February 29th 2012

Ms. Cheryl Blundon, Board Secretary
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ATTENTION: MS. CHERYL BLUNDON

Dear Ms. Blundon:

Please find enclosed, a report on the Nalcor Submission to the Public Utilities Board.

Introduction

This is a report analyzing Nalcor's (N) approach to present value analysis and demand analysis. The purpose of this report is to disaggregate and analyze the costs of delivered Muskrat output, disaggregated from the addition costs that Nalcor imposes on both isolated and interconnected analysis.

Once the stripped-down present value (PV) of delivered output is determined at various interest rates, the analysis adds back the 'rate of return base' in order to give an indication of the true disaggregated cost of delivered Muskrat output.

The present value analysis in this report is carried out applying the formula, methodology and tables found in *Contemporary Engineering Economics* (A Canadian Perspective) Addison-Westley (Ontario) 1995, the standard textbook used in the Department of Engineering at Memorial University of Newfoundland, where the author taught engineering economics from 1988-1995.

Introduction: Nalcor's flawed methodology

It is unfortunate that the Nalcor analysis proceeded the way it did – in building two complicated and unrealizable scenarios. In doing so, Nalcor merely obfuscated the essential determinants. The analysis herein is an attempt to show what a present-value (PV) analysis should have looked like[1]. The analysis herein is aimed at determining, using Nalcor's revealed data, whether Muskrat is a viable investment.

[1] Nalcor exhibit 99 is not a conventional PV or CPW analysis.

What Nalcor did, in creating an interconnected scenario, was to use numerous non-Muskrat elements (Muskrat + excess CCCT production + O&M + rate of return base). What Nalcor did in creating the isolated scenario was to assume massive new demand increases thereby necessitating numerous non-essential elements: (CCCT + wind + O&M + rate of return base).

This method makes it difficult to isolate the true cost of delivered Muskrat output. As such, it is difficult to determine the cost per unit necessary to support only the minimum engineering-construction requirements to deliver Muskrat output.

While it is true that all costs (construction + O&M + rate of return base) are necessary to make an investment decision, it is important to know whether Muskrat is a viable economic choice on economic grounds alone. Once that fact is understood, the rate of return base is added, to see if the decision changes, from viable to unviable, because of any particular changeable element such as rate of return base.

The determination of whether to carry out the Muskrat investment should be done on an analysis which, firstly, deals only with the cost per unit of delivering Muskrat output. If that cost per unit is excessive, there is no need to obfuscate the analysis by creating a fantastic isolated-island increasing demand scenario with countless new CCCT investments.

The inherent weakness of the way in which Nalcor proceeded is that the Muskrat investment decision was never assessed on logical economic elements, rather it was dealt with on the basis of a gross $6B decision against a gross $8B decision. It was clearly inferred that one or the other decision was absolutely necessary, and that the status quo was not an option.

The fact of the matter is that neither of the scenarios was built so as to allow reasonable economic analysis of the Muskrat decision.

The isolated island scenario was constructed by Nalcor, with ever-increasing demand and ever more numerous CCCT investments, for the opaque purpose of making sure that the Muskrat decision was <u>not</u> compared to a simple status quo with incremental additional supply. If such a status-quo comparison were made, the Muskrat investment was bound to fail. As such, the elaborate isolated scenario was *tactically* necessary for Nalcor to construct. It is *economically* unreasonable and unacceptable. This analysis will attempt to show that proof.

Because Muskrat is an all-or-nothing $3.6B[2], the isolated scenario *had to be constructed* to make it seem that the isolated scenario cost more than Muskrat. This was the central flaw in Nalcor's analysis.

[2] See CA-KPL Nalcor - 126

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It is a flaw that is unacceptable in electricity economics, where *incremental* solutions, to *incremental* demand increases, are readily and economically available. However, this incremental route to production seems to have *governmental*, rather than economic obstacles in its way.

Introduction: What are the possibilities of incremental production in Newfoundland?

Newfoundland Power, in its submission to the Public Utilities Board (2006), makes this logic perfectly clear. Newfoundland Power's position seems clearly at odds with the all-or-nothing Muskrat investment.[3]

> Current forecasts of energy and demand requirements in the province suggest that growth will be slow for the foreseeable future. This fact, combined with the high cost of new generation sources relative to existing sources on the Island of Newfoundland, *indicate that smaller projects may more economically match provincial energy growth. Smaller developments also carry less risk. Very large capital intensive projects relative to the size and future growth could impose significant upward pressures on electricity rates for customers*.Smaller generation facilities can be strategically located, geographically, across the province to enhance reliability and also may provide greater opportunity for local engineering firms,contractors and suppliers to participate and develop expertise as opposed to projects of much larger size. (emphasis added)

The Newfoundland government position seems to be one of prohibiting small-scale generation. The Newfoundland Power submission states:

> In particular, a permanent moratorium on small hydroelectric developments is not warranted at this time and could result in increased future costs to electricity customers. The Energy Plan *should include changes to current regulations that prohibit the development of renewable energy such as small hydroelectric generation*.[4] (emphasis added)

Whatever the status of small-scale generation in 2012, it is beyond the scope of this report. However, if it is true that the government is *restricting* efficient production in order to give Muskrat a monopoly on production, such action does not alter the fact that small-scale production can in fact be undertaken for a tiny fraction of the Muskrat scenario.

[3] Newfoundland Power Inc. *Energy Plan Submission February 28th 2006* p.9: "Current forecasts of energy
[4] Ibid.

This report will suggest, in general terms, what might be the prices per kilowatt hour (KWh) of delivered Muskrat output.

This report identifies the flaws in the Nalcor analysis, the most significant flaws being: (i) the creation of scenarios that merge many different costs so that Muskrat costs cannot be disaggregated; (ii) inadequate construction of the isolated island scenario; and (iii) indequate demand analysis.

Part 1:

1.1 Conventional PV analysis: did Nalcor carry out the present value analysis properly?

N uses a concept called cumulative present worth. Cumulative present worth is one of several project evaluation methods. It is not the appropriate method for this analysis. The reasons why CPW is not the best or even a valid way of comparing these projects will be explained.

What N calls CPW – which is typically called *net present value* analysis in conventional engineering economics - is a method of comparing 2 or more projects where there are different streams of income coming in different time periods and as such the streams cannot easily be compared. CPW allows the income streams to be compared. CPW is a method of comparing 2 or more investments each of which has the effect of producing 'savings' in labour-cost or other input cost, over time. The problem when trying to apply a 'savings' analysis to muskrat is the muskrat problem does not involve a 'savings' problem. [5]

The typical income-stream comparison done in CPW (net present value) analysis is a problem like the following: assuming you can choose to receive $120 payable at a 12 month point or $240 payable at a 24 month point. Observationally they appear to average $10/month. But with any given interest rate applied to the staggered payments, the true present value of the 2 streams of income are different and one will be shown superior given the interest rate applied.

This income stream comparison is the standard project problem wherein CPW is the best and most appropriate technique to apply. CPW is best *because there are expected income streams*.[6]

In the muskrat analysis, *income* streams are *not* being compared. These projects are not being done to *maximize the income stream* derivable from either of the choices. Rather the choice is an entirely different question. The question is: what is the lowest cost way of providing a specific number of megawatts (MW) to the island of Newfoundland.

[5] For a typical 'savings' type analysis see *Contemporary Engineering Economics* (A Canadian Perspective) Addison-Westley (Ontario) 1995 p.227
[6] Or expected streams of known 'savings' to the company.

The question is to compare two *cost-streams* not two income streams. The engineering economic approach is to determine which flow of costs are lowest given the interest rate constraint.

The interest rate is a *constraint* because it is the interest rate which determines the borrowing cost of the money-to-build. *Minimizing* the stream of costs to produce a given megawatt (MW) output, constrained by a given interest rate, is *not* the same thing as *maximizing* a stream of income. In the PV cost analysis there is no stream of income to be maximized. As such it seems that N starts with the wrong appreciation of the question and the calculation to apply to it.

From a review of the submission, N repeatedly speaks to determining the least cost discounted present value. Semantic differences aside however, the actual analysis carried out by N does not seem to be an analysis assessing the present value of a discounted stream of costs.[7] Because the data is not clearly presented, it is difficult to understand whether certain numbers are the discounted present value at 2012 or the raw undiscounted cost at some future date[8]. The equations are not presented. This problem plagues N's analysis throughout.

[7] Exhibt 99 is Nalcor's CPW analysis. it does not resemble the PV analysis carried out in this report. It does not resemble the PV analysis called for by *Contemporary Engineering Economics* (A Canadian Perspective) Addison-Westley (Ontario) 1995

[8] For example, the most important statistic: what is the raw undiscounted construction cost and upon what date can it be modelled to occur in real (undiscounted) time. Assuming the raw undiscounted 2017 construction cost is $2553M, this number does not need to be discounted at all. No CPW or PV analysis need be done to this number to assess Muskrat costs per KWh.

The costs per KWh are

$2553M /824MW

This is approximately $3.1M per MW.

Without complicating the analysis by PV or CPW, the question derives to whether a one-time construction cost of $3.1M is too produce a MW of electricity. Is it more expensive than substitutes? The secondary issue is the carrying cost of this $3.1M per MW over the 8760hr of MW produced per year. Is it more than the market is willing to pay for that extra unit, whatever its cost?

The purpose of this footnote is to indicate that Nalcor has not made its data clear and that CPW and PV are not even necessary to make th emost basic assessments of the project's feasibility.

1.2 Conventional PV analysis: the 55 year analysis period

To be tractable, analysis must have a start date and an end date. If for instance, a project had an *infinite* asset-life, it is possible to do analysis on an *infinite* horizon[9]. This might be the case where a bridge is built to last centuries. The only real issue in the bridge-finance, is the paying of the carrying cost of the debt. The *annual* carrying cost would be allocated over all the *annual* crossings of the bridge. This type of infinite analysis assumes that the lender is prepared to lend building-money on an *infinite* horizon. What occurs in real life is that projects (i.e. muskrat) are constrained on the true asset-life and on the borrowing-term.

N has chosen 55 years as the asset life and the pay-off period. This is an unorthodox choice for analyzing the engineering economics of this hydro project. The normal course is for public utilities (which do not have to worry about short-tem debt) to set 40 years as the life of the asset[10]. There are good reasons to keep the pay-off horizon as short as possible, as will be proven below.

So why has N chosen 55 years and are there problems with that choice? N has chosen 55 years because the annual carrying cost of Muskrat - paid off over a 40 year period (or any period less than 55 years) - would be *too high* to justify the project.

Analyzing the cost of Muskrat is no different conceptually than analyzing the mortgage cost of buying a house. The buyer faces a mortgage and annual carrying costs. if the annual carrying costs are too high for the buyer he cannot buy that particular house and chooses a less expensive house. The financing analysis on buying muskrat is different only in scale. All other elements are *essentailly* [11]the same. The house-buyer and the Muskrat-builder face a time-value of money (interest rate) which dictates the annual carrying cost of borrowing.

N faces a market for electricity where kilowatts are being produced world-wide at approximately $0.04/KWh. Regardless of N's internal desire to develop muskrat, the simple fact is that muskrat is a stream of annual KW/h units which must fully carry the annual carrying charges of the borrowing-to-build monies.

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[9] see *Contemporary Engineering Economics* (A Canadian Perspective) Addison-Westley (Ontario) 1995 p.221.

[10] See for example: Three Gorges Dam(china); New Martinsville dam(West Virginia); even in the case of other large scale energy projects such as nuclear, the analysis period asset life is set at 40 years (Vogtle # 3 and Vogtle #4 - Georgia) Georgia Power and Southern Company; Coal is set at 40 years (Cliffside – North Carolina – Duke Energy); AMPGS – Ohio – AMP Ohio)

[11] Nalcor will find fault with this statement, particularly in their inclusion of '*rate of return base'* in their (table 28) calculations, which they set at approximately 20%. This aspect of utilities-financing, where the utility adds 20% to whatever costs it expends, does not change the central fact that financing Muskrat is not essentially different than taking a mortgage on a house, or replacing a forklift in a warehouse.

1.3 Conventional PV analysis: How Nalcor will cope with excessive carrying charges

N presentation of their ‘CPW’ analysis is problemmatic. It is not conventional[12]. For instance, considering just one statement made by Nalcor:

> Though it escalates evenly over time, the burden on ratepayers in the critical early years is minimized. This is accomplished essentially through the equity investor’s flexibility on timing of its equity return in the early years, relative to that in later years[13].

This statement is deeply problemmatic.

Firstly, who is the ‘*equity investor’*? It is the provincial government. Nalcor is a crown corporation. The ‘equity investor’ is the same taxpayer who is the rate-payer on Nalcor electricity. Any sacrifice of the ‘equity investor’ is the sacrifice of the taxpayer.

Secondly, in engineering-economic project-choice decision-making, there is no such thing as ‘flexibiliy of the equity investor’. This is misleading language for project-choice, where uneconomic decisions are not to be taken, notwithstanding the ‘flexibility of the equity investor’.

What is really being said here is: (i) the electricity units cannot carry the carrying charges of the debt burden; (ii) the project would fail if the standard rate of return requirement were applied to it; (iii) in order to break the engineering-economic requirement that the output units carry the debt burden, Nalcor will make the taxpayer carry the debt burden[14] that the unit-price is supposed to carry.

Thirdly, the cheap early-years electricity units only means that the later years of the project carry an inordinate debt burden. This deferred repayment analysis is carry out below[15] and shows that Nalcor’s discussion on p.42 is flawed and unacceptable.

Fourthly, this p.42 Nalcor statement suggests that taxpayers will be forced to fund a project where the stream of KWh output is *not valuable enough* at market prices to sustain the carrying charges of creating that output in the first place. Kilowatts should not be produced if the market price will not pay for the full cost of production. That is the first principle of engineering economics and the first principle of economics.

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[12] see *Contemporary Engineering Economics*: *a canadian perspective*, Addison-Westley (Ontario) 1995 p.221 example 4.9 shows how a hydro-proect should be analyzed using conventional engineering economics analysis.
[13] Nalcor submission, p.42
[14] By forcing the ‘equity investor’ to accept a return lower than what the opportunty cost of those invested funds would be in the next best investment alternative.
[15] See section 1.10

Monies lent to N have an opportunity cost. They could have been used to pay off the provincial debt for which annual carrying charges outweigh the subsidized loan to Nalcor. By lending to N for a project where the government is planning to forego repayment, the government is saying essentially, that it will borrow at 10% interest and give to N at zero percent interest. Whatever way Nalcor's deferrment comment is interpreted, it is unambiguously wrong in terms of engineering economics.

The longer the period of time over which a project must be paid off, the lower the annual payments. This is as true of Muskrat as it is of any house mortgage. Analysis of shorter payoff periods (such as 40 years) shows that the annual carrying charge and consequently, the KWh price are too high.

The 55 year period is discouraged in engineering economics for reasons *unintentionally* demonstrated in the Nalcor report.

Nalcor must rely upon *assumptions* that absolutely will not be the case as the time into the future is extended. One example is illustrative. Nalcor's isolated island scenario calls for no less than 10 CCCT oil-fired turbines most of which are in the 2040's to 2060's. To appreciate how unreasonable it is, to fix the electricity-production method 55 years in advance, it is merely necessary to consider whether the electricity production method chosen in 1955 is the optimal method chosen in 2012 for electricity generation[16]. The answer is, that electricity-production on small scale in 2067, will be as much more efficient in 2067, at the date of the last CCCT, as 2012 turbines are more efficient than 1955 turbines. This is why engineering economics discourages choosing 55 year time horizons.

N saying that this is their 'determined life' of Muskrat, does not change the fact that by choosing a 55 year pay-off period N's results dramatically *overestimate* in real dollars the production cost in 2067 of isolated island electricity.

1.4 Conventional PV analysis: How does Nalcor actually carry out the net present value analysis?

N states the 'costs' that, it says, are central to its isolated CPW calculation (table 28; p.124). These costs are *not* presented as they would be in a conventional NPV analysis[17]. For a net present value analysis, the actual annual cost, located at the year upon which the costs are expended, needs to be presented. N presents a *version* of costs-per-build, and the year-of-build (table 22; p.106). But these numbers are difficult to place within the context of a NPV analysis.

[16] In wind analysis in the appendix.
[17] See for example a project-choice decision analysis *Contemporary Engineering Economics* (A Canadian Perspective) Addison-Westley (Ontario) 1995 p.227

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The table 22 numbers appear to be raw (2012) estimates of construction costs for years such as 2067. The unreality of making estimates of construction costs based on raw geometric increase from 2012 costs is disturbing in its lack of rigour. It is equivalent to looking at 1955 estimates of construction costs for 2012. Doing NPV analysis in this fashion makes NPV analysis look ridiculous to the reasonable observer.

Presenting, in table 22, such geometrically accelerating costs of construction for the same 170 MW CCCT machine as between 2022 ($282M) and 2067 ($882M) not only implies that a 170MW CCCT machine will *remain* the choice,[18] but that the 400% cost increase is remotely accurate.

There are ways to measure the Muskrat project, in present value terms, which avoid the unnecessary and most certainly inaccurate approach of Nalcor. A simple model of PV analysis is presented herein. The purpose is to demonstate, in general terms, relying on Nalcor's data, what a conventional PV analysis should look like.

1.5 Conventional PV analysis: critique of Nalcor's presentation of data

Returning to the table 22 and table 28 analysis. Table 22 shows costs of approximately $7.4B. There is no indication that these dollar values were discounted by NPV at any particular interest rate. They seem to be simply raw (undiscounted) numbers adding up to $7.4B. *This is not an NPV or 'CPW' analysis*. This is merely presentation of raw estimates as produced by SNC-Lavelin in 2008[19].

1.6 Conventional PV analysis: what is the replacement cost of all Holyrood power?

To constitute NPV analysis, a calculation such as the following is required. Drawing from table 22 data, NPV of building and using the 3rd holyrood unit from 2036 to 2067:

For 3rd unit holyrood replacement (2036):

$NPV = \$492M\ (1/1+r)^{24}$

$NPV = \$492M\ (1/1.1)^{24}$

$NPV = 492(.909)^{24}$

$NPV^{2012} = \$49.9M$

[18] See wind analysis in appendix.
[19] p.39

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This is the NPV of *construction* of the 3rd unit 170MW for holyrood in the year 2036 at an interest rate of 10%.

Next to be added to the NPV analysis would be the NPV of all oil- burning costs from 2036-2066 for the production of MW from this 3rd unit.

The calculation process to determine oil-buring costs is as follows:

We know from Nalcor that the transformation of oil into holyrood electricity is 4,380,000 bbl for all 500MW per year.

We know that 4,380,000bbl at $100/bbl is $438,000,000/year to produce 500MW[20].

So consider a line of costs of $438M/year from 2036 to 2067, discounted at 10%:

PV = $438M (P/A, 10%, 31)

PV= $438M (9.4790)

PV= $4,151M

This is the PV at the year 2036 of <u>all</u> of holyrood oil burning costs (to produce 500MW) for the years 2036 to 2067 at an interest rate of 10% and a 31 year period of operation at $100bbl.

We must now calculate the PV (2012) of $4,151M in 2036. In other words, what is the amount that we have to save today to allow us to have $4,151M in 2036.

$PV^{2012} = \$438M(1/1+r)^{24}$

$PV^{2012} = \$4151M(.909)^{24}$

$PV^{2012} = \$420.4M$

The NPV of replacing *all* of holyrood's 500MW in the year 2036 by building three 170MW CCCT (3 x $49.9M) and then burning *all* the oil necessary from 2036 to 2067 at $100/bbl is thus $420.4M + (3x49.9M) = $570.1M at 10% interest rate.

One third of this amount would be a quick estimate of the NPV of just replacing the 3rd holyrood unit and running that 3rd unit alone from 2036 to 2067.[21]

[20] See table 17 p.48
[21] $NPV(3^{rd}\text{ unit only})^{2012} = \$190M$

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In ordinary language, that means that we can put $570.1M away today at 10% interest and this amount would be sufficicient in 2036 to replace Holyrood oil-fired electricty for the following 31 years from 2036 to 2067.

This is the way a PV analysis is done. All the numbers are presented as well as the textbook from which the formula are drawn and the tables for all PV data. This approach is the approach taught to engineers at Memorial Univeristy School of Engineering[22].

One can see the benefits of this analysis, as opposed to the approach that N took at table 28 (p.124). Instead of breaking out the entire calculation process, N simple states that the ‘CPW’ of fossil fuels is $6,048M . N will say that this is derived from their ‘*strategist*’ software. They may be so. However where a basic-level conventional PV analysis of full holyrood replacement and all oil-burning costs for 500MW from 2036 to 2067 produces a figure of $570M, it brings into question the reliability of N assessment.

Even *tripling* the conventional PV result of $570M produces a PV^{2012} of $1.7B for 1500MW of holyrood power from 2036 to 2067. This assuming N is remotely correct in its demand analysis – that we will *need* 1500 new MW in 2036 or 2067 or any future date - an aspect of N’s report that will be critiqued next.

The point of this PV analysis is to show that Nalcor is wrong in its CPW analysis. It is wrong because, in its effort to make Muskrat cheap by comparson, Nalcor manufactured an absurdly-expensive over-investment in what *will be outdated technology* in all the future years that Nalcor professes to do this investment. It over-priced the present-value of that technology. It over-priced the fossil-fuel necessary to replace holyrood in 2036.

1.7 Conventional PV analysis: determining the annual capital-payoff amount of the Muskrat project.

A critical assessment of N’s submission supporting the Muskrat Falls hydro project commences with the cost of the Muskrat project. This data is presented in table 26 (p.117)

The construction cost of Muskrat is $1616M (table 9, p.39) N conservatively state that the true cost be estimated at $2553M (2017)[23].

[22] The author taught economics in the engineering department at Memorial University in Newfoundland from 1988-1995. The text referred to herein was the departmentally-determined text assigned to engineering economics courses.
[23] Nalcor seems to have given 2 different answers to the question of total costs of delivered power from Muskrat. On p.39, Nalcor puts the figure at $2553M. In answer to Ca-KPL 126, Nalcor puts the figure at $3.6B. Both numbers are evaluated.

N suggests that (without the Nova Scotia connection) Muskrat will be 3/5[24] excess supply, or non-revenue generating.

This N estimate of load growth (i.e. 2/5 of Muskrat MW is absorbed by the island market) is most certainly grossly inaccurate. It is an over-estimate based on the N's assumption of simple smooth geometric increase in demand (table 20, p.51). This estimate is grossly inaccurate. At best N should be estimating *zero* growth in electricity demand consistent with 1990-2010.

On the assumption of zero-growth, all of Muskrat's 2017 production is non-revenue-generating excess supply.

With these critical points put aside, it is now necessary to determine the PV and the annual payments required for capital-retirement of $2553M(2017) in a payoff period of 2017-2067 (50 years) at 8% interest.[25]

Annual equivalent worth[26] (i) = -P(A/P, i, N)

AE (8%) = -2553M (0.0817, 8%, 50)

AE (8%) = $208M

$208M is the annual carrying charge necessary to maintianing the financing on Muskrat debt, regardless whether Muskrat ever produces any power or whether that power is consumed or paid for. This $208M cost must be allocated by N to its customer base notwithstanding that the customer base is not using Muskrat power. The presenting existing 7500 GWh of consumed electricity would be required to carry this debt burden.

Optimally engineering economics requires that the debt-carrying charges be assigned to the units of new-project output, not previously existing units of electricity from other souces. It is necessary to determine if the Muskrat option *can pay for itself*. If the units of output cannot sustain the carrying charges, the project should never be built.

N admits that Muskrat power electricty cannot be sold into the market. N assumes that 2/5 of the electricity can be immediately sold into the market. This is most certainly inaccurate but assuming that it was true for the sake of calculation, those 330MW would be required to carry $208M in debt charges from 2017-2067.

208/330 = $0.63M / MW

$0.63M/MW = $0.63M / 8760 MWh per year

[24] P.41
[25] N's choosen interest rate.p.35 and p.38
[26] *Contemporary Engineering Economics, a Canadian Perspective*, Addison-Westley, Toronto, 1995 p.268

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= $630,000 / 8760 MWh

= $71.91/ MWh

= $71.91/1000 KWh

= $.0719/KWh

As such, the carrying charge attached to each Muskrat KWh would be $0.07.

The total amount repaid to creditors by 2067 would be $10.4B.

Assume now that all of Muskrat power comes into the island market and is absorbed in new market demand. It can readily be seen that the $208M annual carrying charges must be carried by the new 824MW:

$208/824 = $252,427 / MW

$252,427 / 8760MWh

$28.81 / MWh

$0.028 / KWh

As such, the carrying charge attached to each Muskrat KWh would be $0.03 on new market demand.

This is under the assumption that there is a smooth secular and sustained geometric increase in inland demand. If this is correct, and if Nalcor's construction numbers are correct, then Muskrat power would be absorbed into new market demand at $0.03KWh.

However, as will be shown below, it is the demand analysis that is the core flaw in Nalcor's investment decision.

Under the assumption that island demand rather *remains stable* at 7500GWh, 80% of which is already statisfied by sunk-cost island-hydro and therefore not to be replaced by Muskrat hydro; under that assumption the entire $208M annual carrying charge falls on the prresently existing 7,500GWh of used power.

$208 / 7500GWh = $0.027

Thus, the dead-weight burden of ($208M annual debt carrying charges added to whatever the presently-charged KWh cost is for the presently-delivered (7,500GWh) power.

These are the basic stand-alone numbers for Muskrat delivery assuming a $2553M borrowing in 2017 at 8% interest for 50 years.

1.8 Conventional PV analysis: Nalcor's response to CA/KPL-Nalcor 126

It is immediately apparent that the above PV analysis, predictated upon a delivered cost to Soldier's Pond of $2553M, does *not* represent the costs of Muskrat electricity delivered to Soldier's Pond.

In response to consumer question 126, Nalcor states that " the in-service capital cost for Musrat Falls assuming an AFUDC of 8.4% is $3.6B."

It is apparent that when Nalcor states on p.39 that "Labrador Island Transmission costs $2553M" (table 9: p.39), Nalcor meant something other than delivered cost to Soldier's Pond.

Assuming this $3.6B figure actually represents the 2012 PV of full delivered costs to Soldier's Pond, we can now do the annual equivalent analysis to determine annual debt carrying charges:

AE (8.4%) = -3.6B (A/P, i, N)

AE (8.4%) = -3.6B (0.0855, 55years)

AE = 3.6B (0.0855)

AE = $307,800,000

The annual carrying charge for a 3.6B (8.4%) borrowing in 2012 is $307.8M per year.

Nalcor says that provincial electricity demand is 7,500GWh. As stated below (in the demand analysis section), 7,500 GWh. As such the $307,800,000 annual carry charge should be allocated over the 7,500,000 MWh (7,500,000,000 KWh)

307,800,000 / 7,500,000,000 = 307.8 / 75,000

= $0.04 KWh

The carrying charge per KWh of a $307.8M annual debt burden is $0.04 KWh. This is an attempt at the basic core project cost analysis.

1.9 Conventional PV analysis: Nalcor's admission of insufficient demand

Nalcor discusses the fact that there will not be sufficient demand to allocate these costs over the produced units of electricity. Through a round-about discussion on p.41-42, Nalcor indicates that they will defer the debt payments in the early years.

Nalcor does its best to make this sound like a smart idea. It is not a smart idea any more than making minimum payments in the early years of a house mortgage and deferring house-mortgage debt is a good idea for every ordinary home owner. Mortgage payers know implicitly what this means for their ling-term financial welbeing and it is surprising that Nalcor would try this technique.

The other surprising and uneconomic thing that Nalcor does is to forego its internal rate of return. Nalcor suggests that its normal internal rate of return is 12% (p.42 footnote). It uses an 11% IRR on p.42. it then concedes that an 8.4% IRR would be satisfactory.

This is puzzling. Internal rate of return is an engineering economics tool for determining the minimium necessary return on projects for the projects to be chosen[27]. An IRR is not chosen arbitrarily as Nalcor seems to be doing on p.41-42. An IRR is supposed to actually represent the opportunity cost of doing a particular project. The IRR says the following: *if we do not make 12% on this project we should not do it because we have many alternative uses of our money that do produce 12% IRR[28].*

That is the meaning of IRR. That is what IRR is used for in engineering economics, so it is difficult to follow how Nalcor is first seeking a 12% internal rate of return[29] then an 11% internal rate of return[30] and then it will settle for 8.4% [31]and says:

> "this return on equity is consistent with the present day return on equity for Newfoundland Power and is only slightly below the long run projected average for Newfoundland and Labrador electrical utilities." (p.42)

If 8.4% is the minimum IRR of all of Nalcor's projects, why was it making reference to 11% and 12% IRR? If the 11% IRR is the accurate IRR, then Muskrat is not-preferred to alternative investments available to Nalcor. This is the implication of choosing a particular internal rate of return and Nalcor's discussion is unsatisfactory because of what it leaves unstated about the real IRR of Nalcor projects.

The second point about Nalcor's reference to 'return on equity' [32] may be a semantic one. Nalcor speaks about 'return on equity' where the IRR is in fact return on capital invested.

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[27] *Contemporary Engineering Economics, a Canadian Perspective*, Addison-Westley, Toronto, 1995, p.690
[28] Nalcor submission p.42 footnote.
[29] Ibid.
[30] P.42 ,line 6.
[31] p.42, line 13.
[32] P.42, line 15.

It is a more significant and a larger concept. Whereas equity only represents the internal monies Nalcor invests (excluding debt), IRR represents the return on all capital invested (including debt). This may be semantics because Nalcor may be using the phrase 'return on equity' to mean return on all invested capital. However, if it not merely semantics and Nalcor is speaking accurately about return on equity only, then the return on all invested capital is *much lower than 8.4%.*

In other words, again, Nalcor is going ahead with a project that fails the true IRR test. Muskrat is significantly below 8.4% IRR if Nalcor's return on equity alone is 8.4%.

1.10 Conventional PV analysis:deferred repayment of the debt burden

Given' Nalcor's deferring of true prices of electricity forward into the future, it is critical to evaluate the PV of the deferred debt repayment story described by Nalcor on p41-42.

Assuming all project costs are expended between 2012 and 2017, therefore 3.6B has been borrowed and spent by 2017 and debt payments on the $3.6B are required *but deferred to 2030*. No payments are made on debt between 2017 and 2030. The following analysis applies.

The annual debt payments ($307M) are *not* paid in any year between 2017-2030. [33]

FV^{2030} (3.6B, 8.4%, 13 years from 2017-2030)

FV^{2030} (3.6B) = $307M annual payment deferred x 22.00 compounding factor[34]

FV^{2030} (3.6B) = $6754M

Nalcor then has 37 years (2030-2067) within which to payoff its deferred amount ($6.75B).

AE (8.4%) = -6754M (A/P, i, N)

AE (8.4%) = -6754M (A/P, 8.4%, 37 years)

AE (8.4%) = -6754M (0.090)

AE (8.4%) = 608M per year from 2030-2067

Dividing this over 824MW per year

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[34] *Contemporary Engineering Economics, a Canadian Perspective*, Addison-Westley, Toronto, 1995 p.A52 table C-14

608M / 824MW = $737,694MW

Muskrat MW price (2030-2067) = $84.21 per MWh ($0.084 per KWh)

The 2030 carrying charge for deferred price Muskrat KWh is $0.084 per KWh.

This analysis must be understood for what it is. It is the core cost analysis, isolating the critical debt values from the non-essential aspects that Nalcor's analysis includes (i.e. CCCT additions to the interconnected scenario). The analysis presented here is meant to allow independent assessment of the project, abstracting from the unnecessarily confusing[35] way that Nalcor wants the project considered.

Once Nalcor's complicating points are factored in, such as the necessity for the utility to make a 'rate of return' profit on its project, then the 8.4% IRR chosen by Nalcor, has not been correctly chosen by Nalcor. The addition of this complicating factor should weigh *against* Nalcor's acceptance of the project.

1.11 Conventional PV analysis: Why the IRR (8.4%) does not reflect what Nalcor seems to be saying in table 27 (p.121)

In table 27 (p.121) Nalcor seems to suggest that its 'rate of return' is about 20% of its expended costs in table 27. The analysis done here, on this issue of 'rate of return', is done for the purpose of showing that 8.4% must not be the true IRR. The analysis is not meant to replicate the complex detailed methodology of granting Nalcor a 20% return on its cost-spending.
This 20% return, suggested in table 27, may include the cost of borrowing that Nalcor must use ot finance the project. However, the 8.4% figure chosen by Nalcor (p.42) would only just cover the cost of borrowing to finance the project and would *not* seem to include any amount to allow Nalcor a profit on its spending. If Nalcor is to make zero return for the company (thereby paying only the debt-service) then 8.4% seems like a tolerable IRR for that task. However, as seems more likely, Nalcor wishes to build-in a rate of return for itself, above and beyond mere debt-repayment (as suggested by table 27) then the initial 11% IRR as hinted at by Nalcor (p.42) is more in keeping with such a rate of return that allows Nalcor to pay the debt-service and make a profit for itself.[36]

Re-calculating the analysis using a 11% IRR as initialls suggested by Nalcor (p.42) the analysis would look like this:

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[35] By *'unnecessarily confusing'* I mean: (i) creating an interconnected scenario that requires more than Muskrat power in the analysis, but requires numerous staggered date CCCT';s (ii) Nalcor's analysis is built on uneconomic smooth secular geometric progressions in all price indexes: oil, construction cost, and demand.

AE (11%) = -\$3.6B (A/P, 11%, N)

AE (11%) = -\$3.6B (11%, 55years)

AE = \$3.6B (0.1104)

AE = \$397,440,000 (this is the annual carrying charge of \$3.6B at 11% IRR for 55 years)

However, under the detferred payment scenario, there will be no significant payments in early years, which I have modelled at 13 years of no payments. Thus the debt is pushed forward to 2030 to be paid then:

FV^{2030} (3.6B, 11%, 13years from 2017-2030)

FV (3.6B) = \$397M annual payment deferred x 26.2116 compounding factor[37]

FV^{2030} (3.6B) = \$10,417,538,300

Nalcor then has 37 years (2030-2067) within which to payoff its new borrwed amount (\$10.4B).

AE (11%) = -10417M (A/P, i, N)

AE (11%) = -10417M (A/P, 11%, 37 years)

AE (11%) = -10417M (0.1129)

AE (11%) = 1,176M per year from 2030-2067

Dividing this over 824MW per year

\$1176M / 824MW = \$1.427M per MW

\$1,427,000 is divided over 8760 hours = \$163/MWh

\$163 is divided over 1000 KW in each MWh = \$0.16 per KWh

Thus if Nalcor requires an internal rate of return of 11%, in order to be able to pay the debt service and make a return to the company as well, the range of true KWh prices is approximately double the present delivery cost of KWh in Newfoundland. Note that

[37] *Contemporary Engineering Economics, a Canadian Perspective*, Addison-Westley, Toronto, 1995 p.A52 table C-14

operating and maintenance has not been included as that figure cancels out with the status quo.

Nalcor will take issue with all of these figures. If Nalcor quibbles only with the precise numbers coming out of the above analysis they will have missed the point of the exercise.

The point of this exercise is (i) to isolate the true economic costs of delivering KWh from Muskrat; (ii) identify the inadequate aspects of Nalcor's own 'CPW' analysis; (iii) demonstrate that Nalcor has chosen *not* to produce the data that go into the PV formula; (iv) Nalcor has chosen *not* to show how the formula is calculated, presenting rather its final figures and seeking that they be accepted at face value; (v) to demonstrate that Nalcor own admissions[38] seem like fatal admissions when the analysis is re-calculated with such admissions in mind.

The point is that Nalcor's PV analysis and its demonstration of the correctness of (Muskrat) project choice has not been done in a conventional[39] manner. It has not been done in the simplest manner possible. It has not been done in a clear manner. From what Nalcor presents, the project should not be chosen.

Part 2

2.1 Nalcor's demand analysis

N carries out its demand analysis in section 2 calling it 'load forecasting'. The analysis is inadequate. The analysis fails to do a rigourous study of the *key* variable that counts in this analysis, namely population. All of Nalcor's demand analysis is of little relevance next ot their failure to deal with the population issue adequately.

Detailed review of figure 1 (p.15) demonstrates that total demand (2010) is approximately 7500 GWh (7,500,000MWh which translates into 7,500,000MWh/8760hr per year = 856 MW of total annual demand).

The bottom-line from figure 1(p.15) is that there is a total annual demand of 7500GWh (856MW) of electricity which produces 7,500,000MWh of electricity in a year.

[38] (i) the admission of 55 year pay-off period; (ii) the admission of a reduction in internal rate of return, (iii) the admission of deficient demand; (iv) the admission that true costs are \$3.6B rather than \$2552M; (v) the admission of a deferred debt-repayment because of deficient demand;
[39] As per the revealed methodologies of calculation required by *Contemporary Engineering Economics, a Canadian Perspective,* Addison-Westley, Toronto, 1995

The important fact to realize about figure 1 is tht 7500GWh (856MW) of power was the same total demand that the province required in 1990. Demand has been essentially flat for 20 years.

Nalcor states this without understanding why this fact is critical. This zero demand growth (flat load) is the espected result where population has fallen from 577,000[40] to 505,000.

2.2 Nalcor's demand analysis: GDP growth

Nalcor devotes several pages of essential irrelevant discussion to the rosy outlook for GDP growth in the economy and the 'penetration' of electricity into households.

Nalcor misses the important fact about GDP growth in Newfoundland. The important fact about GDP growth in Newfoundland and Labrador is not that GDP growth will require more electricity. The important fact about GDP growth in Newfoundland is that real GDP growth increased by 65% from $11.78B(1990) to 19.47B(2010)[41] all that time using only the *same level of electricity* as at the lower level og GDP.

In other words, Nalcor fails to understand economic growth and electricity demand at the most basic level. 65% increase in GDP growth does *not* produce appreciable increase in electricity demand.

It is conceivable that GDP growth in Newfoundland and Labrador can increase another 65% over the next 20 years and we will still be at 7500GWh of annual electricity demand as in figure 1. It is not only conceivable it is almost certain.

What is unbelievable, in its lack of rigour at the most basic level, is Nalcor's failure to recognize the fact that *falling* population (11% decrease from 1990-2010) means almost certain falling in overall electricity demand over the horizon. Nalcor's own data proves this result and Nalcor refuses to see it and draw the appropriate inference from it.

Newfoundland population grew 11% between 1967-1977. Population growth was zero percent from 1977-1987. Population growth was negative 4% from 1987-1997. Population growth was negative 11% from 1997-2007. Population growth was zero from 2007-2012.

In other words, during the strongest economic growth decade in the recent history of the province, population *declined* by 10%. This fact indicates how valid Nalcor's reliance

[40] Nalcor pexhib 45 p.7 column 10
[41] Statscan cansim table 19; 13-018-x gross domestic product, Newfoundland and Labrador in 2002 real prices;

upon economic growth driving population increases is. It is not valid and Nalcor's demand analysis should be rejected.

Nalcor seems to think that a *constant* population (505,000) with increasing GDP and 'penetration' is sufficient to essentially double electricity demand.

2.3 Nalcor's demand analysis: penetration

Nalcor's pentration data in figure 2(p.17) is equally important from an economist's perspective. It shows that pentration rates fell dramatically as the price of substitutes to electrictity fell. This tendency to substitute out of electricity and into alternatives does not seem to be recognized by Nalcor. They do not mention the down-side for *electricity*-demand, of the relative *rise* in the price of electricity (in periods when oil prices *fell*, relative price of electricity *rose*)[42]

This easy substitution *out of* electricity is a warning signal that Nalcor ignores. Nalcor's report only speaks of the hope that higher oil-prices will induce greater electricity penetration.

The scenario that Nalcor fails to address is the effect upon domestic electricity demand, of uncompetitive KWh prices charged by Nalcor as a result of Muskrat financing. Substitutability away from Nalcor electricity by domestic customers over time will have the effect of contracting the demand curve for Nalcor electricity[43].

That Nalcor, or anyone would suggest that the demand for Nalcor electricity is long-run dramatically inelastic[44] – so as to allow Nalcor to price Muskrat KWh at whatever price it needs to pay for Muskrat annual debt carry charges – misses the evidence in figure 2. When the relative price of Nalcor electricity *rose* – there was significant substitution *away from* Nalcor electricity. Nalcor *assumes* a smooth geometric increase in demand for Nalcor power over the relevant range. However by introducing a dramatic change in a state variable (KWh price) the behavior of agents moves dramatically away from the expensive form of energy. Nalcor finds its demand curve *contracting* and its is unable to finance Muskrat.

[42] See figure 2: 1975-1980; 1996-2002;

[43] Serletis, A., Timilsina, G., *International evidence on aggregate short-run and long-run interfuel substitution*, Energy Economics (2011) 200-216

[44] Ibid.

2.4 Nalcor's demand analysis: housing starts

Nalcor relies on house-starts to generate the new electricity demand its hoping for. This reliance is mis-guided. New housing starts in a falling or stable population will *not* produce a doubling of electricity demand. The entire engine of electricity demand relies fundementally on population growth. Population in Newfoundland is declining on a long-term secular trend. Nalcor's inability to make the correct inferences from its own population statistics (exhibit 45 column 10) indicate a flawed and inadequate approach to demand analysis and a demand analysis that is wrong because of this.

2.5 Public Sector Electric Utility History

The Public Utilities Board and the general public are no doubt of the view that Nalcor is the expert in the field of electricity demand and supply and therefore its opinion should be deferred to.

It is important to place the demand prediction decisions of electricity-providers like Nalcor in context in order to dis-abuse the public utilities board and the general public of the apparent expertise of public-sector electricity-providers such as Nalcor.

2.6 Public Sector Electric Utility History: the legacy of electricity overbuilding

Newfoundland and Labrador is not alone, as a community, thinking about whether a given mega-project is somehow a terrible mistake.

In 1973, in the wake of the oil crisis, the state of Washington and more particularly the Washington Public Power System, predicted a growth in electricity demand of 5% per year[45]. They commenced seven nuclear plant constructions. In 1981, the state was told that, having invested $5B into a single unfinished plant, it would take $23B more to finish just one of the seven plants[46].

Washington Public Power demand analysis of smooth geometric 5% annual demand increase, turned out in reality to be a 65% fall in demand for electricity between 1973 and 1981.[47] This example should hit close to home.

[45] Sovacool B.K. *The intermittency of wind, solar, and renewable electricity generators: technical barrier or rhetorical excuse?* Utilities Policy 17 (2009) p.291.
[46] Ibid., p.292.
[47] Ibid., p.292.

In the United States unlike in Newfoundland, public utilities must raise capital investment through bond issues. Nalcorp doesn't have to deal with that inconvenience. It possesses a stranded island of 243,000 households which are forced to accept its debt decisions.

In Washington in 1981, the Washington Public Power System bond issue defaulted. Washington power simply stopped paying on the loans. Six of the seven nuclear projects were abandoned. All the capital cost was lost. The default was the largest municipal bond default in US history. The debt accumulated at that time is still being paid by the rate-payers held hostage by Washington Public Power System.[48]

The tendency of public utilities to make economically-irrational decisions on megaprojects is not an isolated occurrence. In 1983, Cincinnati gas and electric public utility had the Zimmer nuclear power station 97% completed, when it was determined that the costs was too high and it was instead turned into a coal burning facility – a coal burning facility of course would have initially cost a tiny fraction of the Zimmer nuclear power generator. One irrational decision – to build - was followed by an even more spectacular error – to abandon the 97% investment because 3% remained to finish. Such is the way of megaproject wisdom in public-sector electricity utilities.

Michigan did precisely the same thing with its almost-completed Midland nuclear plant.

Between 1972 and 1984, 115 nuclear power plants were abandoned after $20B had already been sunk.[49]

It is not only American utilities that involve themselves in irrational over-investment in electricity mega-projects.

In 1975 Manitoba electric utility launched the Limestone hydroelectric project 'only to have this pre-built $1.7B project mothballed in 1978 *because there was no demand for the electricity*'[50] that it was to produce. This fact alone should be sufficient in determining the weight to be placed on Manitoba Hydro's endorsement of Nalcor's submission. This is what Manitoba Hydro says about their Limestone investment decision:

> When the cofferdam was completed in 1978, the decision was made to suspend the Limestone project, *based upon a dramatic reduction in the expected demands for electricity*. It wasn't until 1985 that the major construction work started up again[51]. (emphasis added)

[48] Ibid., p.292.
[49] Ibid.
[50] Van Den Hoven, Froschauer, *Limiting regional electricity sector integration and market reform, case studies of france and canada* comparative political studies, Vol. 37 No. 9, November 2004 1079-1103; p.1086
[51] Manitoba Hydro, *Limestone Generating Station*, 11-07, p.1.

BC hydro also halted its entire Two-River (Peace river and Columbia river) dam-building program in 1984 when an '*unplanned surplus'* of 1800 megawatts became evident.

I highlight the erratic over-investment by public-sector electricity utilities to suggest that the rate-paying public needs to sit up and pay attention when their utility starts down this mega-project road. When the investment turns out to be a mistake, it's not a multi-national corporation that will pay the bill, it's the ordinary rate-payer in Newfoundland and Labrador.

Conclusion

In the final analysis, Nalcor implicitly and explicitly seems to operate on the assumption of a smooth, growing demand for electricity. Nalcor seems, in this regard, to approach the investment decision in the same fashion as the utilities described above: without a sophisticated or adequate appreciation of demand.

In reality Nalcor faces a very elastic long-run demand for electricity. Not only is that demand curve apt to disappear at the sign of significantly higher KWh prices, but that demand curve is most certainly in the process of a long-term secular contraction because of population shrinkage.

On the issue of substitutability and the ability of an economy to sustain dramatic increases in GDP , all the while decreasing its demand for energy, consider the following. In 1973, the United States consumed 15B bbl oil per year to produce $1,382B in GDP. In 2011, the United States consumed 6.7B bbl oil per year to produce $14,551B in GDP[52]. Canada's consumption pattern is almost identical. The OECD consumption patterns are almost identical. Newfoundland's consumption pattern is no doubt identical to this. The consumer's reaction to the oil shock was a reaction to the increase in price of oil.

OECD GDP continued to increase by 1000% over the following 30 years. All the while oil consumption to produce that output contracted by 50%. The lesson of substitutability is as applicable to Muskrat electricity as it was it oil. Nalcor will find itself without a rate base over which to cost Muskrat debt.

The fundemental issue, that Nalcor implicitly recognizes, is that there is no new demand for Muskrat power. This analysis was done using only Nalcor's own data in order to show Nalcor's disregard of the appropriate inferences to draw from that data. We did not need to use Nalcor data.

[52] Kesicki, F., *The third oil price surge – What's different this time?* Energy Policy 38 (2010) 1596–1606 figure 4, p.1598.

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The *National energy board* (2009) reference tables indicate that newfoundland electricity useage went from 59 petajoules in 2000 to 51 petajoules in 2009. If the National Energy Board is correct, that is a 20% decline in the decade. Independent sources are thus consistently registering the warning signals about electricity demand.

Nalcor had to ignore all of this and *create* new demand by *assuming* smooth continuous geometric increase in demand. This assumption is rejected by Nalcor's own evidence of electricity demand in Newfoundland in the 1990-2010 period and by the secular decline in population.

Delivered Muskrat output barely makes economic sense upon the favourable assumptions that all the power will be absorbed by new demand. Under *that* favourable scenario the costs of production amount to what is now being delivered without Muskrat development.

A development project should not be undertaken where the costs are only just equal to present costs of production. An investment of this magnitude and risk must only be undertaken where the cost-per unit are dramatically lower than presently existing production and where it is a certainty that there will be new demand.

Neither of the requirements are present in the Muskrat case. Present production is equal to or cheaper than delivered Muskrat output. More importantly, future sources of output are most certainly going to prove cheaper than Muskrat power.

Looking only at the Holyrood output (table 17, p.48), 803GWh were produced in 2010 for $100M fuel cost. That amounts to $0.12 KWh which is expensive.

However, this $0.12 KWh is only on 10% of total island demand (803 GWh /7500 GWh). This is only 91MW of electricity. It is not reasonable to undertake an 800MW project because 91MW are twice as expensive as market. It is more efficient to go on spending $0.12 KWh into the future and replace Holyrood with a source of output other than all-or-nothing 800 MW of Muskrat power.

Because of time constraints, this report does not directly address the Manitoba Report. However, this analyis does address the Manitoba Report by *implication*. The flaws in the Nalcor submission, identified by the herein analysis, were missed or ignored by Manitoba Hydro.

The fact that Manitoba Hydro failed to take issue with these points, indicates that the Manitoba Report is inadequate. As to why Mantioba Hydro missed the demand deficiencies identified by this analysis, for that the reader is directed back to Manitoba Hydro's Limestone megaproject demand-prediction mistake.

The analysis herein is only a basic glimpse at issues that would have been better demonstrated by the fully calibrated analysis of a arms-length professional energy economist with all the necessary data at hand. Such an analysis would be superior to the analysis herein and certainly superior to the presentation of Nalcor or Manitoba Hydro.

However, working only with the limited data available in the Nalcor Submission, the Muskrat investment should be rejected[53].

I trust this is satsifactory.

Yours truly,

Edward Conway

[53] This rejection does not necessarily apply to a scenario where all Muskrat power is sold profitably to Nova Scotia. To be profitable, the full-cost of Muskrat development would have had to be endogenized into the sale-of –power agreement to Nova Scotia, an analysis beyond the scope of this report.

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APPENDIX:

The purpose of this appendix is to illustrate, using wind as a likely source of future energy, why Nalcor was mistaken in: (i) choosing a 55 year pay-off period for assessment; (ii) choosing CCCT technology as the likely production technique in the future; (iii) why is was wrong to multiply today's CCCT cost by 400% to arrive at 2067 production costs; (iv) failing to assess wind as a possible future source of energy which will be prohibited by the existence of Muskrat sunk cost.

Choosing Muskrat now prohibits future choice of more efficient output

The fifty-five year pay-off period was too long a period to try and evaluate the manner in which electricity would be produced into the future. Though Nalcor *tactically* required fifty-five years (to keep annual payments low), the consequence of choosing fifty five years comes when Nalcor becomes a predictor of production technique in future decades. Nalcor chose inordinately expensive CCCT technology as the likely future production technique. Again, this choice may have been tactical. Nalcor may have known perfectly well that production process would be dramatically different – but chose CCCT at 400% increase in costs – in order to manufacture a present value for isolated island power at $8B.

What was equally revealing about Nalcor's assessment of the future production technology was Nalcor's relative silence about wind energy. An assessment of Nalcor's submission on wind energy commences with exhibit 5(i): Nalcor's 25MW wind farm construction estimates. Nalcor's data '*is not available in report form'*. Nalcor gives the same answer for its Fermuse farm (exhibit 5J) and the St. Lawrence wind farm (exhibit 5k). Nalcor provides certain simulation data in exhibit 25 (apparently for use in its 'strategist' model). However, none of these results are conventional wind farm results. None of these results allow an assessment of wind energy cost effectiveness. Nalcor's analysis does confront the positive and negative issues of wind output[54].

If wind proved to be efficient in Newfoundland, Nalcor would be left with the result of having a $6.6B sunk cost which could not be avoided together with a cheaper more efficient and potentially unlimited supply of alternative energy *which cannot be used because of the necessity of paying off the $6.6B sunk costs*.

[54] Rosenbloom E. A Problem with Wind Power (Sept 5, 2006) www.aweo.org

An illustration of Canadian wind production

As an illustration of Canadian wind production, assessment of the Wolfe Island 86 turbine[55] wind farm owned by Transalta (an interprovincial power producer) indicates that this farm, with very poor wind intensity in relation to Newfoundland and Labrador[56], produces 0.62MW per turbine (54MW[57]: 26% capacity).

The Wolfe Island results address the wind-intermittancy[58] critique. Wolfe island produces 30MW of *continuous* energy.

Taking only this data for preliminary comparison to Muskrat, Wolfe Island MW cost:

$86M / 30MW (continuous)[59] = 2.86M per MW.

We know the Muskrat cost:

$2553M / 824MW = $3.03M per MW

This preliminary comparison suggests that Nalcor should not have been so silent about wind production.

Nalcor's silence on wind may be tactical. If wind proved to be cost effective, that would eliminate any further discussion of all-or-nothing 824MW hydro-projects.

What the decision-makers on Nalcor should not ignore, regardless of Nalcor's relative silence, is the unbelievably high rates[60] at which wind is being integrating into North American and European utilities[61] (see exhibit 1).

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[55] Each turbine hase a nameplate output of 2.3 MW and costs approximately $1M per turbine.
[56] See Khan (2003) below
[57] www.sygration – *Ontario generator report, March 28, 2011.* The calculations are for one day only (Mar 28, 2011). The calculation is illustrative.
[58] Sovacool B.K. The intermittency of wind, solar, and renewable electricity generators: technical barrier or rhetorical excuse? *Utilities Policy* 17 (2009) 288-296 see note 45 above.
[59] Wolfe Island actually puts out 54MW of electricity, 30MW continuous. The 24 excess MW make the actual cost per MW significantly less than $2.86M per MW.
[60] Kubiszewski I., Meta-analysis of net energy return for wind power systems, *Renewable Energy*, 35 (2010) 218-225;
Performance evaluation of Jepirachi wind park, 34,*Renewable energy*,2009, 48-52;
intermittency analysis project; impact of intermittent generation on operation of california power grid; *GE Energy Consulting*, July 2007;
the costs and impacts of intermittency, an assessment of the evidence on the costs and impacts of intermittent generation on British electricity network, *technology and policy assessment function of the UK energy research centre*, march 2006
[61] Mulder A., *Do economic instruments matter? Wind turbine investments in the EU(15)*, Energy Economics 30 (2008) 2980–2991 at 2984

Large American utilities have determined the way to carry out analysis for wind integration[62]. Integration has been carried out already. Difficulty of integration is not a valid ground for Nalcor to ignore wind energy.

Newfoundland and Labrador has a historical perspective oriented toward hydroelectricity. What should be an unsurprising fact is that Newfoundland has a fundamentally excellent wind profile for wind power production.[63] (see exhibit 2)

Khan (2003) goes further in table 2 and demonstrates that the wind profile is, everywhere in Newfoundland, more efficient for wind generation than anywhere in North America.

Wind turbines operate at a minimum of class 4 wind.[64] This is the prevailing wind class in most of the United States, where relatively inefficient wind power is already in place. Newfoundland is characterized entirely by class 4 winds and greater. Turbine optimality is apparently at class 7 wind which exists in numerous Newfoundland locations.

Illinois is an illustration that will highlight the deficiency of Nalcor's approach to wind energy (see exhibit 4). The pink areas on the Illinois map represent the minimum class 4 wind needed by wind farms. Compare that to the Khan (2003) wind map of Newfoundland.

The market price for wind in the Unitied States is approximately $0.04[65] (see exhibit 5). The point of this fact is to highlight that wind farm capital-installation costs are likely to be equivalent world-wide. The thing that brings price per KWh down is wind profile. Nalcor sits on the most efficient wind profile in the world according to Khan(2003). Yet there is relative silence from Nalcor on wind as an alternative source of energy.

[62] Characterizing the impact of significant wind generation facilities on bulk power systems operations planning, *XCEL Energy North Case Study*, May 2003,
[63] Khan M.J. Wind energy resource map of Newfoundland, Journal of Renewable Energy 2003.12.015
[64] See exhibit 3
[65] *U.S. Department of Energy 2009 Wind Technologies Market Report (August 2010).*

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Conway Exhibit 1

Table 2

Installed wind power capacity (year-end) in MW for some selected years

	1985	1995	2000	2001	2002	2003	2004	2005
Austria	0	1	54	69	133	343	560	827
Belgium	0	5	14	26	31	67	96	167
Denmark	23	616	2,417	2,556	2,886	3,115	3,124	3,129
Finland	0	6	38	39	43	50	82	82
France	0	4	56	82	133	221	357	723
Germany	0	1,137	6,095	8,754	12,001	14,609	16,629	18,428
Greece	0	27	226	270	287	371	470	491
Ireland	0	6	116	135	190	250	378	494
Italy	0	22	363	664	780	874	1,127	1,635
Luxembourg	0	0	15	15	16	22	35	35
Netherlands	0	280	502	545	784	1,055	1,254	1,224
Portugal	0	8	83	125	190	268	553	1,064
Spain	0	115	2,206	3,397	4,891	5,945	8,220	8,317
Sweden	3	67	209	295	357	399	452	493
UK	0	200	412	427	534	742	811	1,565

Source: IEA/OECD.

Conway Exhibit 2

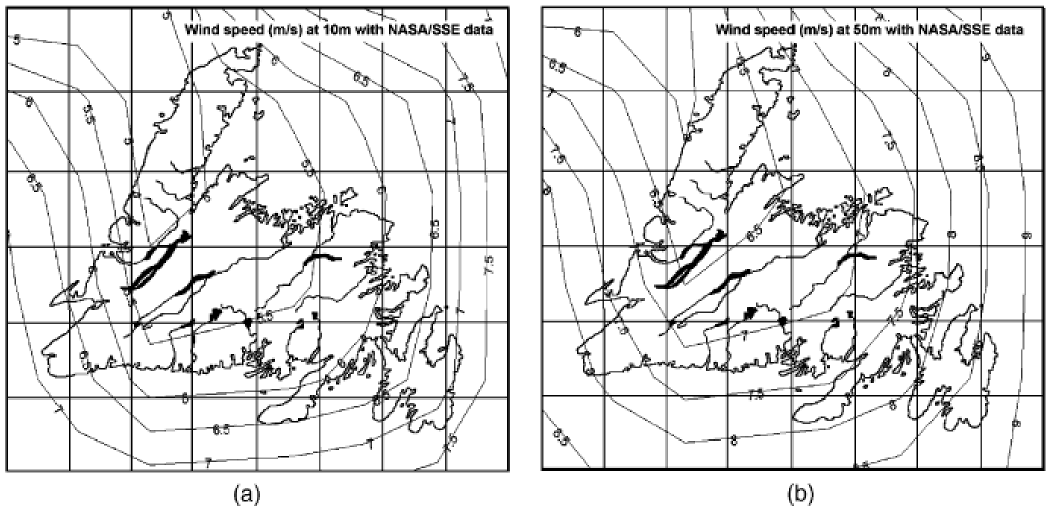

Fig. 4. Wind map (m/s) of Newfoundland using NASA-SSE-data set (a) 10 m height (b) 50 m height.

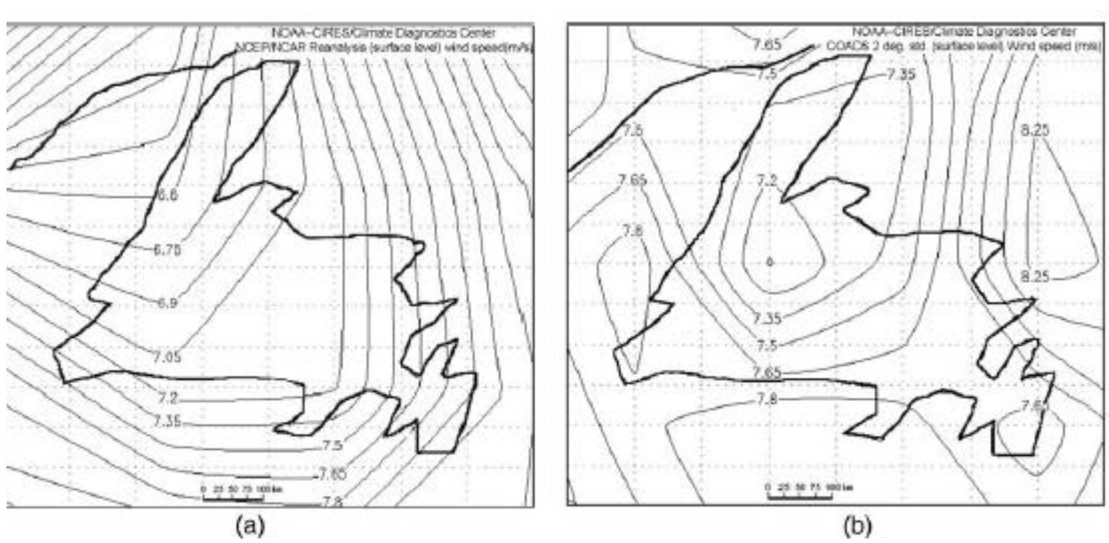

Fig. 5. Wind map of Newfoundland at surface level (m/s) (a) CDC derived NCEP Reanalysis Product averaged over Jan 1948–Aug 2003 (b) COADS (2 deg. standard) data averaged over Jan 1800–Dec 1997.

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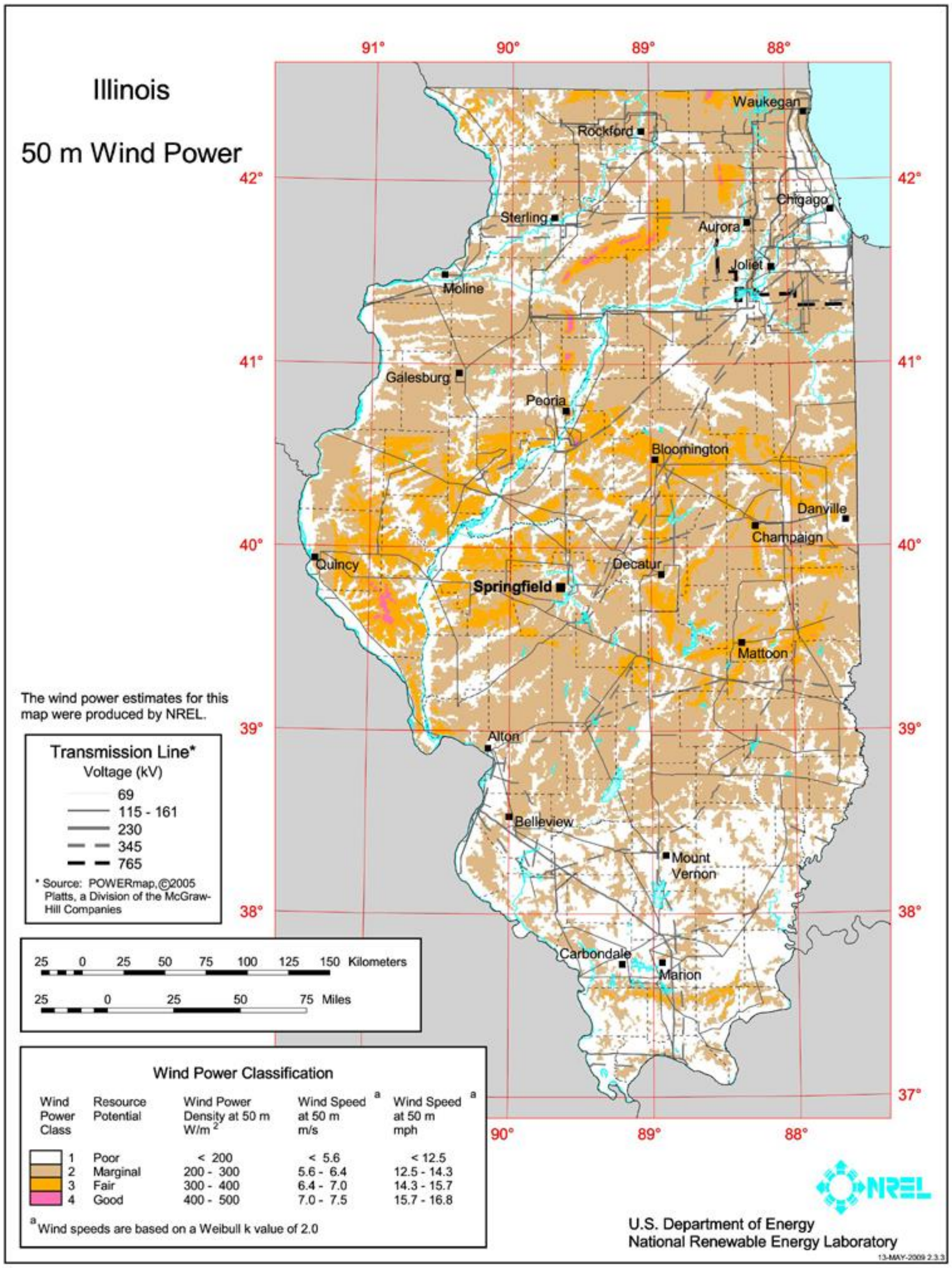
Conway Exhibit 3

Table 2
Wind power classes

Wind power class[a]	Height (10 m)		Height (50 m)	
	Power density (W/m^2)	Wind speed (m/s)	Power density (W/m^2)	Wind speed (m/s)
1	0	0	0	0
2	100	4.4	200	5.6
3	150	5.1	300	6.4
4	200	5.6	400	7.0
5	250	6.0	500	7.5
6	300	6.4	600	8.0
7	400	7.0	800	8.8
	1000	9.4	2000	11.9

[a] Vertical extrapolation of wind speed based on the 1/7 power law.



Conway Exhibit 4 (above)

Conway Exhibit 5 (below)

4. Price, Cost, and Performance Trends

Upward Pressure on Wind Power Prices Continued in 2009

Although some of the cost pressures facing the industry in recent years (e.g., rising materials costs, the weak dollar, turbine and component shortages) have eased somewhat, it will take time before relief flows through the project development pipeline to impact overall average wind power prices. After all, projects built in 2009 may have purchased turbines in 2007 or 2008, and may have established contractual pricing terms at a similar point in time. As such, 2009 was another year of rising wind power prices.

Berkeley Lab collects data on wind power sales prices from the sources listed in the Appendix, resulting in a dataset that consists of price data for 180 wind power projects installed between 1998 and the end of 2009. These projects total 12,813 MW, or 38% of the wind power capacity brought on line in the United States over the 1998-2009 timeframe.[35] The dataset excludes merchant plants and projects that sell renewable energy certificates (RECs) separately. The prices in the dataset therefore reflect the bundled price of electricity and RECs as sold by the project owner under a power purchase agreement. Because these prices are suppressed by the receipt of available state and federal incentives (e.g., the prices reported here would be at least \$20/MWh higher without the PTC / ITC / Treasury Grant), they do not represent wind energy generation *costs*.

Based on these data, the capacity-weighted average power sales price from the sample of post-1997 wind power projects remains relatively low by historical standards, but has been steadily increasing in recent years. Figure 19 shows the cumulative capacity-weighted average wind power price (along with the range of individual project prices falling between the 25th and 75th percentiles) in each calendar year from 1999 through 2009. Based on the limited sample of 7 projects built in 1998 or 1999 and totaling 450 MW, the weighted-average price of wind energy in 1999 was \$65/MWh (expressed in 2009 dollars). By 2009, in contrast, the cumulative sample of projects built from 1998 through 2009 had grown to 180 projects totaling 12,813 MW, with an average price of \$45/MWh (with 50% of individual project prices falling between \$33/MWh and \$53/MWh).[36] Although Figure 19 does show a modest increase in the weighted-average wind power price since 2005, reflecting rising prices from new projects, the cumulative nature of the graphic mutes the degree of increase.

[35] Three primary factors significantly restrict the size of this sample: (1) projects located within ERCOT (in Texas) fall outside of FERC's jurisdiction, and are therefore not required to report prices (reduces sample by about 8,600 MW); (2) the increasing number of utility-owned projects are not included, since these projects do not sell their power on the wholesale market (reduces sample by about 5,300 MW); and (3) the increasing number of merchant (or quasi-merchant) projects that sell power and RECs separately are not included in the sample, because the power price reported by these projects only represents a portion of total revenue received (reduces sample by roughly another 4,200 MW). In addition, certain "qualifying facilities" are not required to report their power sales to FERC.
[36] All wind power pricing data presented in this report exclude the few projects located in Hawaii. Those projects are considered outliers in that they are significantly more expensive to build than projects in the continental United States, and receive a power sales price that is significantly higher-than-normal, in part because it has historically been linked to the price of oil.

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