatory context and the decision-making criteria in effect. In section 3, I will briefly review the Application. In section 4, I will present a critical review of certain aspects of the Applicant's approach.

In section 5, I will describe additional analyses that need to be carried out before one could conclude that the Proposed Project represents the long-term least cost alternative. In section 6, I will summarize my findings and recommendations.

2. Introduction

Under the *Maritime Link Cost Recovery Process Regulations* (the "Regulation") to the *Maritime Link Act* (the "Act"),

> **5** **(1)** The Review Board must approve the Maritime Link Project if, on the evidence and submissions provided, the Review Board is satisfied that the project meets all of the following criteria:
>
> (a) the project represents the lowest long-term cost alternative for electricity for ratepayers in the Province;
>
> (b) the project is consistent with obligations under the *Electricity Act*, and any obligations governing the release of greenhouse gases and air pollutants under the *Environment Act*, the *Canadian Environmental Protection Act* (Canada) and any associated agreements.
>
> **(2)** An applicant must provide the Review Board with the best information and evidence available at the time to apply the criteria in subsection (1).

The regulation does not define the terms "long-term" or "lowest cost alternative", apparently leaving their interpretation to the discretion of the Review Board.

In its Application, Nova Scotia Power Maritime Link affirms that "The Maritime Link Project is the lowest long-term cost alternative that meets all legislative requirements described in Section 5 (1) (b) of the *Maritime Link Act*".[1] This affirmation is supported by the analysis presented in Section 6 of the Application, as well as related appendices and IR responses.

In the following sections, I will examine several aspects of this analysis. First, though, I would like to speak to the criteria by which these arguments should be evaluated.

First, the question of "least cost". The Applicant's analysis compares three resource alternatives (Maritime Link, Other Import and Indigenous Wind), under a variety of load and price scenarios, and concludes that the Maritime Link scenario is the least cost scenario. In my view, however, it is not enough for the Board to conclude that the Maritime Link alternative is of lesser cost than the other alternatives it has analyzed. On the contrary, in order to affirm that the ML option is least cost, it must be convinced that **there does not exist another lower cost alternative,** even if that alternative has not been presented or analyzed by the Applicant.

This is a much deeper question than the one that the government of Newfoundland and Labrador put to its Public Utilities Board in the Muskrat Falls Reference in 2011. In that reference, the PUB was asked only to determine whether or not the Muskrat Falls Project was a **lower cost alternative** than the very specific Isolated Island Scenario presented by Nalcor. As the Board is probably aware, after in-depth study, the NLPUB concluded that it did not have before it information of sufficient quality to allow it to make a definitive determination with respect to the Reference Question.

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[1] Application, page 11.

The question set by the Nova Scotia Regulation is much more complex, because it is open-ended. Implicitly, it places the burden of proof on the Applicant, for unless the Applicant succeeds in convincing the Board that there is no other alternative of lesser cost, the Board cannot affirmatively conclude that the Project represents the lowest long-term cost alternative for ratepayers in the Province.

The question is all the more complex because of the very long period of analysis presented for analysis. The Applicant's analysis is for a Planning Period of 25 years, plus end effects,[2] and the Agreements last for 35 years.

If the future could be known with certainty, or even if that uncertainty could be reduced to a few well delimited parameters, energy planning would not be as profoundly complex a subject as it is. With long-term projections in hand, it is easy to forget that the future really is unknown. Fuel or electricity price forecasts from ten or even five years ago bear little relation to today's reality, and this is by no means an uncommon situation.

Thirty-five years may not be a long time in geological time or in human history, but in technological time, it is a very long time indeed. Thirty-five years ago, crude oil prices were approaching $15 a barrel, and it would be three more years before IBM's first personal computer, with 64 kB of RAM, would be released.

I am not aware of any time in human history when consensus projections of the 35-year future were anywhere near accurate. The one thing of which we can be virtually certain is that, by 2041 or well before, there will be dramatic surprises. Whether fortunate or unfortunate surprises, we

[2] Application, page 118 and NSPML (CA/SBA) IR-30b. Curiously, the Planning Period does not include the full 35-year duration of the Nova Scotia Block.

do not know. That doesn't mean that it is impossible that the world will be as we project it, but the chances are slim, and the errors bars are enormous.

In a typical rate case, investment hearing or long-term plan, the deep uncertainty that attaches to all long-term forecasts is simply part of the context. Regulators approve plans and investments based on the best available projections, fully aware that the future may play out quite differently. For rates, this year's errors can to a large extent be corrected in next year's decisions. For investments, the potential long-term damage that could flow from any one decision is, in most cases, relatively limited.

The present proceeding is different. A decision to approve the ML Project will have important repercussions on the Nova Scotia ratepayer for many years to come. According to the analysis presented by the Applicant, the potential benefits are great. But in order to minimize the risk, in the event that the future does not evolve according to reference scenarios, it is essential to demonstrate that the proposal is robust under a very wide variety of possible futures.

Suppose that the Board were to find that, throughout the range of possible future it considers plausible, the Project does indeed represent a lower long-term cost than the other alternatives presented by the Applicant, as well as all the other alternatives that the Board has examined. Clearly, the Board would find that the Proposal does indeed "represents the lowest long-term cost alternative for electricity for ratepayers in the Province," and it would approve the Project.

Now suppose that, in other possible futures the Board has examined, the Project turns out to be of substantially higher cost than another alternative (whether one of those proposed by the Applicant, or not). How should the Board weigh the likelihood of the possible futures in which the Project is the lowest cost alternative of which the Board is aware, against those where it is not?

To make matters even more complicated, we have to acknowledge that, unlike our projections, history rarely moves in a straight line. It is one thing to postulate high, medium and low scenarios, where load or gas prices grow at a high, medium or low rate. We know that history

doesn't work like this. When J.P. Morgan was asked what the market will do, he answered, "It will go up and down." This is why, at a glance, we can tell the actuals from the projections in a graph: the actuals have saw-teeth, the projections do not.

Unfortunately, there are certain situations where the saw-teeth can be important. Given the nature of discounting, the NPV results will be very different in the price first goes up and then down, than if goes down and then up – even if the endpoint, and thus the average growth rate, is the same. The more we delve into the complexities of possible futures, the more complicated it gets.

These questions bring us dangerously close to issues of burden of proof and of standard of correctness. I am not a lawyer, and cannot advise you on these aspects. However, from a pure energy planning point of view, I believe that the Board must recognize the profound uncertainty within which it has been asked to decide. And, from the perspective of simple intellectual coherence, I do not see how that Board can affirm that "the project represents the lowest long-term cost alternative for electricity for ratepayers in the Province" unless it is convinced of the robustness of that affirmation. In other words, it must find that the Project represents a lower long-term cost for ratepayers than any other reasonable strategy would produce, in the vast majority of possible futures — not just those analyzed by the Applicant.

It should also be noted that the second criterion, in s. 5 (1) (b), leaves no margin of error. To meet this criterion, the Board must find that "the project **is** consistent with obligations under the *Electricity Act*, and any obligations governing the release of greenhouse gases and air pollutants under the *Environment Act*, the *Canadian Environmental Protection Act* (Canada) and any associated agreements." As the Applicant has indicated in response to an IR, this is not a question of optimization, but of respect for the law. If the Board were to identify plausible scenarios in which, under the project, these obligations would not be met, it is hard to see how it could approve the Project.

3. The Maritime Link Project

The analysis presented by the Applicant, which compares the Maritime Link Project to two other alternatives (Indigenous Wind and Other Import) under a variety of load growth and price scenarios, is based on the analysis carried out by its contractor Ventyx, using its proprietary Strategist software.

The use of a proprietary program like Strategist in the context of a proceeding like this one creates a difficulty all its own. The Applicant decided what scenarios to study and what hypotheses to use long before the Application was filed before the Board. Given the accelerated timeline of the proceeding, it is apparently impossible for it to explore additional scenarios or hypotheses.

This reality would be very different if we were in a long-term planning proceeding. In many jurisdictions, planning tools like Strategist are used interactively with a consultative planning process, exploring scenarios and hypotheses which are developed by the participants. This approach goes a long way, not only to help level the playing field between a utility and the other participants, but also to help develop robust plans that perform well under a wide range of possible futures.

In this case, however, it is not possible to obtain Strategist runs with hypotheses different from those selected by the Applicant. This means that it is impossible for scenarios other than those pre-selected by the Applicant – whether based on other resource alternatives, other possible futures, or both – to be analyzed on an equivalent basis to those presented in the Application.

Ideally, the Applicant would have presented sufficiently detailed spreadsheet models to make it possible to quantitatively explore alternate scenarios. Unfortunately, this has not been the case. A number of spreadsheets were indeed provided in response to the first round of Information Requests. However, they were neither sufficiently complete nor sufficiently detailed to allow the production of a planning model in sufficient detail to allow informed analysis of alternate hypotheses.

According to the Applicant's responses to numerous IRs requesting the Strategist output data, these data exist only in TXT files, in which each data series 2015-2040 is broken down over four pages. Without spending dozens of hours transcribing these files into spreadsheets, these files are for all intents and purposes useless. NSPML has not seen fit to present its worksheets that present these data in a manageable way. Given the accelerated calendar of this hearing, it has thus been impossible to work directly with the scenarios analyzed by the Applicant.

Based on media reports, it appears that the Department of Energy will be filing, on the same date as this report will be filed, a study prepared by John Dalton of Power Advisory. This report, a version of which was made public earlier this year, is apparently based on an hourly dispatch model of the Nova Scotia electric system.

As this report is not yet in evidence, it has not been possible to present Information Requests in its regard. This is particularly important because the published version of the report contains virtually no supporting detail. Unlike the Application, this report will only be subject to one round of Information Requests.

In the face of these two sophisticated analyses, each however with its own limitations – in particular, the input assumptions – it is unreasonable to expect interveners, or the Board's own staff or consultants, to present comparable analyses of alternate scenarios. But, in light of the analysis presented in the previous section, this unfortunate situation does not make the Board's task any simpler. In order to approve the Project, the Board must come to the conclusion that the Project is the lowest long-term cost alternative for electricity for ratepayers in the Province. That means that it must be convinced that no better scenarios exist, whether or not they been analyzed to the same level of detail as those presented by the Applicant.

* * *

There is another important feature of the proposed Project that must be mentioned here. The Project is a large investment which, once made, will become a fixed component of the all of Nova Scotia's energy futures. While other decisions will remain to be made in the future,

according to the evolving energy context, the Project, if approved, will to a large extent condition or even define those future options.

In the non-Project alternatives, however, no irrevocable decisions are made at this time. If the Project does not go forward, NSP will have many choices to make, which I presume will be reflected in a new Integrated Resource Plan. But this plan will remain a roadmap – the decisions will be made one at a time, each one reflecting NSP's and the Board's best understanding of the choices and the possible futures before it. As such, each incremental decision will reflect the historical information which does not exist today.

This inherent asymmetry can be described, in risk management terms, as a loss of optionality. Like a corporation with a large cash reserve, an investment has to be measured not only against the other investments that could be made at the same time, but also against the option of keeping some or all of the cash to be invested at a later time, when some of the current unknowns have become "knowns".

> "There are known knowns; there are things we know that we know. There are known unknowns; that is to say, there are things that we now know we don't know. But there are also unknown unknowns – there are things we do not know we don't know."
>
> — Former United States Secretary of Defense, Donald Rumsfeld

The Applicant's response to an IR regarding this issue suggests that the Applicant sees no value in retaining such flexibility. When asked by CA/SBA to "provide all work papers or other documents that discuss the real option value from being able to defer capital investment

commitment decisions and utilize information known at future decision dates," NSPML simply replied, "There are no work papers or other documents on this topic."[3]

For a company considering alternate investments, the flexibility benefit of holding cash ("keeping your powder dry") can be represented as an increased hurdle rate for proposed investments. It is not good enough that the NPV of one proposed investment is marginally better than that of another — it also has to be sufficiently great to justify the loss of flexibility that the investment implies. Similarly, the benefits of a large investment like the Project have to be substantial to compensate the risk inherent in abandoning the flexibility to respond to future changing circumstances, given that long-term projections of a highly uncertain future are inherently flawed.

4. Critical review of the Application

4.1. Load forecast

All electric system planning begins with the load forecast. It is well known that uncertainty increases with forecast duration. In the context of this Application, where the Applicant's Planning Period is 35 years and the Agreements last ten years longer, it is of capital importance to ensure that the load forecast covers a sufficient range to ensure that the universe of possible futures is reasonably covered.

The conventional approach is to make a "best estimate" forecast, using available forecasts of key economic indicators and other factors, and then to establish high and low forecasts surrounding this medium forecast, in order to provide "bookends" of the plausible futures.

[3] NSPML (CA/SBA) IR-83b.

A striking feature of the Applicant's load forecast is that the reference forecast, based on available forecasts of key economic indicators and other factors, is used not as the medium forecast, but as the Low Load scenario. The so-called Base Load scenario is based on increasing these values by 50%, along with other adjustments.[4] At the same time, no scenario is presented with load growth lesser than that found in the reference load forecast.

In its responses to IRs, the Applicant confirmed that it has presented no forecast with load growth lower than that found in its reference forecast, and NSPML has indicated that no robustness tests of this nature have been or will be carried out.[5] The unavoidable conclusion is that what is presented in the Application as the low load forecast in fact corresponds, in traditional utility planning, to the medium forecast. What is here presented as the Base Load is in fact a high-growth scenario;[6] no true low load growth scenario is presented. Thus, the reference load forecast is presented as the lower "bookend".

Confirmation for this hypothesis is found in response to an IR where NSPML was asked to summarize the differences in load forecast between the 2009 IRP Update and the Application. In its response, it compares the NSPML Base Load forecast with the IRP High forecast, and it compares the NSPML Low Load forecast with the IRP Base Load forecast.[7]

It is interesting to note that, in the three and a half years since the 2009 IRP Update was published, both NSP's upper and lower load forecasts have dropped by up to 18%, as shown in Figure 1.

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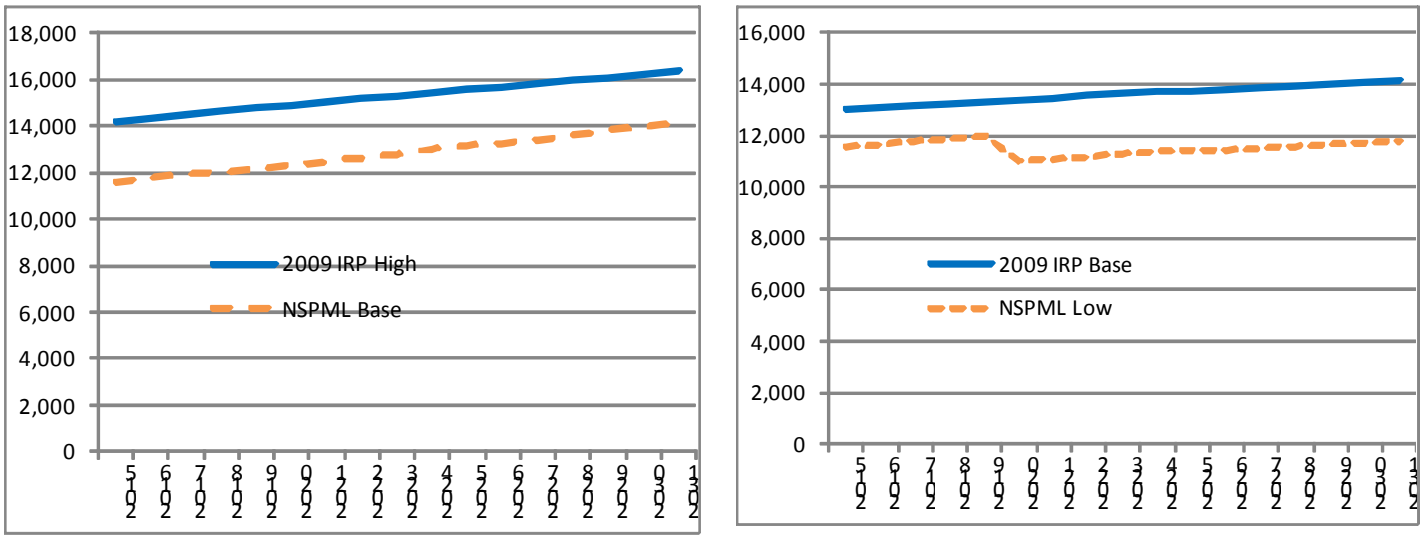
[4] App. 6.03, p. 4.

[5] NSPML (CanWEA) IR-66.2.

[6] NSPML (Synapse) IR-2, Att. 2 refers to the Base Load scenario as "HIGH LOAD".

[7] NSPML (CanWEA) IR-85.

Figure 1. Comparison of 2009 and current load forecasts.



To embark on a commitment as serious and as long-term as the Maritime Link without even considering the consequences should low growth turn out to be lower than the reference forecast is surprising, to say the least. If, under a true low load growth scenario, the costs of the Maritime Link option would be greater than those of other alternatives, the Board must be aware of this in order to make a reasoned decision with regard to the Application.

It is true that, like the present Application, NSPI's 2009 IRP Update also did not include a scenario lower than the reference scenario. However, this choice was explained — and justified — by certain aspects of the energy context in 2009 which are no longer valid. This justification was presented in the section entitled, "**Additional Analysis — Comment on a Lower Load World,"**[8] which explains that "Base Load and High Load optimizations were of primary focus"

[8] NSPI, 2009 IRP Update Report, Nov. 30, 2009, page 29.

because the intent of the update was to reconsider NSPI's options and risks, taking into account then-recent developments.

> A lower load optimization would indicate which resources might be avoided if load is lower. Fewer (or later installation of) supply-side resources would be required to meet energy demand and hence environmental constraints. If, for example, the load were significantly lower than the base load forecast, the level of investment required to precisely meet legislated targets would be less. **To the extent that the resources called for in the early years of NSPI's IRP planning period are incremental (that is, there is no single large scale investment called for), this would be monitored and commented upon when approval for a specific level of investment is sought.**[9] (emphasis added)

In other words, given that **there was no single large scale investment called for,** analysis of low load scenarios could be deferred until such time as approval for specific investment would be sought.

We are now precisely in such a situation, where authorization for a single large-scale investment is requested. The risk of over-building is real, and careful examination of low-load scenarios is essential.

The Applicant has indicated that it is "unable to estimate the probability that loads will be greater than the base forecast or less than the low forecast." It simply states that these forecasts were created to provide "a reasonable range" over which to test the robustness of project alternatives.[10]

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[9] Ibid.

[10] NSPML (CanWEA) IR-86.3.

Other utilities, using a more sophisticated analytical framework, are able to make such statements. BC Hydro, for instance, uses a Monte Carlo model to estimate the uncertainty of its load forecast.

> This model produces high and low uncertainty bands for each customer category around the Reference forecast by examining the impact on load from the uncertainty in a set of key drivers.
>
> The major causal factors used by the model are: economic growth rate (measured by GDP), the electricity rates charged by BC Hydro to its customers, the effective energy reduction achieved by DSM programs, the sales response to electricity rate changes (price elasticity) and weather (reflected by heating degree-days). Probability distributions are assigned to each of these causal factors, and a distribution is assigned to a residual uncertainty variable. As with the 2010 Load Forecast, BC Hydro added to the Monte Carlo a probability distribution for electric vehicles (EVs) and DSM/ load forecast integration on codes and standards.
>
> The Monte Carlo model uses simulation methods to quantify and combine the probability distributions, reflecting the relationships between the five causal factors and electricity consumption. A probability distribution for the load forecast is thus obtained which shows the likelihood of various load levels resulting from the combined effect of the input variables. This distribution implies the following confidence interval bands:
>
> - Low band: There is a 10 per cent chance that the outcome will be below this value in a particular year.
> - High band: There is a 10 per cent chance that the outcome will exceed this value in a particular year.[11]

NSPI takes no position as to the probability that loads will be lower than its Low Load scenario. However, given that this scenario is in fact its reference scenario, the probability is evidently substantial, and far higher than it would be if a true low scenario had been presented.

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[11] BC Hydro, 2011 Electric Load Forecast, App. 2A to the 2012 Draft Integrated Resource Plan, page 24.

As a result, the risk that actual future load growth will be at levels which are outside of the "bookends" presented for the analysis creates a real — and unacceptable — risk that the true costs of meeting future loads will not have been predicted by the analysis submitted in support of the Project.

I recommend that, before advancing further in this proceeding, the Board require the Applicant to present a true low growth load forecast, such that, in the Applicant's opinion, the likelihood of load growth lower than this low forecast is 20% or less.

4.2. DSM

The Applicant's analysis is based on its two load forecast scenarios, reduced by its DSM forecast. The same DSM forecast is used for both scenarios. It is presented on a cumulative basis in Appendix 6.03 (page 7).

The source of this forecast is a document presented by Efficiency Nova Scotia Corporation (ENSC) in response to an Information Request concerning NSPI's avoided cost methodology.[12] NSPML describes it as an "outlook", but ENSC describes it instead as a "profile". In its 2013-15 DSM Plan, ENSC sets out DSM "targets" for 2013-14 as well as a DSM "outlook" through 2017. It seems clear that this "profile" consists of a long-term estimate with significantly greater uncertainty than ENSC's targets or its 2017 outlook.

These energy and capacity DSM estimates, with annual increments (not presented in the original document) are as follows:

[12] NSUARB-E-R-12, ENSC Response to Multeese IR-6, Att. 1.

	ENSC Projection of Cumulative Energy Savings GWh	annual increment	ENSC Projection of Cumulative Demand Savings MW	annual increment
2012	135		26	
2013	260	125	49	23
2014	394	134	75	26
2015	528	134	100	25
2016	677	149	129	29
2017	816	139	155	26
2018	960	144	182	27
2019	1,104	144	210	28
2020	1,263	159	240	30
2021	1,412	149	268	28
2022	1,556	144	296	28
2023	1,700	144	323	27
2024	1,845	145	351	28
2025	1,980	135	376	25
2026	2,110	130	401	25
2027	2,240	130	426	25
2028	2,375	135	451	25
2029	2,500	125	475	24
2030	2,620	120	498	23
2031	2,740	120	521	23
2032	2,865	125	544	23

For the period 2032-2040, the Applicant reduced the annual increment in DSM savings by half, "assuming that DSM effects would be equal to load growth in [the] low load case (essentially keeping load growth to zero)".[13] Thus, the explanation is that, for the "Low Load Scenario," this

[13] App. 6.03, p. 7.

is the level of incremental growth which results in zero net growth. No explanation is provided for using this same reduced incremental DSM level in the Base Load Scenario.

This DSM forecast is problematic for a number of reasons. First, while the Applicant insists that it has no independent knowledge of future DSM and is relying on ENSC data, ENSC has never characterized these estimates as targets or even as an outlook, nor has it taken any position as to the possibility or the likelihood of DSM gains greater or lower than those shown in these estimates. It should be recalled that this profile was apparently developed by ENSC in order to allow calculation of NSPI's avoided costs. To the best of my knowledge, ENSC has never publicly described the process by which it developed this profile, nor has it presented error bars or in any way characterized its own degree of confidence that future DSM gains will follow this profile.

Second, for the period 2032-2040, in the Low Growth scenario, no justification has been presented for limiting DSM gains such that net load growth is zero. Both BC Hydro and Hydro-Québec have entertained scenarios where net growth declines, due to DSM gains greater than load growth.

The hypothesis of reduced DSM gains after 2032 is even less justifiable in the Base Load scenario. Since, in this hypothetical future, load growth has not slowed as much as in the Low Load scenario, there is no reason to believe that DSM gains should slow, based on maintaining non-negative load growth in a different hypothetical future.

The evidence presented by the Applicant provides no reason to think that ENSC has carried out any serious planning exercice in the time-frame of interest here. In the absence of direct testimony in this regard from ENSC, one must assume that the level of uncertainty with regard to annual DSM gains in the 2020s and 2030s is extremely high. A more rigorous approach, in the

face of substantial uncertainty, would be to prepare multiple DSM scenarios. This, for example, is what B.C. Hydro did in its ongoing IRP process. The 2012 Draft IRP includes five (5) DSM scenarios, with different degrees of aggressiveness both in targets and in strategies.[14]

- Option 1 reflections a slowing down of BCH's current DSM Plan, with most program spending reduced by 25%;
- Option 2 reflects the current DSM Plan;
- Option 3 involves increased program spending;
- Option 4 adds more aggressive codes and standards as well as conservation rate structures, to generate additional savings.
- Option 5 is based on a fundamental shift in BC Hydro's approach to saving electricity, which "places greater emphasis on tactics that change market parameters and societal norms and patterns that influence electricity consumption and conservation," with emphasis on net-zero buildings, widespread district energy systems and micro-distributed generation, community densification, best practices in construction and renovation, etc.

The cumulative energy gains of these five options range from approximately 11 TWh/yr by 2032 for Option 1 to to 22 TWh for Option 5. The associated demand savings range from 2,000 to 4,000 MW.[15] Capacity-focussed DSM options, including industrial load curtailment, are expected to provide an additional 425 to 1,200 MW of demand savings.[16]

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[14] B.C. Hydro, 2012 Draft Integrated Resource Plan, pp. 3-12 to 3-16.

[15] Ibid., pages 3-18 and 3-19.

[16] Ibid., page 3-21.

As could be expected, there is a wide range between the high and low DSM forecasts. This would almost certainly be the case in Nova Scotia as well, if the exercise were carried out.

Underestimation of DSM performance can in fact contribute significantly to over-supply.[17] Hydro-Quebec Distribution's current surpluses present an interesting case-study of this phenomenon. These surpluses, which are extremely costly and have had a significant rate impact, are expected to last well into the next decade. While there are multiple causes for this situation, one important cause was the under-estimation of future DSM gains in 2002, when HQD went to tender for three supply contracts, totalling about 8 TWh/yr. Actual DSM gains exceeded the 2002 forecast gains by almost 100% in 2011, and by 2018 are expected to exceed them by 200%. Had DSM forecasts in 2002 been less conservative, considerably less energy would have been committed, and today's surpluses would be far lower.

In order to properly frame the possible outcomes of future DSM programs, the Board should ask the Applicant to prepare a range of DSM scenarios, with estimates of the costs and gains of each, and to integrate these into its analysis of the Project.

4.1. Import capacity

WKM Energy Consultants Inc. argues that, since essentially all of the firm capacity between Quebec and New Brunswick is committed (300 MW held by HQ, 389 MW held by NB Power Genco and 2 MW held by Emera[18]), transmission upgrades would be required before firm imports via NB could be arranged.

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[17] In NSPML (CanWEA) IR-86.5

[18] App. 6.07, p. 9

This would be true, if those existing long-term firm transmission reservations were used to supply long-term firm power sales. To the best of my knowledge, however, they are not. Insofar as HQ and/or NB Power are using those firm transmission reservations to sell into the New England market at market prices and have surplus capacity, it is hard to see why one or the other wouldn't be interested in a firm power sale to NSPI.

As for the NB-NS interface, it appears that upgrades would indeed be required to provide additional firm transmission service. However, it must be emphasized that the mandate given to WKM Energy Consultants was to study the options to supply 500 MW of firm transmission capacity to Nova Scotia. While this is indeed the firm transmission capacity of the Maritime Link, under the Agreements NSPI has access to no more than 153 MW of firm power. It is hard to see why firm transmission is required to import non-firm power. The WKM Report gives us no insight into the transmission upgrades that would be required to import just 153 MW firm into Nova Scotia.

Clarity is also lacking with respect to non-firm transmission capability. According to Fig. 2, there are 305 to 325 MW of TRM on the NB-NS interface, which is available for non-firm transmission except when required for system needs.[19]

The ML Base Case scenario includes up to 800 GWh/yr of imports over the NB tieline. NSPML is apparently presuming that Nalcor's sales of surplus power to or through New Brunswick, above and beyond the amounts to be sold to NSPI, will facilitate additional non-firm purchases from or through New Brunswick.[20] However, this scenario is unlikely, given the analysis presented above of the availability of surplus Muskrat Falls power. In any event, if Nalcor were

[19] NSPML (CanWEA) IR-50b.

[20] NSPML (CanWEA) IR-47e.

indeed to have these additional volumes to sell to more distant markets, it is not clear why NSPI would not simply purchase this power instead of buying from New Brunswick.

With existing infrastructure, there is an import limit of around 300 MW, depending on system conditions.[21] From 2000-2009, annual imports averaged around 200 GWh,[22] which represents less than 25 average MW. This confirms that there is sufficient non-firm transmission capacity to substantially increase imports over the NB tieline without upgrades.

4.2. Reliance on NL surplus energy

According to the Applicant, the Maritime Link project consists of the lowest long-term cost alternative for electricity Nova Scotia electricity customers. This conclusion is based on the Strategist analysis, which compares NPV of marginal costs under certain pre-defined scenarios. It should be noted that these scenarios were not selected by the Strategist program, but where provided to Ventyx by the Applicant, as inputs.

The heart of the Application is the Nova Scotia Block, the terms of which are defined by the Energy and Capacity Agreement. While in fact this energy is made available without charge to the Applicant in exchange for assuming 20% of the capital and operating costs of the Muskrat Falls Project, including the Maritime Link, the economic analysis closely resembles that of a generating station, the capital and operating costs of which are those of the Maritime Link (adjusted).

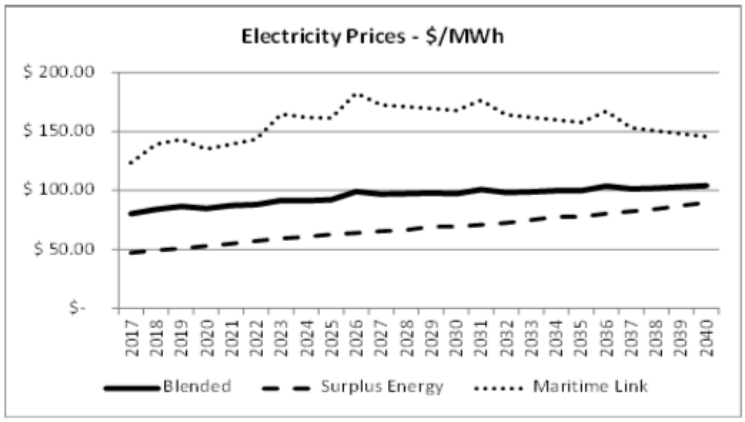
4.2.1. Unit costs

[21] NSPML (CA/SBA) IR-200, Att. 4, NSPI, Report to NSUARB Regarding NSPI/NB Power Interconnection, June 2009, p. 4 of 10

[22] Ibid., p. 7 of 10.

The Application is singularly silent with respect to the unit costs of the Nova Scotia Block itself. The only indication of these costs is found in Figure 4.4, reproduced here.[23]

Figure 4-4 Weighted Average Electricity Prices Per MWh



The figure demonstrates that the unit costs of the Nova Scotia Block vary between 12 and 18 cents/kWh. The details are provided in NSPML (NSUARB) IR-37 Att.1.

The top line, representing the unit costs of the Nova Scotia Block, are found in row 7 of the "Figure 4-4" page of this Excel attachment. They are obtained by dividing the annual revenue requirement for the Maritime Link[24] by the annual energy provided. These unit costs start around $140/MWh for the first five years and then rise rapidly to $183/MWh in 2026; they then decline gradually for the life of the project, with small increases in 2031 and 2036.

Taken alone, these costs are very much higher than those of other generating resources available to NSP. Fig. 4-4, however, blends these costs with those of surplus energy purchases which are

[23] Application, p. 92.

[24] No source is provided for the revenue requirement, but it appears to come from line 10 of the "Financials – Project" page of the financial model filed as App. 4.01.

assigned a much lower cost. **As the entire economic logic of the Application is based on this hypothesis, it is important to examine it in detail.**

The Surplus Energy unit costs are found in line 12 of the "Fig. 4-4" page. They are based on a "revenue requirement" (purchase cost) and volumes, which come from the "Surplus Energy by Month" page of the same spreadsheet. The volumes are based on separate monthly purchases from NL and from NB, set out on lines 3 through 32 of the same page; no indication is provided as to how exactly the monthly purchase prices (rows 41-52) were calculated.

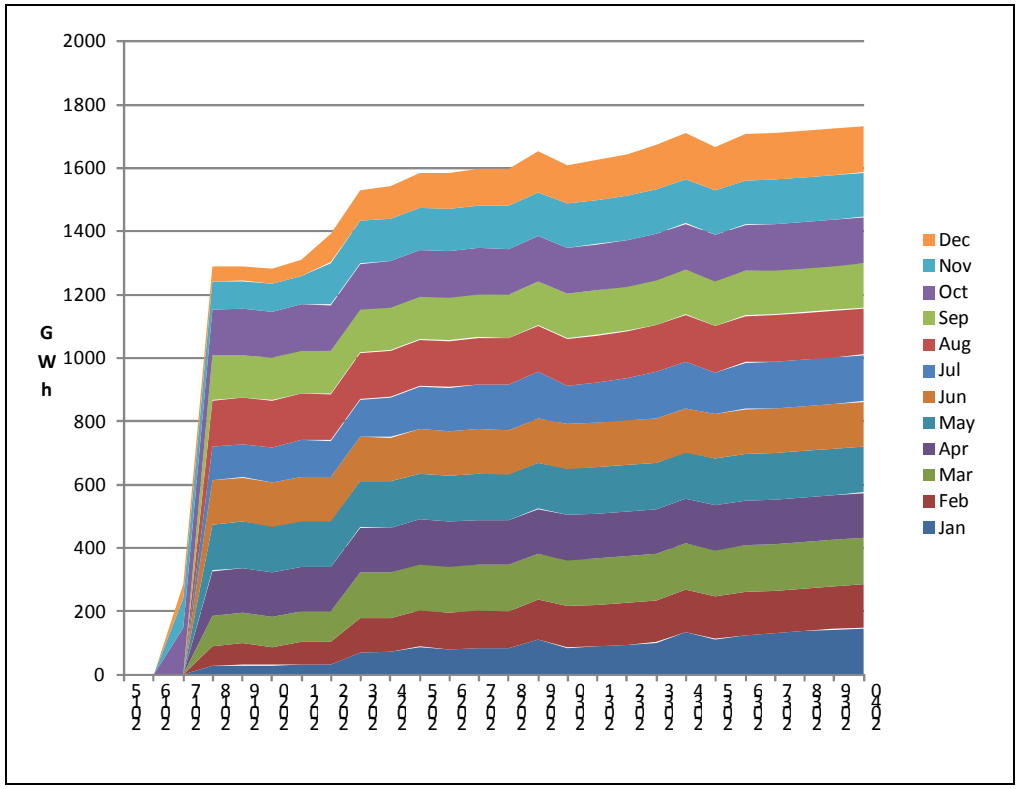
It is also somewhat surprising that this analysis ends in 2040, despite the fact that the Nova Scotia Block will last for 35 years.

4.2.2. Surplus energy volumes available

The annual and monthly amounts of surplus energy that the Applicant expects to import over the Maritime Link are indicated in Figure 2.[25]

7[25] Derived from NSPML (NSUARB) IR-37 Att.1, "Surplus Energy by Month".

Fig. 2: Anticipated Surplus Energy Purchases



The annual volume of surplus energy forecast to be purchased over the Maritime Link thus rises from 1288 GWh in 2018 to 1732 GWh in 2040. (No indication is given of the amounts of surplus energy forecast for the remainder of the Study Period.) This is the equivalent of about 147 average MW from 2018 to 2021, rising to over 180 average MW by 2025, and gradually increasing to almost 200 average MW by 2040.[26]

[26] These figures are based on constant deliveries 24/7. If limited in whole or in part to on-peak periods, the average MW levels would be substantially higher.

NSPML states that it "does not require legal rights to the excess amount as the excess energy will be available to the market, for which NS Power is the first in line providing them with economic advantage without the need for contractual commitments beyond the NS Block.[27]

NSPML is confident that it will have access to Nalcor's surplus energy, because "the excess energy will be available to the market," and because its geographical position makes "Nova Scotia customers 'first in line' to receive and purchase additional energy as it goes to market."[28]

Asked to elaborate, the Applicant stated that:

> The economic benefit which Nalcor can derive from selling to the "first-in-line" **increases the likelihood** the energy will be sold to NS Power. However, beyond the NS Block (including Supplemental Energy) there is **no contractual constraint** in the Nalcor Transactions **prohibiting the sale of energy to parties other thanNSPML**. The market constraint is captured in the "first in line" concept, which ensures that, where the energy is being sold at market prices, the greatest net amount after transmission costs realized by Nalcor would come from the market closest to it –Nova Scotia.[29]

The Applicant acknowledges that "energy flowing over the Maritime Link could be limited by availability of surplus energy." However, it reports that, although "Nalcor has indicated that it was not prepared to contract at any higher levels at that time," Nalcor´s "intention" is for "its surplus energy to be delivered to market via the ML." The Applicant further states that Nalcor Nalcor has reviewed its estimates of energy purchases, and finds them to be "reasonable." No documentary evidence of Nalcor's endorsement of these estimates is provided.[30]

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[27] NSPML (Liberal) IR-3

[28] NSPML (CanWEA) IR-101.1

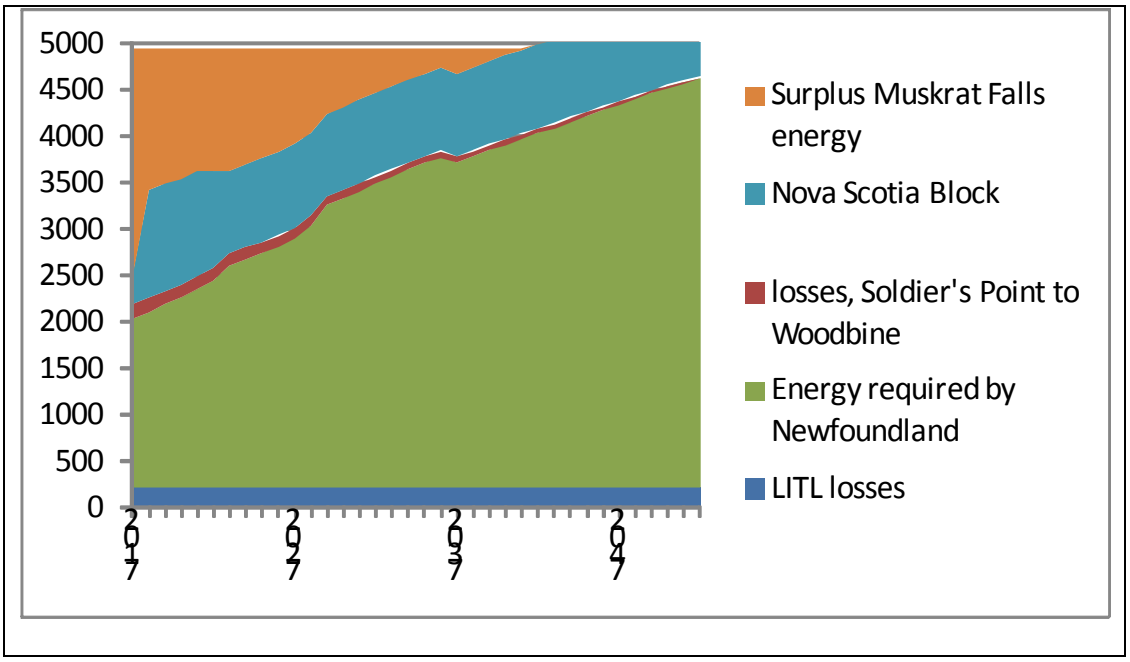
[29] NSPML (CanWEA) IR-101.2

[30] NSPML (CanWEA) IR-61.3-61.5

Nalcor has indicated on many occasions that the percentage of Muskrat Falls power to be consumed in Newfoundland will increase over time. It is thus important to verify that the volumes of surplus energy that the Applicant is counting on will in fact be available in the later years.

In 2011 hearings on the Muskrat Falls Reference, Nalcor presented evidence to the NLPUB as to the evolution of Newfoundland's expected usage of Muskrat Falls power from 2017 through 2067. Figure 3, based on Nalcor's data, shows the breakdown of the expected use of the annual energy produced at Muskrat Falls.[31]

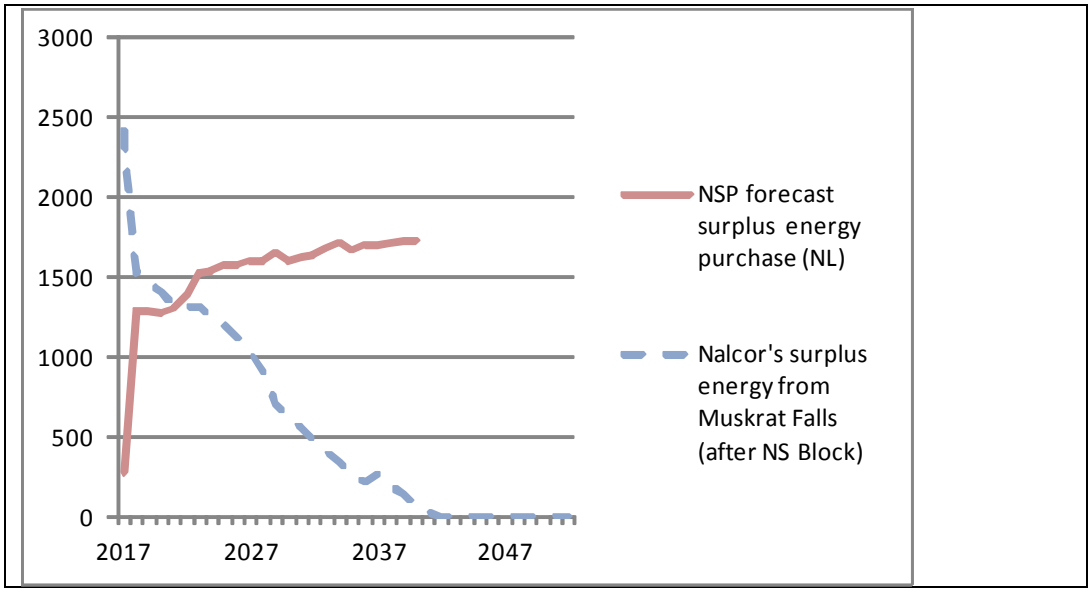
Fig. 3: Forecast Availability of Muskrat Falls Power



[31] Data source: NLPUB, NALCOR (CAKPL-Nalcor-27 rev. 1, p. 6). This graph uses the 4.5% loss rate identified in NSPML (CanWEA) IR-75. According to NSPML (CanWEA) IR-75, when Muskrat Falls is at full power output of 824 MW, the loss rate rises to 7.5% (61.8 MW/824 MW).

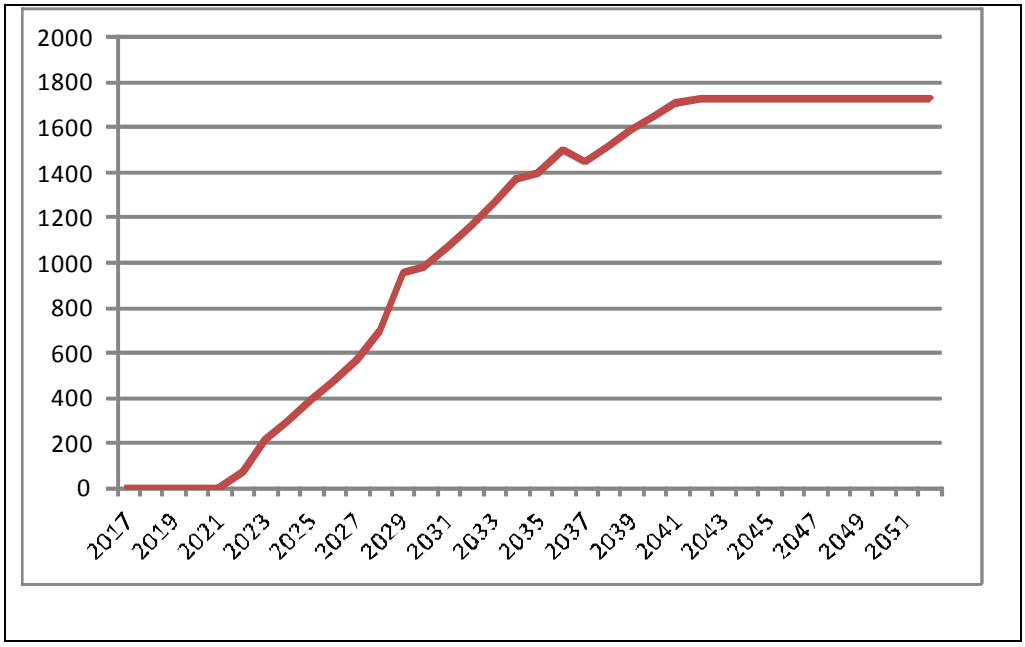
When the evolution of Nalcor's surplus energy from Muskrat Falls is plotted against the Applicant's anticipated Surplus Energy purchases from Nalcor, we get this:

Fig. 4: Nalcor Surplus Energy vs. NSP Forecast Surplus Purchases



Thus, based on Nalcor's figures, the Applicant's forecast surplus energy purchases will only be able to be fully supplied by Muskrat Falls for a few years. Starting as early as 2021, the surplus energy from Muskrat Falls, after supplying Newfoundland`s needs, will not be sufficient to supply these forecast purchases. The shortfall — the amount of Muskrat Falls energy that is included in the Maritime Link Base Case but that will be unavailable, according to the data submitted to the NLPUB by Nalcor — can be seen in Figure 5. (This figure presumes zero load growth after 2040. Any additional load growth would result in greater shortfall.)

Fig. 5. Energy shortfall



NSPML states that the amount of economy energy through the Maritime Link "is an output of the Strategist model."[32] Apparently, the inputs to Strategist did not include any limitations on the amount of energy available for export in Newfoundland.

Recall that Muskrat Falls, with 854 MW installed and a forecast capacity factor of about 68%, is expected to produce approximately 5 TWh of energy per year. The LITL has a maximal transfer capacity of 900 MW or, after losses, 760 MW.

The Applicant has suggested that the Surplus Energy purchases could be supplied by a number of resources other than Muskrat Falls, such as the 300 MW of recall energy from Churchill Falls,

[32] NSPML (CA) IR-62.

which "will now have access to market through existing routes and the Maritime Link."[33] However, already in 2009, 170 MW of the recall power was required to meet Labrador loads. The remainder already has access to market, via a group of long-term firm transmission reservations totalling 250 MW held by Newfoundland Labrador Hydro (NLH, a Nalcor subsidiary) on the Hydro-Québec transmission system. The energy is marketed in the U.S. by Emera Energy.[34]

The NLH reservations expire in 2014, but Hydro-Québec's OATT provides a right of renewal. Given the scarcity of ATC out of Quebec, it would be surprising if NLH did not renew these reservations in order to maintain its access to this transmission path. The expectation that Nalcor will be marketing recall power over the Maritime Link thus appears speculative, at best.

4.2.3. Alternate markets

At the same time, it is important to note that Nalcor also has access to a number of other potential markets, which will be competing with Nova Scotia for the purchase of Muskrat Falls power. The most important of these consists of new mining developments in Labrador. Just last November, the government of Newfoundland and Labrador released two studies concluding "that the mining industry has a significant impact on the economy of Newfoundland and Labrador, and that Muskrat Falls will be an important source of power for potential mining developments."[35]

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[33] NSPML (CanWEA) IR-96.1-2

[34] Govt. of Newfoundland and Labrador, News Release, "Historic Arrangement Sees Newfoundland and Labrador Wheel Upper Churchill Power Through Quebec to North American Markets," April 2, 2009.

[35] Newfoundland Labrador Canada, News Release, "Reports on Labrador Mining Support Need for Power", November 1, 2012. http://www.releases.gov.nl.ca/releases/2012/nr/1101n01.htm

> "The mining industry holds tremendous growth potential, with upwards of $10 billion to $15 billion of investment in Labrador mining projects possible over the next decade," said the Honorable Jerome Kennedy, Minister of Natural Resources. "The reports released today support the conclusion that the development of potential projects will be dependent in part on the availability of power, and Muskrat Falls power is needed to support mining developments in Labrador."

The news release mentions a number of mining projects:

- In operation: Voisey's Bay, Wabush Mines, Iron Ore Company of Canada's (IOC) Carol Lake and Labrador Iron Mines Ltd (in)
- In construction: IOC Concrete Expansion Program and Tata Steel Minerals Canada
- Feasibility study completed: LIM Expansion
- Feasibility studies underway: Alderon Iron Ore Corporation's Kami project, Tata Steel Canada Labmag project, Vale Inco's Voisey's Bay underground mine and Labec Century Iron Ore's Joyce Lake
- Pre-feasibility studies underway: IOC Labrador West Strategic Development, North Atlantic Iron Corporation, Aurora's Paladin Michelin project and Julienne Lake

One of the studies stated that Labrador mining production could more than triple, from 26 to 81 million tonnes of ore, if all the projects went ahead. It concluded that this would result in 358,000 person-years of employment and $17.5 billion in tax revenue.

The news release concludes:

> "Muskrat Falls will be an important source of power for mining, and the availability of power for mining developments will encourage investment right here in our province, rather than in competing jurisdictions," said Minister Kennedy. "Such mining developments would bring major economic benefit to the province which would benefit the people of our province today and for generations."

There seems to be little doubt that, from the perspective of the NL government (Nalcor's shareholder), the economic benefits of using surplus Labrador power to local mining interests would dwarf those that would flow from exporting economy power to Nova Scotia.

It is important to emphasize that Nalcor has made no commitments whatsoever to NSPML with regard to the availability of Surplus Energy. The presumption that these large quantities of energy will be made available to NSPML in the 2020s and 2030s remains simply that: a presumption.

As we have seen, that presumption is simply not credible, if Nalcor's forecasts presented to the PUB of the evolution of supply and demand in Newfoundland prove to be accurate.

For all these reasons, the analysis of whether or not the Maritime Link Project represents the lowest long-term cost alternative for electricity ratepayers in the Province should be based on the analysis of the costs and benefits set out in the Agreements (the Nova Scotia Block), rather than on unsupported presumptions concerning the availability and price of additional energy which has not been offered by Nalcor.

Indeed, even if the presumed availability of surplus power were credible, Nalcor's assumption that this energy will be made available to NSP at bargain-basement prices must also be taken with a grain of salt.

NSPML argues that, for geographic reasons, Nalcor has every reason to sell to the Applicant rather than transmitting its energy farther. This may be true, if all other terms are identical — but there is no reason to assume they will be. It is easy to imagine scenarios where Nalcor might negotiate a long-term purchase agreement with a more distant purchaser, under terms more appealing than the short-term sales envisioned by NSP.

Several states in the Northeast have Renewables Portfolios Standards, or similar instruments, which can substantially improve the economics of energy sales from qualifying sources. At this time, the status of hydropower from large facilities remains somewhat ambiguous; however, it is certainly possible that Muskrat Falls power will be eligible for such premiums in at least some of the Northeastern states. Furthermore, it must be recalled that Newfoundland has some of the best wind resources in the world, and that Nalcor has argued that the ML will facilitate the development of wind power there. One can imagine a long-term PPA with New York or a New

England state purchasing Newfoundland wind power, balanced and firmed by MF power, at prices considerably greater than those set out in the Application – and perhaps considerably more than NSP is willing to pay. Under such circumstances, the economic analysis carried out by Strategist becomes entirely irrelevant.

To cite a more concrete avenue for potential higher-priced Nalcor sales into the US market, I will describe the Champlain-Hudson Power Express (CHPE) project, with which Nalcor has been closely associated. Its Applicant, TDI, describes the project's purpose as follows: [36]

> The Project consists of a 2,000 megawatt (MW) HVDC underwater/underground HVDC transmission system that includes two 1,000 MW bipoles (each bipole includes two cables connected as a bipole pair), one extending between the Canadian border and New York City, New York and the other extending between the Canadian border and Bridgeport, Connecticut (Figure 3.1-1). CHPEI has designed the Project to meet the New York City area's need for additional sources of competitively priced electricity from safe and reliable renewable sources of energy. The stated purposes of the Project are to:
>
> - Provide 1,000 MW of primarily carbon-neutral source electricity to New York City without contributing to additional congestion on the electric grid entering the City;
> - Provide significant new transmission infrastructure into New York City without the aesthetic impacts from traditional overhead transmission using, HVDC cables that will be buried primarily within waterways or along relatively short underground routes;

[36] NYS PSC, CHPE Inc. Article VII Application, Exhibit 3: Alternatives Analysis, p. 3-1 and 3-2.

- Place downward pressure on the price of electricity in the Location Marginal Price (LMP) spot markets operated by New York Independent System Operator (NYISO) in the New York City area;
- Reduce air pollution and greenhouse gas (GHG) emissions within the New York City area by alleviating the need to operate one or more existing fossil fueled power plants within the City during periods of congestion;
- Improve stability of the electric grid serving the New York City area due to the highly reliable and controllable nature of HVDC technology and its compatibility with Smart Grid initiatives; and
- Reduce the dependency of the New York City region on fossil fuels, such as imported oil thereby improving the security of the electric grid.

It is well known that wholesale power prices in New York City are substantially higher than in the northern part of the State, due to transmission congestion.

> **Wholesale, on-peak electricity prices in New York City are the highest in the contiguous United States**. In 2010, the average day-ahead, on-peak spot price of electricity in New York City was $65 per megawatt hour, higher than in neighboring New England and Mid-Atlantic regions. There are three main reasons for higher prices in New York City: high-cost, in-city generation; often insufficient in-city generation to meet demand; and limited transmission capacity leading into the city.[37] (emphasis added)

The CHPE project is meant to take advantage of these elevated prices, as well as the New York State RPS:[38]

> Governor Paterson's "45 by 15" program, which he announced in his State of the State address on January 7, 2009, is one of the nation's most aggressive energy efficiency and renewable energy initiatives with a goal to meet 45 percent of its electricity needs through energy efficiency and clean renewable energy by 2015. In furtherance of this goal, the Renewable Portfolio Standard (RPS) goal was increased from 25 percent to 30 percent on January 8, 2010 (PSC 2010). Because the Project will bring clean renewable energy to New York City, it will assist New York in meeting its "45 by 15" goal to have 30 percent of its electricity needs met by renewable power.

[37] US

[38] NY

Nalcor has been associated with the CHPE from early on. In a letter supporting CHPE's motion before the FERC requesting authority to charge negotiated rates for the sale of transmission rights, Nalcor indicated that it was in discussions with CHPE as a potential anchor customer:

> Currently, Nalcor's subsidiary holds a transmission service agreement to wheel 265 MW of power on the Hydro-Québec TransÉnergie (―HQT‖) grid from Labrador to the HQT-Massena interconnection. **As it moves forward with development of the Lower Churchill Project**, as well as significant wind resources, it will continue to increase its participation in the Northeast U.S. energy markets via acquisition of open access transmission service over the HQT system as well as other potential transmission paths. As part of such efforts, **Nalcor is presently in discussions with CHPE regarding the potential acquisition of transmission capacity over the Project as an anchor customer.**[39] (emphasis added)

The CHPE project continues to move forward. In December 2012, two administrative law judges of the New York State Public Service Commission recommended that a Certificate of Environmental Compatibility and Public Need be granted by the Commission. However, the failure of Nalcor's complaint before Quebec's Régie de l'énergie with respect to its request for long-term firm transmission service over the TransÉnergie system has, for the moment, dealt a blow to Nalcor's ability to reach the northern terminus of the CHPE in the near future. There is no reason to believe, however, that this impasse will not be resolved well before 2040. The economics of selling RPS-eligible power to New York City — if the CHPE project succeeds — are much more attractive than the surplus power prices anticipated by NSPML.

So, to summarize, the Application is counting on energy from Muskrat Falls that, based on Nalcor's own testimony to the NLPUB, will not be available. NSPML's suggestion that Nalcor will have other sources of power ignores the fact that it will also have other avenues to market

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[39] Federal Energy Regulatory Commission (FERC), Champlain Hudson Power Express, Inc.) Docket No. ER10-1175-000, MOTION TO INTERVENE OF NALCOR ENERGY AND COMMENTS IN SUPPORT OF APPLICATION, p. 3.

that power. The prices at which NSPML intends to purchase this power means that, for Nalcor, these sales will remain a last resort. There is no reason to believe that Nalcor will not continue to make vigorous efforts to find alternatives — which explains its refusal, to date, to make any commitment whatsoever to Emera over and above the Nova Scotia Block.[40]

4.2.4. Alternative strategies to replace Nalcor Surplus Energy

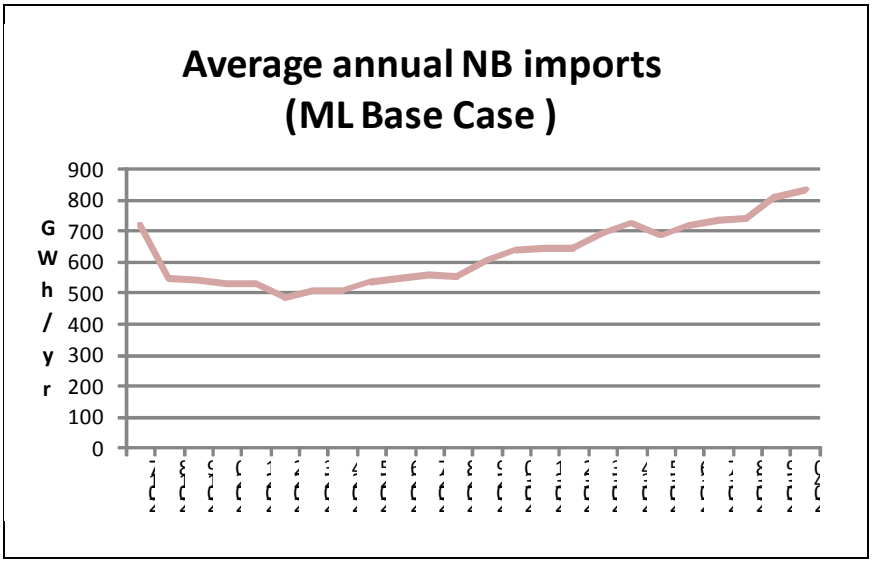
Assuming that the Maritime Link project goes forward, what alternatives will be available to NSPI to make up the energy shortfall, if the planned surplus energy purchases from Nalcor cannot be realized?

In its Base Case, NSPML is already relying on imports from New Brunswick which eventually rise to over 800 GWh/yr, as shown in Figure 6.[41]

[40] NSPML (CanWEA) IR-61.3 – 61.5.

[41] NSPML (NSUARB) IR-37 Att.1, "Surplus Energy by Month".

Fig. 6



It is not clear how much non-firm power NSPML believes it can import over the existing NB intertie, but there is no reason to believe that there is additional import capacity there, beyond these amounts.

The most likely alternative sources to make up the energy shortfall identified above are increased reliance on thermal power, or building additional wind power. Further analysis is required to determine if the shortfall could be met by thermal resources without compromising the decommissioning of Lingan-1 and -2, which is a key element of the justification of the ML Project.

Replacing the missing power with new gas-powered CCGTs would result in lower GHG emissions than continued reliance on coal, but more than those described in the ML scenarios in the Application, and with additional capital costs. Adding new wind power, in addition to the Maritime Link, would not add GHG emissions, but would also result in increased capital costs.

In other words, should Nalcor Surplus Energy not be available in the expected quantities, NSPI would have to incur very substantial additional costs in order to avoid non-compliance with the RES. Indeed, as this non-availability would not be known in advance, but rather revealed on a day-to-day basis, there would be virtually no lead time to arrange alternate solutions. Under these constraints, non-compliance might be unavoidable.[42]

Even assuming compliance, any one of these options would result in increased costs, above and beyond those reported by Strategist for the Maritime Link Base Case, casting into question the Application's conclusion that the Maritime Link is the least-cost alternative, from the ratepayers' perspective.

4.2.5. RES compliance

The unavailability of a significant portion of the Surplus Energy that NSP expects to purchase from Nalcor would also have important repercussions with respect to RES compliance.

Currently, the RES accounting under the ML scenarios counts both ML and NB imports as RES-compliant. In a Response, NSPML states that "This assessment **has assumed** surplus energy imports [including those via the NB tieline] are RES eligible."[43] (emphasis added) This assumption is of questionable validity.

While it is safe to assume that most energy imported from Hydro-Quebec is renewable (especially after the closure of Gentilly-2), that is not true for power purchased from either New Brunswick or New England.

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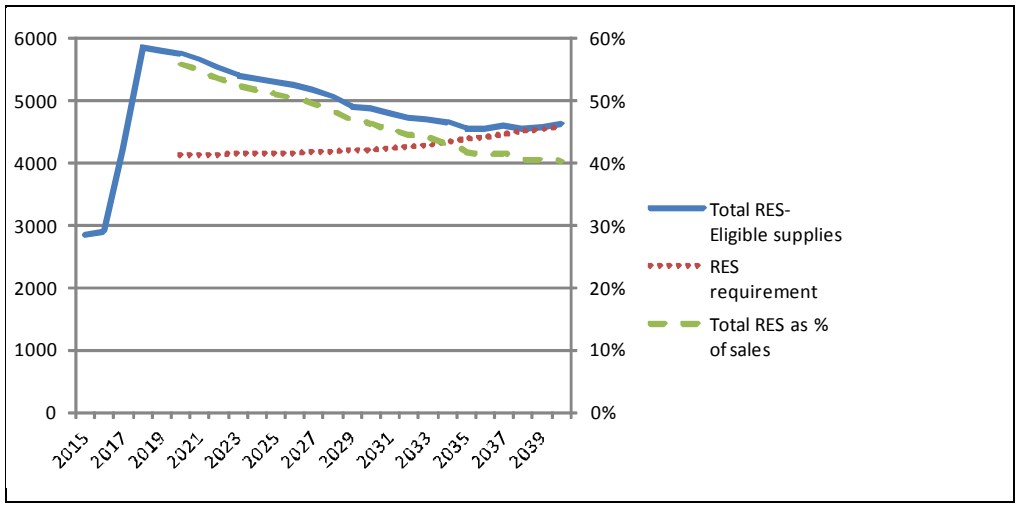
[42] Conceivably, NSPI's lack of alternatives to Nalcor energy to meet the RES requirements could, in some cases, allow Nalcor to extract higher prices than those available in New England.

[43] NSPML (CA/SBA) IR-48d.

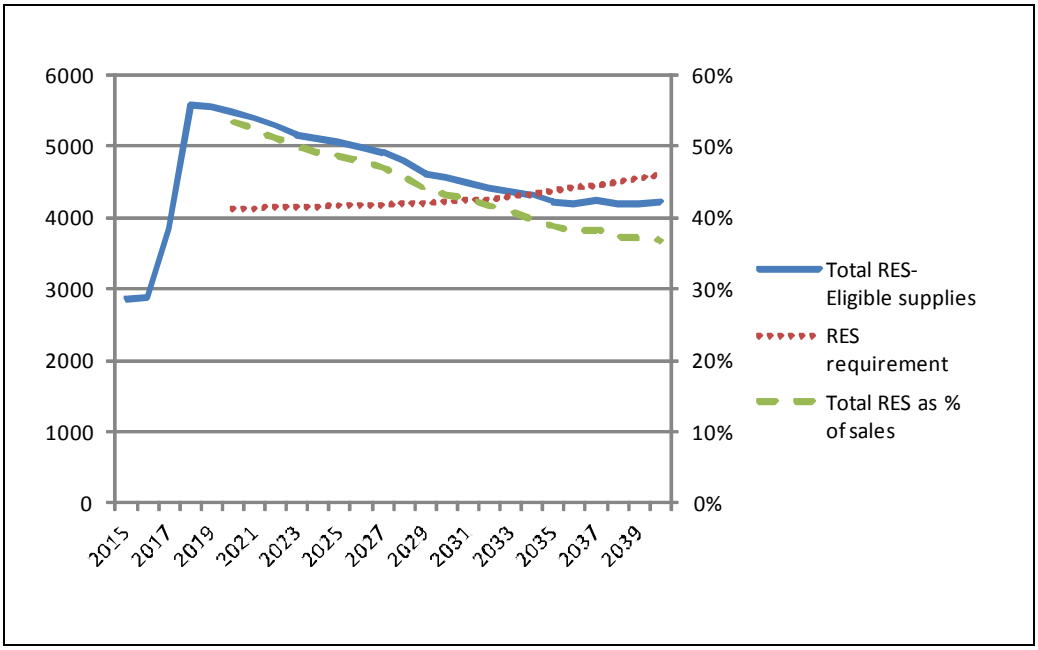
If we assume that 100% of the imports over the NB tieline are RES-eligible, the ML scenario still just barely meets the RES requirements through 2040, after replacing the unavailable quantities of NL Surplus Energy with non-RES-compliant replacements.

Fig. 7: RES-Eligible Supplies vs Requirements (100% NB Imports Eligible)



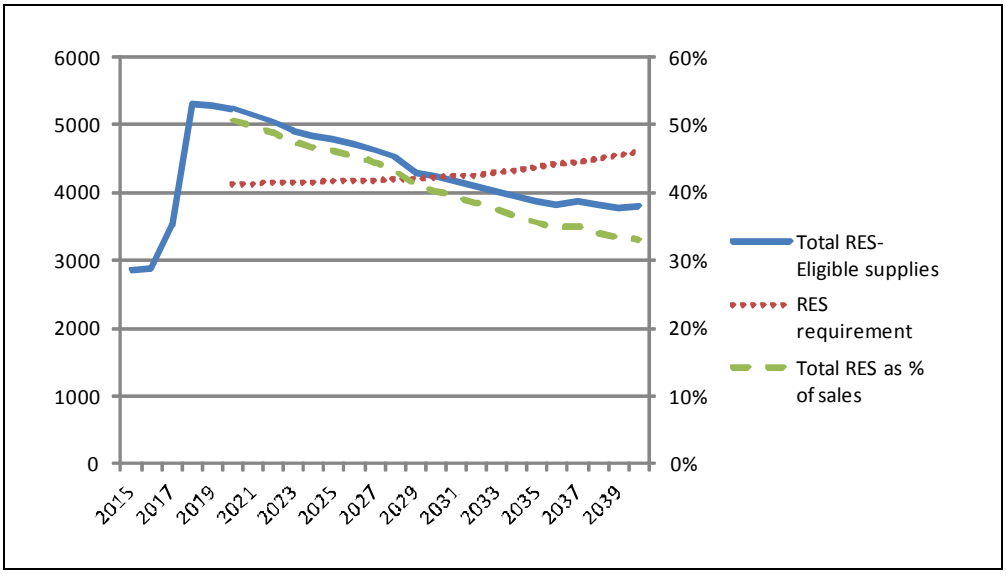
However, if only half of the NB imports are RES-eligible, the RES requirement would not be met, starting in 2035.

Fig. 8: RES-Eligible Supplies vs Requirements (50% NB Imports Eligible)



If none of the NB imports are RES-eligible, the ML Base Case scenario would be non-compliant starting in 2031, and the RES shortfall would reach almost 800 GWh/yr in 2040.

Fig. 9: RES-Eligible Supplies vs Requirements (no NB Imports Eligible)



This demonstrates that the non-availability of the forecast quantities of NL Surplus Energy would result not only in increased costs, but also in non-compliance with the RES, unless 100% of the NB surplus energy is RES-compliant.

4.3. Wind power

There are significant problems with the way that wind power is represented in the Application, some of which will be addressed in this section.

4.3.1. Curtailment

NSPML raises an important issue with respect to the integration of substantial wind power resources during low load periods. The Applicant states that it requires 480 MW of steam generation at all times. For the purposes of this testimony, let us assume that this is correct.

NSPML presumes that, whenever load net of wind generation is less than this amount, wind generation must be curtailed. Using simulated data, it evaluates the amount of curtailment required in 2020 and in 2040 for each marginal increment of wind power. Based on this analysis, it concludes that, for the first 425 MW of incremental wind, the capacity factor would be reduced from 37% to 35%, and that, for additional increments, it would be reduced to 32%.[44]

This somewhat simplistic methodology is inadequate to properly represent the effects of increasing levels of wind power during low load periods, especially in the context of the RES, for several reasons. First, it fails to properly account for export possibilities. The Applicant explains its discounting of export possibilities as follows:

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[44] NSPML (Synapse) IR-2, Att. 1 and 2.

> Experience has shown that when NS Power has high wind energy generation during low load periods and exports to NB/NE are desirable, NB/NE are also under high wind energy generation conditions. Under these conditions interconnected utilities are not likely to purchase any excess energy from NS Power or will do so at a depressed market price. This problem becomes more severe with larger quantities of wind energy on the interconnected system. For the purpose of the curtailment analysis, NS Power assumed that no exports during low load periods will be available for large quantities of wind on the system. [45]

NSPML seems to suggest that Nova Scotia, New Brunswick and even New England are generally all affected by the same weather systems; as a result, high wind generation periods in one would likely be true in the other as well. This is an over-simplification. First, New Brunswick does not have significant wind integration (less than 300 MW or about 7% of installed capacity), and with the recent refurbishment of Point Lepreau it is unlikely to have a significant increase in wind penetration over the study period.

Second, even large weather systems do not affect all locations simultaneously. For example, if a weather system were to move in and impact the Pubnico wind farm in NS, travelling north, it could be 10 to 20 hours before it would affect production at the Lameque wind farm in NB. By that time, the wind may have stopped blowing in Pubnico. In other words, Pubnico wind could be exported to NB for at least 10-20 hours before Lameque gets the same wind. At that point, if needed, Lameque power could be exported to NS.

That said, large weather systems do occur that affect all of NS. However, there is no basis for assuming that this same effect would be seen throughout all the regions where NS could market its wind power. ISO-NE ranges from Maine to Connecticut and is interconnected with New York State and with Hydro-Quebec. These are very different meteorological regions. There is no

[45] NSPML (CA/SBA) IR-52g.

reason to presume that a high-wind period in NS will also be a high-wind period in Western New York State, or Connecticut.

Even if wind production were positively correlated across the region, ISO-NE will continue to accept price-taking bids at the NB border. In the worst case, such bids could lead to negative pricing, where NS would have to pay to off-load its energy and the "buyer" would be paid to take the energy, but no evidence has been presented to suggest that these high-wind/low-load periods frequently (or ever) result in negative prices.

Thus, it is incorrect to assume that it will be impossible to export power during these periods. Curtailment is the equivalent of exporting at a price of zero. As long as market prices are positive, there is no reason to curtail indigenous wind in Nova Scotia.

Furthermore, under the RES, wind generation is important to NS, even if its economic value were to be offset by low export revenues. The wording of the RES Regulation strongly suggests that it is meant to apply to retail sales, not to wholesale electricity trade.[46] However, even if it were to be determined that the RES applies to exported electricity as well, generating and exporting a renewable kWh would nevertheless contribute to meeting the RES, and so would be preferable to curtailment, even if export prices are very low. Thus, it would be in NS's interest to avoid curtailing wind power whenever possible. As NSPML itself indicates, "in the Wind cases, excess loads [sic] can be exported over NB-NS tieline up to the tieline's maximum capacity."[47]

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[46] S. 6A (1) reads: "Each year ..., each load-serving entity must supply its customers with renewable electricity in an amount equal to orr greater than 40% of the total amount of electricity supplied to its customers as measured at the customers' meters for that year."

[47] NSPML (CanWEA) IR-133.5

The Applicant's approach of discounting the capacity factor of future wind power developments to account for presumed curtailment is therefore incorrect and inappropriately penalizes the indigenous wind financial analysis.

4.3.1. Indigenous Wind scenarios

The justification for the wind capacity additions in the Indigenous Wind scenario is found in NSPML (CA/SBA) IR-48, Att. 1 (for the Base Load case) and Att. 2 (for the Low Load case). These spreadsheets demonstrate that the amount of wind power added in the scenario is based on the amount needed to meet the RES requirement. Under the Applicant's Base Case, 425 MW is added in 2019 (at a CF of 35%), and 50 MW additions in 2028, 2034 and 2037 (at 32% CF), for a total of 575 MW.

As noted in the previous section, NSPML reduces the capacity factor of incremental wind to account for curtailment that it incorrectly presumes will be required during low-load periods. The direct result of this methodological error is to exaggerate the installed wind capacity required to meet the RES, and thus to artificially inflate the cost of the Indigenous Wind scenarios.

NSPML bases its calculations on an average CF of existing wind farms in Nova Scotia of 37%, which it reduces to account for curtailment. This is overly conservative, since the new turbine technologies available in today's market have significantly increased the turbines' production capacity. Given the quality of Nova Scotia's wind resource, CanWEA's members expect that wind farms with newer turbines could produce at a CF of 40% or higher. Even if they were curtailed for 5% of their production hours, this would yield a delivered CF of 38% or more, with the same installed capital costs as those assumed by the Applicant. Thus, using a CF of 37%, net of curtailment, (equal to the value used by NSPI before curtailment) represents a conservative assumption.

As noted above, import capacity from NB with existing infrastructure is approximately 300 MW and imports average around 200 GWh/yr, which is the equivalent of less than 25 average MW.

There is thus substantial headroom to increase non-firm imports. Since, as noted above, NSPML presumes in the ML scenarios that imports over the NB intertie are RES-eligible, an "apples-to-apples" comparison requires using those same premises for the Indigenous Wind scenarios.[48] Assuming then that RES-eligible imports of 500 GWh/yr are available over the NB intertie without transmission upgrades, the incremental wind power required to meet the RES falls to 275 MW in 2019 plus 50 MW each in 2033 and 2037, for a total of 375 MW, a reduction of 35% compared to the Applicant's stated need for 575 MW of additional wind power.

Full costing of this scenario would require analysis of balancing requirements as well. Given the enormous storage reserves of Hydro-Quebec, there is every reason to believe that it would be open to negotiating a balancing contract, perhaps in the context of a long-term power purchase agreement. Reasonable estimates of the costs of such a transaction should be included in the scenario. Even so, it is clear that this scenario will be far less costly than the Indigenous Wind scenario described by NSPML.

4.3.2. Balancing and regulation capacity

It is claimed that the Maritime Link will enable the development of substantial new intermittent generation in Nova Scotia.

> In addition to improved reliability, this second interconnection provides an opportunity for an expanded balancing area which can assist in the integration of the amount of wind committed to be added to the NS Power system.[49]

The NS Block does indeed provide dispatch and regulation services, as set out in the ECA. However, these services are very limited in scope. Dispatchability is limited to scheduling that

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[48] Alternatively, the ML scenarios should be revised to exclude RES-eligible imports from New Brunswick.

[49] App. 6.05, p. 18.

can be modified ± 40 MW around the fixed 153 MW (to be delivered 16h x 7 days, year-round), in half-hour increments with 60 minutes' notice, provided that the total daily energy schedule remains unchanged. Regulation Service is limited to ±10 MW.

More important, energy to be delivered above the Nova Scotia Block Associated Capacity is non-firm[50]. As such, these flexibility resources differ from true dispatchable resources and regulation, which are normally firm.

As WKM Energy Consultants, Inc. explained, in a response concerning obtaining balancing services from Hydro-Québec:

> **To provide balancing services** from Quebec to Nova Scotia requires that dynamic scheduling be instituted between Quebec and Nova Scotia. To do so requires that **firm transmission** be reserved from Quebec to Nova Scotia **for the full range of the balancing changes**. For example, to provide plus or minus 30 MW of balancing it would be necessary to reserve **60 MW of firm transmission**.[51]

Thus, firm transmission above and beyond the Nova Scotia Block would be required for the Maritime Link to provide true balancing services for additional wind power in Nova Scotia.

As a result, the real capacity of the ML Project to enable additional development of wind power or other intermittent renewable resources is extremely limited. Based on the logic that the

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[50] ECA, Schedule 5.

For Scheduling and Deliveries, see s. 2(d)(viii): Energy that is being delivered that is above the Nova Scotia Block Associated Capacity is non-firm and therefore subject to curtailment including the requirement to deliver Capacity to other Nalcor customers."

For Regulation Service, see s. 3 (b): notwithstanding Section 3(a) of this Schedule 5, Emera shall not be entitled to request the use of Capacity in excess of the Associated Capacity of the Nova Scotia Block unless Nalcor has unused transmission Capacity in the ML …"

[51] NSPML (CanWEA) IR-55c.

backup resources needs to be able to be relied on in case the wind generator is not producing when its power is needed, these so-called balancing resources have no real value, since, in the event that the backup power is need during an hour when the Nova Scotia Block Associated Capacity is being used in full, the backup resource is non-firm and thus subject to curtailment. [52]

Even NSPML acknowledges that the Maritime Link would allow, **at most,** the integration of 40-80 MW of incremental renewable energy:

> The incremental renewable energy that could be accommodated by the dispatchable range of the Maritime Link would depend on the type of renewable generation under consideration and the forecast confidence that is available for that technology. It would also depend on the level of intermittent generation penetration present on the system and the flexibility of other online generation. All else being equal, 40-80 MW of new intermittent source should be possible.[53]

The benefits for future wind power flowing from the Maritime Link Project are therefore extremely limited. On the other hand, the "crowding out effect" due to the long-term commitment to purchase the Nova Scotia Block, together with the economic pressure that will flow from the high price of that power, are significant. The overall impact of Maritime Link Project on future wind power development in Nova Scotia is therefore expected to be negative.

Furthermore it is unclear exactly what integration costs have been included in the Indigenous wind scenario, and how there were assessed. The Applicant seems to have derived the cost of wind from the most recent tender. In Appendix 6.02, it explains that a significant portion of the cost of integrating wind is related to the fact that most wind generation developers have opted for NSPI's ERIS (non-firm) interconnection services, and therefore do not invest in the transmission

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[52] NERC Standard BAL-002 indicates that entities requiring regulation service must have backup plans in case of the loss of that service (NSPML (CanWEA) IR-110.2).

[53] NSPML (EAC) IR-8c.

upgrades that would enhance grid operation. However, most of the projects submitted to the last tender in Nova Scotia did in fact request NRIS service (as evidenced by the interconnection queue at the time). Furthermore, the winning project (the costs of which apparently form the basis for the Applicant's wind cost model) did in fact request NRIS service. Thus, the expected cost of future wind power has already included this additional integration cost. Without a clear accounting of the wind integration costs used as inputs to Strategist, it is impossible to exclude the possibility of double-counting.

Finally, the Applicant's wind integration analysis lacks depth on a number of fronts. For instance, the analysis of minimum unit commitment is based on a 48-hour period of existing wind production scaled up to 785 MW. The analysis does not provide any detail of the frequency of these occurrences, nor does it analyze how improved wind and production forecasting could significantly reduce the required unit commitment described in this section. Additionally the study ignores the rapid down-ramp capability of wind generation, overestimating the frequency of events that could not be managed in this way.

4.4. Conditionality of RES requirements

According to s. 6A (1) of the Renewable Electricity Regulations, as amended by Regulation 11/2013 (Jan. 17, 2013), as of 2020, "each load-serving entity must supply its customers with renewable electricity in an amount equal to or greater than 40% of the total amount of electricity supplied to its customers as measured at the customers' meters for that year."

S. 6a (2) goes on to state that:

> **(2)** NSPI must meet the renewable electricity standard in subsection (1) by
>
> (a) continuing to meet the requirements in clauses 6(2)(a) and (b);
>
> (b) continuing to meet the requirements of subsection 6(4); and
>
> (c) directly or indirectly acquiring, to deliver to customers in the Province, 20% of the electricity generated by the Muskrat Falls Generating Station if the Muskrat Falls Generating Station and associated transmission infrastructure is completed and in normal operation and the UARB has approved an assessment against NSPI under the *Maritime Link Act* and its regulations.

CanWEA asked NSPML to explain how it would comply with the RES provisions in the event that, for whatever reason, MF and its associated infrastructure was not in operation by 2020. It responded that "NS Power interprets the requirement for Muskrat Falls energy to be contingent on Muskrat Falls and the Maritime Link being operational and approved, in accordance with [s. 6A (2) (c) of] the Renewable Electricity Regulations."[54]

NSPML thus appears to interpret s. 6A (2) (c) to mean that NSPI will remain exempt from the RES requirement unless and until the Muskrat Falls Generating Station and associated transmission infrastructure (including the Maritime Link) are in service.

By my reading of s. 6A (2) (c) (and I am not a lawyer), the conditionality with respect to the Muskrat Falls project does not affect the obligation to meet the requirements of 6A (1), i.e. to meet the RES of 40% starting in 2020, but rather to how that obligation is to be met. In other

[54] NSPML (CanWEA) IR-108

words, if MF is not in service, NSPI is relieved of the obligation to meet the RES with Muskrat Falls power, but not of the obligation to meet the RES.

The Applicant has stated: "There is no expectation that Muskrat Falls or the other projects will be delayed to 2020. NS Power has consistently reiterated that the company will meet its legal obligations."[55] However, nowhere in the evidence filed by NSPML have I identified a "Plan B" to meet the RES until such time as Muskrat Falls power is available over the Maritime Link. In the hopefully unlikely but nevertheless possible circumstance where this power is not available by 2020, it seems that NSPML's only alternative would be non-compliance with the RES.

Earlier, NSPML suggested that the obligation to comply with the RES is absolute:[56]

> **As has been confirmed in prior decisions of the UARB, NS Power has a legal obligation to meet the renewable energy requirements. While there are penalties provided by law for failure to comply, this is not a question of cost, but a mater of complying with the law.**

In this context, making compliance dependant on actions in other companies and governments over which neither NSPML nor its parent have any control is a questionable choice.

Furthermore, as discussed above in section 4.1, NSPML's reliance to meet the RES on levels of surplus energy from Newfoundland that will in all likelihood not in fact be available means that, even in the best of circumstances, there is a strong likelihood of non-compliance later on, even if the Maritime Link and the other components of the Muskrat Falls project are all completed on schedule.

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[55] NSPML (CanWEA) IR-113.2

[56] NSPML (NSUARB) IR-71 (c)

NSPI has demonstrated, in the past, serious concern about not meeting the RES requirements and has covered this risk through its procurement policy. For instance, in the Power Purchase Agreement (PPA) approved by the Board for the 2012 RFP, NSP and the Renewable Energy Administrator required that renewable projects providing energy to NSPI in order to meet the RES would financially compensate NSPI for any replacement energy required by NSP that the projects failed to deliver. Given the heavy reliance on the Maritime Link and Muskrat Falls project to meet the RES, it would be appropriate for similar financial penalties to be in place if the RES is not met through this project, with the burden borne by shareholders, not ratepayers.

5. Alternate scenarios

Given the very limited time and budgets available for this proceeding, it has not been possible to prepare detailed alternate scenarios. In any event, given the reliance of the Application on the proprietary Strategist software, together with the extreme difficulty of working with the TXT outputs provided, it would not have been possible to provide alternate scenarios with an equivalent level of detail.

That said, the analysis presented above indicates the broad outlines of the type of scenarios that would need to be studied in detail before the Review Board could come to a reasoned conclusion that the Maritime Link Project represents the least-cost long-term alternative for Nova Scotia ratepayers.

This section will describe the scenarios that, at a minimum, require in-depth analysis.

5.1. Correction for availability of NL surplus energy

As discussed above, all scenarios should be re-run with NL surplus energy limited to the volumes that Nalcor forecasts will remain from Muskrat Falls after Newfoundland's needs are met. The supposition that Nalcor will develop other energy sources and make them available to NSPI remains entirely speculative, and should be disregarded.

5.2. Correction for missing low load forecast

As noted above, the so-called Low Load Forecast is in reality a medium load forecast. All scenarios should also be run with a true low load forecast, in order to understand the consequences should load growth in Nova Scotia be less than that forecast in the reference forecast.

5.3. "Worst case" scenarios

NSPML indicates that it did not see a need to explore high and low power sensitivity cases against the low load forecast. It states:[57]

> It is not practical to include every sensitivity on every scenario in robustness testing. Robustness sensitivities showed that varying load did not change the preferred option and varying prices did not change the preferred option.

Thus, the Applicant has presented no evidence to the Board to suggest that, under a combination of the so-called Low Load forecast (which, as discussed above, is in reality NSPI's reference forecast) and high power prices, ML remains the least cost choice. *A fortiori*, this has not been demonstrated for any scenarios involving load growth lower than that shown in NSPI's 2012-GRA load forecast.

The whole purpose of robustness analysis is to avoid surprises. Using the Applicant's "bookends" approach, it is essential that the low end of the load forecast encompass the worst case deemed plausible.

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[57] NSPML (CA/SBA) IR-233.

As for market power prices, current prices and long-term forecasts are at historically low levels. In such a context, the possibility that prices will rebound must be considered. Thorough examination of higher priced scenarios, under a range of load forecasts, including the missing low load growth scenario, is thus essential.

5.4. Corrected Indigenous Wind scenarios

Based on the analysis presented above in section 4.3, it is clear that an Indigenous Wind scenario can meet both Nova Scotia power and energy needs and the RES with considerably less installed wind capacity than described in the Application. As the capital costs of such a scenario would be dramatically lower than those presented for the Indigenous Wind scenario in the Application, complete analysis of such a scenario is required before one could conclude that the proposed ML Project is the least-cost solution.

6. Summary and recommendations

In this section, I will summarize the key findings of the analysis provided above, and formulate a recommendation to the Review Board.

Findings:

- The decision to avoid examining the consequences of a low-growth load forecast, which is masked by calling the reference forecast a Low Load forecast, means that the risks accompanying such a possible future are passed over in silence. Given that the economics of the Application are based on the blending of high-priced Nova Scotia Block power with low-priced Surplus Power, it is likely that, in a low load growth scenario where less Surplus Power is required, the blended rate would be considerably higher.

- The reliance on a superficial long-term DSM outlook, together with the unjustified assumption that incremental DSM gains will suddenly drop by 50% in 2032, further compromises the credibility of the analysis.

- Taking into account Nalcor's projected power needs on the Island of Newfoundland, which constitute the fundamental justification of the Muskrat Falls Generating Station, the additional power available for export to Nova Scotia and beyond is not sufficient to provide the Surplus Power relied on in the Application for more than the first few years. The shortfall exceeds 1.5 TWh/yr by the end of the Planning Period. Furthermore, even the power required to supply the Nova Scotia Block is expected to exceed Muskrat Falls generating capacity before the end of the Agreements.

- The presumption that all surplus Muskrat Falls power will be available to Nova Scotia at the forecast prices is further compromised by a) the possibility that Nalcor could find a long-term purchaser for its surplus in New York or New England, who would be able to pay a premium due to by-passing transmission constraints (as in the Champlain-Hudson Power Express project), RPS eligibility or both, and b) the possibility that Nalcor will devote a substantial portion of its surplus Muskrat Falls power to supplying new mining developments in Labrador, as recently suggested by the NL government.

- The costs associated with adding 500 MW of firm transmission through New Brunswick are not necessarily required, since only 153 MW of firm transmission are available over the Maritime Link. In the event of a firm power purchase agreement with Hydro-Québec or NB Power, their existing long-term reservations could probably be used. Furthermore, the existing infrastructure has an import limit of 300 MW (depending on system constraints), allowing substantial headroom above current average imports of 200 GWh/yr.

- The Applicant's decision to reduce the effective capacity factor of incremental wind to account for curtailment during high wind/low load periods is based on an exaggerated

view of the synchronicity of wind events across the Northeast. Because of the RES, it will remain preferable to export, even at low prices, than to curtail. As a result, the Applicant has substantially underestimated the effective capacity factor of incremental wind.

- Since the amount of incremental wind added in the Indigenous Wind scenario is based on the RES requirements, correcting the capacity factor for incremental wind and taking into account the possibility of RES-eligible imports from New Brunswick (as per the Maritime Link scenarios) means that substantially less incremental wind will be required, resulting in a downward impact on the cost of the Indigenous Wind scenarios.

- The balancing and regulation provisions of the Energy and Capacity Agreement are extremely limited, both in scope (±40 MW for scheduling, and ± 10 MW for regulation) and in quality (all deliveries over 153 MW subject to curtailment). As a result, the benefits for future wind power flowing from the Maritime Link Project are therefore extremely limited, especially when compared to the "crowding out effect". The overall impact of Maritime Link Project on future wind power development in Nova Scotia is therefore expected to be negative.

- The forecast RES compliance of the ML Base Case is based both on the supposition that the forecast amounts of Surplus Energy from Muskrat Falls will be made available to it, and that the energy imported from or via New Brunswick will be RES-eligible. Reducing the NL Surplus Energy energy purchases to the amounts forecasted by Nalcor, RES compliance is achieved only if 100% of New Brunswick imports are RES-eligible.

For all these reasons, the Review Board should not make a finding that the ML Project represents the least-cost long-term alternative unless it has confirmed this conclusion by reviewing, at a minimum, the following scenarios:

- Re-run all scenarios correcting for the amount of NL surplus energy that will remain after Newfoundland needs are met. This is indeed a best-case scenario, as new mining developments in Labrador will reduce available energy even further.

- Re-run scenarios with a true low load forecast.

- Re-run the Indigenous Wind scenarios taking into account a) the availability of several hundred GWh/yr of RES-eligible energy from or via New Brunswick (the same assumption used in the ML scenario), and b) eliminating the capacity factor discount that flows from the Applicant's inappropriate curtailment assumptions.

- Alternatively, re-run the Maritime Link scenarios without the assumption of RES-eligible imports from New Brunswick.

Unless and until such time as these analyses are carried out, with the same rigour as those presented by the Applicant, the Review Board should conclude:

- That the proposed ML Project probably does not represent the least-cost long-term alternative for Nova Scotia ratepayers, and

- That the commitments that constitute the ML Project are not sufficient to ensure respect for the Renewable Energy Standard.

ATTACHMENT A — Qualifications

Cofounder of the Helios Centre, Philip Raphals has extensive experience in many aspects of sustainable energy policy, including least-cost energy planning, 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.

From 1992 to 1994, Mr. Raphals 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.[58] 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 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 appeared as an expert witness on behalf of Grand Riverkeeper Labrador Inc. in the hearings of the Joint Review Panel (JRP) on the Lower Churchill Generation Project, which retained many of his suggestions. He also submitted an expert justification analysis to the Comprehensive Study with respect to the Labrador Island Transmission Link, and presented

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[58] 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).*

testimony to the Newfoundland and Labrador Public Utilities Board in the context of its advisory hearings concerning the Muskrat Falls project.

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 developing the low impact renewable electricity guideline for the Canadian Ecologo programme.

Mr. Raphals has worked with one of the leading proponents of scenario planning, Global Business Network, on several projects. He was part of an expert panel that prepared a long-term scenario analysis for Canada's Nuclear Waste Management Organization, and was part of the strategy team, together with GBN founders Peter Schwartz and James A. Ogilvy, in a scenario planning project with Pemex Distribution.

Mr. Raphals is a frequent expert witness before the Quebec Energy Board (the Régie de l'énergie du Québec). He has been qualified by the Régie de l'énergie as an expert witness with respect to transmission tariffs (FERC), issues related to the integration of wind power, security of supply with respect to hydropower, energy efficiency and avoided costs, and sustainable development criteria.

ATTACHMENT B — CURRICULUM VITAE

"Energy research for a sustainable future"

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PROFESSIONAL EXPERIENCE

1996- **HELIOS Centre, Executive Director (since 2004)**

An independent, non-profit research organization dedicated to the analysis of energy regulatory or investment options and the design of strategies and policies for the sustainable use and development of energy resources. Responsible for management and development of the Helios Centre, direction of its publication Enjeux-ÉNERGIE (2004-2007), and consulting activities.

Selected projects:

- ***Régie de l'énergie:*** Expert testimony on behalf of the Regroupement national des conseils régionaux de l'environnement du Québec (RNCREQ), l'Union de consommateurs, the Fédération des commissions scolaires du Québec, and other groups (including the Groupe de la charge locale), in hearings concerning:
  - Hydro-Québec's transmission tariff (R-3401-98, R-3493-04, R-3605-06; R-3549 phase 2, R-3640-07 and R-3669-08 phase 1; R-3669-08 phase 2 (harmonization with Order 890); R-3738-10);
  - the framework agreement between HQ-Production and HQ-Distribution (R-3622-06),

  - the need for a balancing contract for wind energy (R-3550-04 and R-3648-07),
  - Hydro-Québec's security of supply (concerning its resource plans R-3470-01 and R-3550-04, its interruptible tariffs in R-3518, and its Suroît project in R-3526-04),
  - Hydro-Québec's energy efficiency plan and avoided costs (R-3473, R-3519 and R-3708-09),
  - sustainable development criteria (R-3525-04), and
  - acquisition of power from small hydro developers (R-3410).
- ***CanWEA (Canadian Wind Energy Association):*** *L'impact de l'énergie éolienne sur les tarifs d'Hydro-Québec Distribution* (2013)
- ***Canmet ÉNERGIE:*** Review of regulatory policies relevant to Smart Grid development in Canada's provinces and territories (2012)
- ***Grand Riverkeeper Labrador :*** Comments on the proposed justification for the Lower Churchill Project (2011); Testimony before the Public Utilities Board of Newfoundland and Labrador regarding the Muskrat Falls Reference (2012); Affidavit In support of Federal Court File No. T-2060-11 (judicial review of Joint Panel Report (2012); Comments on the justification of the proposed Labrador-Island Transmission Link (2012)
- ***Natural Resources Defence Council :*** Power supply issues concerning the Champlain Hudson Power Express (2010)
- ***SPG Hydro inc. :*** *Étude de marché sur la filière de l'hydrolienne fluviale. (2008)*
- ***Service d'actions entrepreneuriales Manicouagan :*** Étude sur les coûts de revient de la nouvelle filière de l'hydraulienne fluviale. *(2008)*
- ***Communauté innue d'Ekuanitshit :*** Conseils sur les enjeux énergétiques et économiques du Complexe La Romaine *(2008)*
- ***Groupe Pacific:*** Electric supply options for a new residential community on Montreal Island. *(2008)*
- ***Hydro-Québec / ACDI / Électricité d'Haïti:*** Études sur le potentiel et la mise en œuvre des énergies renouvelables en Haïti
  - Survol des technologies d'énergie renouvelable et technologies d'appoint (2007)
  - Options pour l'intégraiton des énergies renouvelables dans le réseau de Jacmel *(2007)*

- ***Centre local de développement Manicouagan:*** Étude sur les coûts de l'Entente entre le gouvernement du Québec et Alcan *(2007)*
- ***Association québécoise des consommateurs industriels d'électricité:*** Étude sur l'évolution des prix disponibles sur les marchés d'exportation d'Hydro-Québec Production *(2007)*
- ***Latin American Energy Organization (OLADE):*** Competition in Energy Markets: An Analysis of the Relevance of North American Experiences to the Latin American and Caribbean Region. Project leader and principal consultant (with Peter Bradford). Project includes an in-depth review of the impact on restructuring on electricity and natural gas consumers in the U.S. and Canada, with an emphasis on regulatory policy concerning transmission, guidance and oversight of case studies of electricity restructuring experience in Brazil, Chile, Peru and Trinidad and Tobago, and the development of policy guidelines to regulate energy markets in the public interest in Latin America and the Caribbean. *(2003 - 07)*
- ***Law Offices of Scott Hempling*** **(Washington, D.C. law firm specializing in energy regulatory matters):** Senior policy advisor. *(2005-06)*
- ***Hydro-Québec, Direction Réseaux Autonomes:*** Renewable energy potential in off-grid communities *(2005-06)*
- ***National Grid USA: Economic Development and Environmental Imacts of Narragansett Electric's Energy Efficiency Programs:*** Analysis of avoided cost component (for the Goodman Group) *(2006)*
- ***Cree Nations of Nemaska, Waskaganish and Chisasibi:*** Comments on the Justification of the Eastmain -1A/Rupert Diversion Project *(2006)*
- ***Cree Nation of Nemaska:*** Advice concerning wind energy development and community energy planning (*2005-06)*
- ***Canadian Wind Energy Association:*** Submission to the Ontario Power Authority's Supply Mix Consultation (with Hélimax Énergie inc.) *(2005)*
- ***National Roundtable on the Economy and the Environment:*** Background paper on the role of hydropower in a carbon-constrained energy future for Canada *(2005)*
- ***Federal Review Commission, Eastmain 1A/Rupert Hydroelectric Project:*** *Report on the conformity of the Eastmain 1A/Rupert Environmental Impact Study, with respect to project justification (2005)*
- ***Institut d'énergie et de l'environnement de la Francophonie (IEPF):*** Editorial supervision and co-author, *Mettre en Place Une Autorité Nationale Désignée pour le MDP: Pourquoi et Comment?,* presentation at COP-11 in

Montreal; Profiles of the Clean Development Mechanism potential of the developing countries in the Francophonie (with Helios staff). Presentation at COP-10 in Buenos Aires. *(2004)*

- ***Mushkegowuk Council (Ontario):*** Critical review of power supply options (including transmission upgrades) for De Beers' Victor diamond mine (CEAA environmental assessment process). *(2004)*
- ***Pemex – Refinación:*** Co-facilatator with Jay Ogilvy and Napier Collyns of Global Business Network of a strategic planning scenario workshop for the company's management. *(2004)*
- ***Nuclear Waste Management Organization:*** Expert participant in inter-disciplinary scenarios team for long-term management of high-level reactor waste in Canada. *(2003)*
- ***Energy Foundation:*** Proposed eligibility criteria for hydropower in the New York State Renewables Portfolio Standard. *(2003)*
- ***Low Impact Hydropower Institute:*** Principal consultant for pilot project to develop an international green standard for small-scale hydropower, funded by North American Fund for Environmental Cooperation. *(2002-03)*
- ***Commission for Environmental Cooperation:*** Expert reviewer for *Environmental Challenges and Opportunities of the Evolving Continental Electricity Market. (2002)*
- ***Pimicimak Cree Nation:*** Research on hydropower mitigation costs and operations reviews. *(2002)*
- ***Hydro-Québec-Recouvrement/ARC/CACQ/FACEF :*** Review of low-income customer assistance programs in U.S. *(2001)*
- ***International Rivers Network:*** Commissioned book-length study: *Restructured Rivers: Hydropower in the Era of Competitive Markets*. *(2001)*
- ***Low Impact Stakeholders Alliance (Ontario):*** Options paper on environmental rating of electricity; consultations on certification of hydroelectric facilities for green power market. *(2000-01)*
- ***Innu Nation (Labrador):*** Overview of Quebec and U.S. energy policy issues. *(2000)*
- ***Grand Council of the Crees (of Quebec) :*** Orientations for a Cree Energy Policy *(2009)*

  Drafting project justification section of *Draft Directives for the Preparation of the Impact Statement for the Eastmain-1A and Rupert Diversion Project* (for COMEV, the tripartite Evaluating Committee under the JBNQA). *(2003)*

Expert testimony before U.S. Court of Appeal (D.C. Circuit) on role of exports in Hydro-Québec planning; technical analysis for FERC consultation on Regional Transmission Organizations and for the World Commission on Dams. *(1999)*

Assistance in preparation of technical affidavits submitted to the Federal Energy Regulatory Commission concerning the application by Hydro-Québec U.S. Inc. for energy marketer status. *(1997)*

- ***HéliMax Inc. :*** Report on the Implications of the Kyoto Protocol for Renewable Energy Projects in Developing Countries (1999)
- ***World Bank:*** Critical review of French translation of *Environmental Assessment Sourcebook,* chapter on economic analysis of projects and policies. (*1999*)
- ***Option consommateurs :*** Study on traditional and incentive ratemaking approaches in electricity regulation (1998)

  Study on electricity market restructuring options and rate impacts. *(1997)*
- ***Standing Committee on the Economy and Labour, National Assembly of Quebec:***

  Analysis of Hydro-Québec's Strategic Plan 2000-2004. *(2000)*

  Analysis of Hydro-Québec's Strategic Plan in relation to the Committee's June 1997 recommendations; drafting of questions. *(1998)*

  Expert assistance in oversight hearings concerning Hydro-Québec, especially with respect to market restructuring and energy efficiency, including drafting introductory texts, seminars with committee members, drafting report. *(1997)*
- ***Rivers Canada :*** Preliminary study on the implications of the restructuring of electricity markets in North America for the preservation of Canada's rivers. *(1997)*
- ***Quebec Forestries Industries Association:*** Workshop on electricity market restructuring and competition, and their impacts on Quebec electricity rates, energy efficiency and biomass generation. *(1997)*
- ***Averyt and Associates (for Green Mountain Power) :*** Report on Native issues in the context of Quebec energy policy. *(1996)*
- ***Ad hoc working group of American and Canadian environmental groups :*** Design of legislative mechanisms to reduce the environmental impacts of electricity restructuring. *(1996)*

1995- **Independent energy analyst**

Environnement Jeunesse *(1996-97)*
Representative at the *Commission of inquiry into Hydro-Québec's purchase policy for private producers.*

Université de Montréal *(1995)*
Coordination of a lecture series on *Energy and ressources at the dawn of the 21st century.* Lectures by David Freeman (then CEO of New York Power Authority), Allen Kupcis (CEO of Ontario Hydro) and Victoria Yegorova (Donetsk Research Institute, Ukraine).

Government of Québec: Natural Resources Department *(1995)*
Study on approach used for the regulation of energy in British Columbia and on the interest of this model for Quebec, published for the Quebec Public Debate on Energy.

Government of Canada: Environment Department *(1995)*
Quebec chapter of a study on the treatment of externalities (social costing methodologies) in Canada, under subcontract from Passmore Associates.

Grand Council of the Crees (of Québec) *(1995-)*

Expert assistance on costs and benefits of different generating technologies, alternative solutions, and methodologies for taking externalities into account in competitive energy markets.

1992-95 **Deputy Scientific Coordinator**
Great Whale Public Review Support Office

- Member of the support staff for the committees and commissions responsible for the assessment of the Great Whale project.
- Responsible for analyses concerning project justification.
- Drafting of preparatory documents and preliminary versions of reports; selection and oversight of consultants.
- Co-author, with James Litchfield and Roy Hemmingway, of a study on integrated resource planning and its application to the project.
- Editor of study on mitigation measures at the La Grande hydroelectric complex.
- Assisted in editing and publishing of 9 other studies on issues related to the project (mercury, dam safety, traditional ecological knowledge, etc.)

- Involved in designing, planning and carrying out all aspects of the public review process.

1987-92 **Freelance science journalist**

- Articles on energy, science and medicine in *Science*, *The New Scientist, The Medical Post* and other specialized publications.

ÉDUCATION

1976 M. Music (performance), Boston University

1974 B.A., *cum laude*, in philosophy, Yale University. Minor in biological sciences.

LANGUAGES

- **English, French and Spanish** (written and spoken fluently)
  Familiarity with **German and Italian**

CONFERENCES

Greenhouse gas emissions and hydropower. 13th Annual Waterkeeper Alliance Conference, Northwestern University, Evanston, Illinois, June 24, 2011.

Invited testimony, Senate Standing Committee on Energy, the Environment and Natural Resources. February 2011.

La filière hydrolienne : Une introduction. AQPER Colloque — Québec: Carrefour des énergies renouvelables octobre 2009.

L'avenir énergétique au Québec et ailleurs : structures institutionnelles et les nouvelles technologies d'énergie verte. Réseau des ingénieurs du Québec, Congrès annuel des ingénieurs, 25 novembre 2008.

Tarification sur la base des coûts, ou des coûts d'opportunité ? Réplique au Groupe de travail sur la tarification des services publics (Groupe Montmarquette), Forum québécois sur l'électricité, 14 mai 2008.

La filière de l'hydraulienne fluviale : un premier regard sur les coûts, Ocean Renewable Energy Group, Spring Symposium, Canada's Ocean Energy Future: New Partnerships and Wider Opportunities, Québec, 21 avril 2008 (à venir).

Les coûts de l'Entente Alcan: un deuxième regard, Conférence sur le développement durable dans l'industrie de l'aluminium (Céddi-AL), Baie-Comeau, Québec, September 20, 2007.

The Restructuring of North American Energy Markets, Seminario regional de OLADE sobre el future de los mercados energéticos en Latinoamérica y el Caribe, Buenos Aires, March 8, 2007.

Des monopoles aux marchés concurrentiels : Implications environnementales de la restructuration des marchés, 3e conférence internationale sur la mise à niveau environnementale : Entreprise et économie d'eau et d'énergie, CITET, Tunis, le 8 décembre 2006.

Technologies émergentes de production d'électricité, AQPER Colloque sur l'énergie éolienne … et autres énergies vertes30 octobre 2006.

politiques européennes sur les énergies renouvelables, l', 9 juin 2006.

L'application conjointe : un outil méconnu mais prometteur, Les énergie traditionnelles, les énergies nouvelles, les énergies de demain », November 4, 2005.

La sécurité énergétique et les sources alternatives de production d'énergie : oui mais à quel prix ? », (Montreal, April 18, 2005).

« Le MDP dans la Francophonie: Fiches d'information sur le potentiel et les opportunités dans les pays de la Francophonie », présentation aux représentants de la Francophonie en marge de 10^{e} Conférence des parties de la Convention sur le climat (Buenos Aires, December 2004).

"Toward an International Green Standard for Small-Scale Hydropower, ," World Renewable Energy Conference, Denver, Colorado (September 2, 2004).

"The Role of Hydropower in Green Power Markets," Ontario Green Power Trade Show, (Toronto, Oct. 2002)

"Creating Value by Working with NGOs," HydroVision (Portland, Oregon, August 2002)

"Quebec Energy Policy," Environmental Law McGill Forum on James Bay and Sustainable Development (Montreal, March 2002)

"Approaches to Green Power Certification," Ontario Green Power Trade Show, (Toronto, Nov. 2001)

Guest Lecturer, Hydropower and Sustainable Energy Policy, Yale School of Forestry and Environmental Sciences, FES 850b (Energy Policy and Environmental Protection, 2001-02)

North American Commission for Environmental Cooperation, Symposium on Understanding the Linkages between Trade and the Environment (discussant). (Washington, D.C., October 2000)

Harvard Electricity Policy Group, Special Session: Retail and Wholesale Transmission Markets: Can They Be Unified? Defining the Issues and the Ramifications (Invited participant) (Washington, D.C., March 19, 1999)

Ontario Low Impact Stakeholders' Alliance, Public Workshop, *Environmental Ranking of Hydropower Facilities in Canada*. (Toronto, May 2000)

Canadian Association of Members of Public Utility Tribunals, annual meeting. Lecture on the implications of electricity deregulation for the evironment. (1997, *Whistler, B.C.)*

National Forum on Markets, Regulation and the Future for Canadian Energy Utilities. Talk on IRP in a competitive market. (1995, *Whistler, B.C.*)

Quebec Public Debate on Energy : presentations on the application of integrated resource planning in the Quebec context and on resource portfolio analysis. (1995, *Montreal*)

COMMITTEES AND BOARDS

2010- Choeur de chambre Tactus, Board of Directors (Chair)

2009-10 Ecologo Advisory Committee, Renewable Low-Impact Electricity

2008 Expert Review Panel, National Centres for Excellence, Centres of Excellence for Commercialization and Research (CECR).

2007-08 Comité d'Experts francophones, Stratégies nationales de développement durable des pays africaines, Délégation au développement durable de la France.

2005 Conseil de la science et de la technologie du Québec, Groupe de travail sur les défis en énergie.

2004-05 Quebec Climate Change Action Centre, Advisory Committee

2003-04 National Roundtable for Energy and the Environment, Ecological Fiscal Reform and Energy Program, Advisory Committee on Energy Efficiency

1999- Low Impact Hydropower Institute, Renewable Advisory Panel (Chair since 2003)

1997- Helios Centre, Board of Directors (Vice President)

1995-98 Working Group on Methodology, Focalisation, Evaluation and Scope of Environmental Impact Assessment (NATO *Committee on Challenges to Modern Society*)

1995-97 Environnement Jeunesse, Board of Directors

PUBLICATIONS

■ ACADEMIC AND TECHNICAL PRESS

P. Dunsky and P. Raphals, Challenges for Effective Competition in Large Hydro-Dominated Markets — The Case of Québec, in Zaccour, Georges (ed.), *Deregulation of Electric Utilities*, (Boston : Kluwer Academic Publishers), 1998

P. Dunsky and P. Raphals, « Pour une fiabilité énergétique accrue — Quelques leçons à tirer de la récente tempête de verglas », in L'Énergie au Québec : Quels sont nos choix? (Montréal : ÉcoSociété, 1998), pp. 85-98.

P. Raphals and P. Dunsky, Ouverture des marchés de l'électricité au Québec — Modèles, impératifs d'une réelle concurrence et implications pour les prix globaux, Option consommateurs, October 1997

M.A. Bouchard and P. Raphals, *Mécanismes et méthodologies d'évaluation d'impacts dans le cadre de la restructuration du marché de l'électricité*, Association québécoise pour l'évaluation des impacts, June 1997

■ TESTIMONY

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 the Government of Newfoundland and Labrador, Department of Environment and Conservation, on behalf of Grand Riverkeeper Labrador Inc., June 12, 2012.

Demande d'approbation du Projet de Lecture à Distance, Phase I d'Hydro-Québec Distribution, Dossier R-3770-2011, *Mémoire* du RNCREQ (with Christian Martel), December 6, 2012.

Testimony before the Public Utilities Board of Newfoundland Labrador on the Muskrat Falls Reference, February 23, 2012.

Affidavit before the Federal Court of Canada concerning the judicial review of the Joint Panel Report on the Lower Churchill Generation Project (Court File No. T-2060-11), February 1, 2012.

Comments on the Justification for the Lower Churchill Generation Project, submitted to the Joint Review Panel for the Lower Churchill Generation Project, on behalf of Grand Riverkeeper Labrador Inc., February 28, 2011.

La politique d'ajouts : L'application du concept de neutralité tarifaire à la Charge Locale (Témoignage expert pour UC, ACEFO, FCEI, UMQ et ACEFQ), R-3738-2010, 15 novembre 2010.

La modification des Tarifs et conditions de TransÉnergie en fonction de l'Ordonnance 890, R-3669-08 phase 2 (témoignage expert pour le RNCREQ et UC), 15 juin 2009 ; v. rév. 23 sept. 2010.

La proposition du Transporteur concernant les Services de compensation des écarts de livraison et de réception, R-3669-08 phase 2 (témoignage expert pour le RNCREQ et UC), 19 juin 2009 ; v. rév. 23 sept. 2010.

Les coûts évités d'Hydro-Québec Distribution, R-3708-09 (témoignage expert pour le RNCREQ), 3 novembre 2009.

La tarification des Services de compensation des écarts de livraison et de réception, Régie de l'énergie du Québec, R-3669-08 (témoignage expert pour le RNCREQ), 4 novembre 2008.

The Fixed Charge in Hydro-Québec Distribution's Domestic Rates, Régie de l'énergie du Québec, R-3677-08 (pour le RNCREQ), 28 octobre 2008.

L'énergie éolienne, l'équilibrage et la demande à la pointe, dans le contexte du contrat patrimonial, Régie de l'énergie du Québec, R-3648-07 (témoignage expert pour le ROEÉ et le RNCREQ), 28 mars 2008.

Reforming the rate structure to better reflect marginal costs : Comments on Hydro-Québec Distribution's 2008 Rate Proposal (Testimony of Jim Lazar, in collaboration with Philip Raphals), Régie de l'énergie du Québec, R-3644-07, October 30, 2007.

P. Raphals, Allocation of transmission costs in Hydro-Québec Distribution's 2008 rate filing, Régie de l'énergie du Québec, R-3644-07, October 30, 2007.

Commentaires sur la demande tarifaire 2008 d'Hydro-Québec TransÉnergie, Régie de l'énergie du Québec, témoignage expert pour le RNCREQ, R-3640-07, 15 octobre 2007 (en anglais).

Commentaires sur l'entente cadre 2006 entre Hydro-Québec Distribution et Hydro-Québec Production, Régie de l'énergie du Québec, R-3622-06, April 18, 2007.

TransÉnergie's *Tarifs et conditions*: comments concerning rates, discounts, interconnection costs and generation imbalance service, Régie de l'énergie du Québec, R-3549 phase 2, Expert testimony, October 18, 2005.

Implications pour Hydro-Québec Distribution de l'ajout des parcs éoliens en Gaspésie, Régie de l'énergie du Québec, R-3550-04, témoignage expert, May 25, 2005.

Témoignage expert sur la demande tarifaire 2005 de TransÉnergie, Régie de l'énergie du Québec, R-3549-04, 22 décembre 2004.

La contribution du projet Suroît à la sécurité des approvisionnements en électricité d'Hydro-Québec Production, Régie de l'énergie du Québec, R-3526-04, 22 avril 2004.

Proposition pour un critère non monétaire relié au développement durable, Régie de l'énergie du Québec, du Québec, Régie de l'énergie du Québec, R-3525-04, 12 août 2004.

Les coûts évités d'Hydro-Québec Distribution, Régie de l'énergie du Québec, R-3519-03, témoignage expert, 15 mars 2004.

Le tarif BT et l'Entente concernant son alimentation, Régie de l'énergie du Québec, R-3492-02, phase 2, pour la Fédération des commissions scolaires du Québec, 22 octobre 2003.

Concernant la demande d'approbation des dispositions tarifaires applicables à une option d'électricité interruptible, Régie de l'énergie du Québec, R-3518-03, 21 novembre 2003.

On Hydro-Québec's Energy Efficiency Plan 2003-2006, Régie de l'énergie du Québec, R-3473-01, February 5, 2003 (expert testimony, with Tim Woolf).

Rapport d'expert concernant les tarifs de court terme de TransÉnergie, Régie de l'énergie du Québec, R-3493-02, 13 septembre 2002.

La sécurité des approvisionnements patrimoniaux dans le cadre du Plan d'approvisionnement, Régie de l'énergie du Québec, R-3470-01, phase 2, témoignage expert, April 23, 2002.

Testimony Concerning Hydro-Québec's Revised Application For The Modification Of Rates For The Transmission Of Electric Power, Quebec Energy Board Régie de l'énergie du Québec, R-3401-98, February 7, 2001 (expert testimony with Peter A. Bradford and Ellis O. Disher).

Critical Review of the Reliability Assessment Prepared for the Régie de l'énergie du Québec, Régie de l'énergie du Québec, R-3416-98, June 7, 2000 (with Robert McCullough).

General Regulatory Principles Concerning the Choice of Test Year and the Identification and Treatment of Non-Regulated Activities, Régie de l'énergie du Québec, R-3405-98, April 9, 1999 (expert testimony with Peter A. Bradford).

L'attribution d'une quote-part à la filière de la petite production hydroélectrique : Principes, méthodes et considérations, Régie de l'énergie du Québec, R-3410-98, March 26, 1999 (with Philippe Dunsky).

Affidavit concerning the role of exports in Hydro-Québec's planning, U.S. Court of Appeals for the District of Columbia Circuit, Docket 98-1280, January 22, 1999.

La sécurité des approvisionnements en énergie au Québec, Régie de l'énergie du Québec, R-3416-98, October 26, 1998.

Analyse de la Proposition d'Hydro-Québec concernant les modalités d'établissement et d'implantation des tarifs de fourniture, Régie de l'énergie du Québec, témoignage expert, R-3398-98, May 5, 1998.

■ REPORTS AND STUDIES

P. Raphals, *L'impact de l'énergie éolienne sur les tarifs d'Hydro-Québec Distribution*, pour Canadian Wind Energy Association (CanWEA), 2012.

P. Raphals et al., La filière de l'hydrolienne fluviale : Étude de marché en Amérique du nord (pour SPG Hydro inc.), septembre 2008.

P. Raphals, La filière de l'hydraulienne fluviale : un premier regard sur les coûts (pour le Service d'actions entrepreneuriales Manicouagan), 7 avril 2008.

P. Raphals, M. Tampier, N. Muszynski, R. Michaud, S. Favre et J. Vianou, Potentiel des énergies renouvelables en Haïti: Survol des technologies d'énergie renouvelable et technologies d'appoint (pour Hydro-Québec), 31 décembre 2007.

P. Raphals, N. Muszynski, R. Michaud, J. Vianou et S. Favre, Potentiel des énergies renouvelables en Haïti: Options pour l'intégration des énergies renouvelables dans le réseau de Jacmel (pour Hydro-Québec), 31 décembre 2007.

P. Raphals. 2007. Les coûts de l'Entente Alcan: un deuxième regard, prepared for the CLD Manicouagan, September 21, 2007, 34 pp.

P. Raphals. 2007. Commentaires sur les prix disponibles sur les marchés d'exportation d'Hydro-Québec Production, prepared for the Association québécoise des consommateurs industriels d'électricité.

P. Raphals. 2006. Comments on the Justification of the Eastmain-1-A / Rupert Diversion Project, prepared for the Cree Nations of Nemaska, Waskaganish and Chisasibi, 49 pp.

P. Raphals, S. Krohn and M. Tampier. 2006. Technologies permettant de réduire l'utilisation du diesel dans les territoires des réseau autonomes d'Hydro-Québec, Prepared for Hydro-Québec, Direction Régionale – Réseaux Autonomes et Planification du réseau. (Montréal: Centre Hélios), 158 pp.

P. Raphals. 2005. Projet Eastmain-1-A / dérivation Rupert : Rapport sur la conformité de l'étude d'impact (volet justification). Prepared for the Federal Review Panel, 40 pp.

P. Raphals. 2005. The Role of Hydropower in a Carbon-Constrained Energy Future for Canada : Briefing paper for the National Roundtable on the Environment and the Economy, 39 pp.

P. Raphals and P. Bradford. 2005. The Evolution of Competitive Energy Markets in North America, for OLADE (Latin American Energy Organization), 115 pp.

P. Raphals. 2004. L'hydroélectricité et les marchés d'énergie verte. *Cahiers de l'énergie,* vol. 1, no. 4. (Centre Hélios), 14 pp.

P. Raphals. 2004. Seeding Green Power: Community Pilot Project To Develop an International Green Standard For Small-Scale Hydropower (Final Report), for Low Impact Hydropower Institute, 47 pp.

P. Raphals. 2002. Comments Concerning Discussion Draft ECP-79, Guideline On Renewable Low-Impact Electricity (Environment Canada Environmental Choice Program (Ecologo), 14 pp.

P. Raphals. 2001. *Restructured Rivers : Hydropower in the Era of Competitive Markets* (Berkeley: International Rivers Network), 115 pp.

P. Raphals. 2001. *Balisage — Services aux ménages à faible revenu* (Montréal : Centre Hélios), for Hydro-Québec-Recouvrement/ARC/CACQ/FACEF, 29 pp.

P. Raphals. 2000. *Options for Environmental Rating of Electricity* (Montréal: Centre Hélios), for Ontario Low Impact Stakeholders' Alliance, 14 pp.

P. Raphals. 2000. *Overview of Energy Policy Issues Relevant to the Proposed Churchill River Complex,* (Montréal : Centre Hélios), 103 pp.

P. Dunsky and P. Raphals. 2000. *Analyse critique du Plan stratégique 2000-2004 de la société Hydro-Québec* (Montréal : Centre Hélios), 63 pp.

P. Raphals. 1999. *Implications of the Kyoto Protocol for Renewable Energy Projects In Developing Countries : Initial Considerations* (Montréal: Centre Hélios), 21 pp. (for Hélimax Énergie inc.).

P. Dunsky and P. Raphals. 1998. *La réglementation des tarifs d'électricité — Discussion des approches traditionnelle et incititatives et de leurs effets sur l'efficacité énergétique* (Montréal : Centre Hélios), 42 pp.

P. Raphals and P. Dunsky. 1998. *Les chiffres derrière le Plan — Analyse des éléments quantitatifs du Plan stratégique 1998-2002 d'Hydro-Québec* (Montréal : Centre Hélios), 47 pp.

P. Dunsky and P. Raphals. 1998. *Plan stratégique 1998-2002 d'Hydro-Québec — Comparaison avec les principales recommandations de la Commission de*

l'économie et du travail, for the Standing Committee on the Economy and Labour (Montréal : Centre Hélios, January 1998), 21 pp.

P. Raphals and P. Dunsky. 1997. *Commentaires sur le projet de Règlement sur la procédure de la Régie de l'énergie* (Montréal : Centre Hélios, December 1997), 22 pp.

P. Raphals. 1997. *Competitive Electric Power Markets : Implications for New Hydroelectric Development in Canada,* for Rivers Canada, November 18, 1997. 18 pp.

P. Raphals and P. Dunsky. 1997. *Ouverture des marché de l'électricité au Québec – Options, impératifs d'une réelle concurrence et conséquences pour les prix.* (Montréal : Options Consommateurs). October 1997, 86 pp.

P. Dunsky and P. Raphals. 1997. *Challenges for Effective Competition in Large-Hydro Dominated Markets : The Case of Québec*. Presented to International Workshop on Deregulatoin of Electric Utilities, Sept. 10, 1997. 16 pp.

P. Dunsky and P. Raphals. 1997. « Concilier l'inconciliable », *Le Devoir (page des Idées)*, July 7, 1997, A-8.

P. Dunsky and P. Raphals. 1997. *L'efficacité énergétique*, pour la Commission de l'économie et du travail de l'Assemblée nationale du Québec, (Montréal : Centre Hélios, March 1997), 28 pp.

P. Raphals. 1997. *La restructuration des marchés de l'électricité,* pour la Commission de l'économie et du travail de l'Assemblée nationale du Québec, (Montréal : Centre Hélios, March 1997), 41 pp.

P. Raphals. 1996. *Mémoire d'Environnement Jeunesse présenté à la Commission d'enquête sur la politique d'achat par Hydro-Québec d'électricité auprès de producteurs privés* (January 30, 1996), 90 pp. plus appendices.

P. Raphals and P. Dunsky. 1996. *La réglementation de l'énergie au Québec : Commentaires sur le projet de loi sur la Régie de l'énergie* (Montréal : Centre Hélios, 1996), 52 pp.

P. Raphals and P. Dunsky. 1996. *Propositions du Centre Hélios concernant l'avant-projet de loi sur la Régie de l'énergie* (Montréal : Centre Hélios, 1996), 13 pp.

P. Dunsky and P. Raphals. 1996. *Quelques réflexions au sujet des dispositions de la future Régie de l'énergie du Québec* (Montréal : Centre Hélios, 1996), 21 pp.

P. Dunsky and P. Raphals. 1996. *Avis au Ministre d'État des Ressources naturelles concernant la proposition tarifaire 1996 d'Hydro-Québec* (Montréal : Centre Hélios, 1996), 15 pp.

P. Raphals. 1995. "Effectiveness of Environmental Assessment in Canada: Acceptability and Optimality Paradigms," in NATO/CCMS Pilot Study on Methodology, Focalisation, Evaluation and Scope of Environmental Impact

Assessment, Report on Eighth Workshop, Kusadasi (Turquie), April 26-30, 1995, pp. 1-9.

P. Raphals. 1995. *Energy in Québec : planning and regulation.* Brief submitted to the Quebec Public Debate on Energy, 67 pp. *(also published in French)*

P. Raphals. 1995. *Energy in British Colombia: Integrated resource planning and regulation,* Report prepared for the Quebec Natural Resources Department, 98 pp. *(also published in French)*

P. Raphals. 1995. "Evaluation of the Public Participation Process in Environmental Impact Assessment (Canada)," in NATO/CCMS Pilot Study on Methodology, Focalisation, Evaluation and Scope of Environmental Impact Assessment, troisième rapport, July 1995, pp. 21-31.

P. Raphals. 1995. *Economic aspects of hydroelectricity in Quebec: Costs and risks.* Prepared for the Grand Council of the Crees (of Québec). 34pp. *(also published in French)*

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)*

■ ARTICLES

P. Raphals. 2005. "Le boom de l'éolien au Québec," *L'Annuaire du Québec 2006,* pp. 230-235.

P. Raphals. 2000. "Comprehensive Review on Dams Urges Consultation," *Energy Analects,* November 27, 2000.

P. Raphals. 2000. "Power Industry Changes Spur Debate at Conference," *Energy Analects,* June 26, 2000.

P. Raphals. 2000. "Energy Policy Shift Providing Advantages To Hydro-Quebec," *Energy Analects,* May 29, 2000.

P. Raphals. 2000. "Power from the people" (analysis of Quebec Bill 116), *The Montreal Gazette,* May 24, 2000.

P. Dunsky and P. Raphals. 1998. « L'après-tempête de verglas — Pour minimiser les risques à l'avenir », *Le Devoir*, page des Idées, January 1998.

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P. Dunsky and P. Raphals. 1997. « Énergie au Québec — Concilier l'inconciliable », *Le Devoir*, page des idées, July 7, 1997.

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P. Raphals. 1992. "The Hidden Cost of Canada's Cheap Power," *New Scientist,* vol. 133, no. 1808, February 15, 1992, pp. 50-54.

OTHER ACTIVITIES

Professional cellist

Choral singing (amateur)

Recreational soccer