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→ ARCHIVED - Economic Analysis Lower Churchill Hydroelectric Generation Project

# ARCHIVED - Economic Analysis Lower Churchill Hydroelectric Generation Project

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## 1. Introduction

Nalcor Energy (Nalcor) proposes to construct hydroelectric generating facilities at Muskrat Falls and Gull Island, both located on the Churchill River, approximately 30 and 100 km southwest of Happy Valley-Goose Bay, Labrador respectively. At a combined cost of \$6.4 billion, these facilities are expected to result in a total installed capacity of 3,074 megawatts (MW). Of this, 824 MW are expected from the Muskrat Falls facility and 2,250 MW are anticipated from the Gull Island facility. The proposed project involves the construction and operation of a concrete dam, reservoir and powerhouse at both facilities, as well as the construction of interconnecting transmission lines to connect the facilities with the existing 5,428 MW Churchill Falls Generating Station.

In order to ensure that the environmental assessment for the Lower Churchill Hydroelectric Generation Project satisfied provincial and federal legislative requirements, a Joint Review Panel (the Panel) was appointed by Newfoundland and Labrador and the federal Minister

of Environment. The Panel, which was appointed on January 8, 2009, was mandated to assess the environmental effects of the Project including consideration of the need for and purpose of the Project, as well as alternatives to the Project. The Panel submitted its Joint Review Panel Report (JRP Report) to the two governments on August 25, 2011.

The JRP Report addresses the factors identified in the Panel's terms of reference and sets out the rationale, conclusions and recommendations of the Panel relating to the environmental assessment of the Project. The Panel assessed the environmental effects of the project and their significance, including effects on the atmospheric, aquatic and terrestrial environments, wildlife, land and resource use in general and for aboriginal purposes, culture and heritage, economy, employment and business, family, community life and public services, and effects caused by accidents and malfunctions. The Panel also considered environmental management strategies, cumulative effects, the purpose and need for the Project, feasible alternatives and the capacity of renewable resources to meet the needs of current and future generations.

The Panel determined that the Project would have significant adverse effects in the following areas: fish habitat and fish assemblage in reservoirs; terrestrial, wetland and riparian habitat; the Red Wine Mountain caribou herd; fishing and seal hunting in Lake Melville, should consumption advisories be required; and culture and heritage (the "loss of the river"). The Panel also identified a range of potential economic, social, cultural and biophysical benefits of the Project.

This economic analysis of the Project is meant to help inform decision making under the *Canadian Environmental Assessment Act*. Information from the Panel process, as well as from an independent review of the project conducted by Navigant Consulting Ltd., will inform this report. Recent forecasts of Canadian energy supply and demand will also support this analysis.

## **1.1. Approach to Analysis and Relevant Criteria**

In order to accurately evaluate both the project profitability, as well as the general economic advisability, of the project, it is important to consider the many different criteria that have the potential to impact upon the project. The factors that may influence the degree to which the Lower Churchill project is capable of achieving its objectives are many – for this reason, a "road-map" outlining how this report will proceed, and how all of the pieces of this story fit together, is provided here.

The key economic issue concerns whether the project in its entirety, or the Muskrat Falls or Gull Island components individually, would provide an economic benefit while representing the least-cost option for supplying power to the Island of Newfoundland.

From an analytical perspective, these are two separate questions and they require two different analytical approaches.

The first question the paper will address is Nalcor's assertions surrounding the lowest-cost options for meeting domestic electricity demand in the Island of Newfoundland. To analyse this issue, Nalcor uses a concept called cumulative present worth (CPW), which essentially is a method for comparing costs of alternative supply options. The report will also use this approach.

The analysis will show that while the Gull Island project is directed at export markets, the need for the Muskrat Falls project is very much driven by Nalcor's expectations of future electricity demand growth on the Island. That is, export sales are not the justification for the Muskrat Falls project.

The discussion, therefore, will begin with an examination of the domestic electricity demand outlook, of the key drivers that underpin it and of the risks associated with long-term demand forecasting. In order to assess whether the Project is the lowest cost option for meeting domestic demand needs, this analysis will then focus on the alternatives. For this discussion, it will be important to keep in mind that Nalcor has identified Muskrat Falls (and the Labrador-Island Link) as providing power to the Island. Gull Island is therefore not included in the domestic demand analysis because its power is clearly earmarked for out-of-Province sales. Further, while it is clear that Nalcor intends to export a portion of Muskrat production that is surplus to provincial needs, Nalcor demonstrated in its analysis that Muskrat was the lowest cost option even without the possible benefits of export sales from Muskrat Falls.

The section of the report that looks at alternatives to the project will focus a good deal of attention on specific options for meeting Island demand requirements. In its review, the Panel identified a variety of alternatives to the project that warrant further consideration. The potential for these alternatives to meet domestic demand will be largely dependent on many of the other factors that are discussed throughout this report, including actual demand into the future, and the degree to which these alternatives are combined with each other and/or further initiatives, such as conservation and demand-side management.

This report will outline the alternatives, present the opinions of Nalcor and Navigant on their feasibility and provide an NRCAN commentary and supporting analysis on key issues using the data provided by Nalcor to the Panel.

This analysis will then address the question of whether or not the projects can earn a profit. The analytical approach for addressing this question uses standard project cash flow techniques. This report will describe Nalcor's results as presented to the Panel as well as NRCAN's analysis based on information provided to the Panel by Nalcor.

Finally there will be a very short discussion of the Project's environmental impacts.

Some mention should be made of the limited scope of this analysis compared to the wider implications of the Lower Churchill project. This analysis will focus predominantly on the economics of the project and its ability to meet Island demand at the lowest cost while reducing greenhouse gas emissions within Newfoundland and Labrador. Different options for meeting Island demand requirements will be discussed and compared. However, there was neither the time nor the data to do a thorough economic assessment of all options. Also, the project may be perceived as being nationally important. It will increase the amount of clean power in our national portfolio and is expected to displace the use of power generated by burning fossil fuels, such as the burning of coal in Nova Scotia. While this report will touch on some of this, these larger benefits are beyond the scope of this report.

## **2. Electricity Sector Profile**

### **2.1. The Electricity Industry**

#### **2.1.1. Contribution to Economy**

The electric power industry's contribution to Canada's GDP was 2.2 per cent in 2010. This is a very capital-intensive industry - 91,798 people were directly employed by the industry in 2010 accounting for 0.6 per cent of total Canadian employment while utility investment as a percentage of total investment in the economy was 6.0 per cent in 2010.

The importance of the electricity industry to the economy is not captured, however, through GDP and employment statistics. Electricity is a strategic good, a key input to many industries and an important engine of the economy – the modern economy really cannot function without it. Furthermore, since electricity production and distribution is characterized by significant scale economies and natural monopolistic elements, governments have historically played a significant role in its structure, its development and its goals.

Studies of the development of the electricity industry in Canada indicate that governments in Canada have generally sought to use cheap power to encourage social and economic development. Governments have tried to achieve this policy goal in two ways: firstly, by consolidating the ownership of the electricity generation and distribution industry, governments sought to take advantage of the natural economies of scale and thus ensure that electricity could be produced and distributed at a lower cost; secondly, governments

established pricing policies and mechanisms that ensured lower production costs were passed on to households and industry[1]. It is worth noting in this context the following citation from the Newfoundland and Labrador Energy Plan:

“The Government of Newfoundland and Labrador will maintain least-cost power as the primary objective in electricity rate setting in the province”[2].

### **The Project’s Contribution to the Economy**

The investment phase of the Project represents a cost borne by a Crown corporation, and, by extension, taxpayers, but it could also be an important contributor to jobs and economic activity. According to Nalcor, the Project is expected to cost \$6.4 billion in 2010 dollars: \$2.9 billion for Muskrat Falls and \$3.5 billion for Gull Island. The capital cost comprises \$2.5 billion for labour, \$2.9 billion for materials and \$1.0 billion for equipment. Related tax revenue to the provincial government during the construction period is estimated at \$340 million.

Nalcor estimates that construction activities would enhance provincial income by about \$2.1 billion, of which \$700 million would go to labour and business in Labrador.

The Project is expected to generate nearly 15,600 person-years (10,000 for Gull Island and 5,600 for Muskrat Falls) of direct employment in the province. Most of this would be in Labrador and would be associated with reservoir preparation, construction of the dams, installation of the generation equipment, and construction of the proposed power lines.

Nalcor estimated that 65 per cent of the total direct construction jobs would come from the province while the rest would need to come from elsewhere in Canada and other countries.

Nalcor does not expect that the construction boom would be followed by a significant down-turn in activity. It expects that the additional source of power plus the employment and business experience gained from the project would result in other industrial opportunities in both Labrador and on the Island.

It is important to bear in mind that there are some short-term costs and risks to the economy arising from the investment phase of the Project. Newfoundland and Labrador is undergoing somewhat of a construction boom. The Vale smelter is under construction, the White Rose project is undergoing an expansion and the Hebron field is under development. These projects are putting a strain on the labour market as well as the construction and other service industries. Labour shortages referred to above represent a cost to the project and to the economy as other businesses struggle to compete for skilled



labour and services. Finally, while Nalcor does not expect a significant slow-down after this project, there is a risk that this project plus all the others taking place over the same time period may well lead to a slow-down in the latter half of the decade.

**Table 1: Newfoundland and Labrador**  
**Power Plant Operators**

<b>Power Plant Operator</b>	<b>Share (Percent)</b>
Algonquin Power Corp	0.1
Chi Canada Inc	0.6
Churchill Falls (Labrador) Corp.	70.8
Deer Lake Power	1.8
Hibernia Management and Development	0.7
Nalcor Energy	23.4
Newfoundland Light and Power	2.0
Skypower Corp.	0.4
Vale Inco Lmt.	0.4

Source: Statistics Canada

In the long-term the major economic impact of the project is through export revenues and through providing relatively low-cost electricity to Newfoundland and Labrador. The long-term employment impacts are negligible – Nalcor estimates that there will be a net gain of 80 jobs.

### **2.1.2. Characteristics of Producers**

The electrical industry in Canada is highly concentrated and Newfoundland and Labrador is no exception to that general rule. Three companies provide nearly all generation, transmission and distribution services in the province.

Electricity generation and distribution in Newfoundland and Labrador is provided by Newfoundland Power (NP) and Newfoundland and Labrador Hydro (NL Hydro). These utilities are both regulated by the Board of Commissioners of Public Utilities of Newfoundland and Labrador, which has regulatory authority over rates, policies, capital expenditures and the issue of securities.

NP is a subsidiary of Fortis Inc, which is an investor-owned company. NP is primarily a distribution utility on the island portion of the province, serving 85 per cent of all residential and commercial customers. NP generates approximately 7 per cent of its electricity needs and purchases the remainder from NL Hydro.



NL Hydro is a Crown-owned electric utility and the primary generator of electricity in the province. It also provides distribution services in rural areas of the island and throughout Labrador, and to some of the province's heavy industrial customers. In 2009, 88 per cent of the utility's generating capacity was hydroelectric. NL Hydro's power generating assets include eleven hydroelectric plants (including Churchill Falls), one oil-fired steam turbine plant, four oil/diesel-fired combustion turbine plants, 25 diesel-fired internal combustion plants, and thousands of kilometres of transmission and distribution lines. NL Hydro operates an additional four hydroelectric plants under license from the Government of Newfoundland and Labrador.

In 2007, Nalcor Energy was formed by the Government of Newfoundland and Labrador to act as the parent company to NL Hydro. Nalcor is responsible for the development of the province's energy resources, including the generation and transmission of electricity through NL Hydro.

Table 1 shows power plant operators in the Province and their respective share of the province's power. Note that although CF(L)Co (Churchill Falls (Labrador) Corporation) has the largest share, the majority of its power is directly sold to Hydro-Quebec as per the long-term power purchase agreement signed in the 1960s. CF(L)Co does sell 300 MW annually to NL Hydro for use in Labrador and export sales (referred to as "recall power"). In addition, CF(L)Co sells 225 MW to Twin Falls Power Corporation to service the mining industry in Labrador West.

The Labrador and Island systems are not connected. Indeed, the Island system is isolated and not connected to any other grids.

## **2.2. Electricity Demand Profile**

### **2.2.1. Energy Demand**

Electricity demand is normally analyzed within the context of the demand for all energy forms. That is because energy consumers want the service that energy provides and the different energy forms compete with each other to deliver that service. In other words, energy consumers in the end want energy to heat their homes and buildings or to drive their industrial processes; the different energy forms, such as electricity and oil in the case of Newfoundland and Labrador, often compete to deliver the required energy. Demand for electricity is therefore linked to its price, energy requirements of households and industry and to the prices of competitor fuels.

Since the factors driving the market share of electricity versus other energy forms will be important when considering the future outlook for electricity demand and ultimately for considering the economic justification of the proposed projects, we will examine them in some detail in the discussion below.

Analysts typically evaluate energy and electricity demand from three perspectives: residential, commercial (e.g., shopping centres, office buildings, wholesalers), and industrial (e.g., mining, manufacturing, forestry and construction). Generally, we would also discuss transportation. However, electricity has not been an important energy source for the transportation sector in Newfoundland up to now. Since neither Nalcor nor any other major forecasters are expecting electricity to take on an important role in the transportation sector in the foreseeable future, the discussion will ignore transportation.

In 2009, total electricity consumption in Newfoundland was 10.7 terawatt-hours (TWh), of which 35 per cent was for residential, 21 per cent commercial and 23 per cent industrial; the remaining 21 per cent was accounted for by line losses and electricity used in its own production (referred to as own use). The line loss and own use number is unusually high – it has historically been closer to 1.0 TWh or just 10 per cent of total demand.

**Table 2: Total Electricity Demand**  
**(TWh)**

	<b>1990</b>	<b>2000</b>	<b>2009</b>
<b>Residential</b>	2.8	3.1	3.7
<b>Commercial</b>	1.8	2.0	2.2
<b>Industrial</b>	4.8	4.6	2.5
<b>Line losses &amp; Own use</b>	0.8	1.3	2.3
<b>Total</b>	<b>10.2</b>	<b>11.0</b>	<b>10.7</b>

Source: Statistics Canada 57-003, Report on Energy Supply and Demand in Canada

### **Residential Energy Demand**

Residential energy demand has fallen over the last 20 years. Residential demand drivers are thought to be population, personal disposable income and the housing stock. Between 1990 and 2009, population fell by 0.7 per cent per annum, personal disposable income grew in real terms by 1.7 per cent per annum, and the housing stock also grew by 1.3 per cent per annum.

Table 3 shows that while Newfoundland's total residential energy demand was falling, electricity demand actually grew. Price and technological changes are thought to be the key factors driving this change in market share.

Electricity prices have declined in real terms over the period while heating oil prices have risen – quite dramatically in recent years. Thus, households are switching to electric home heating from oil heat – in 1993, 43 per cent of households had electric space heating but by 2009 the number had risen to 63 per cent[3].

Households are also purchasing electricity-using appliances. The number of households with electric washers and dryers has gone from about 75 per cent in 1993 to about 95 per cent in 2009. Electric dishwashers and freezers have also seen increased penetration of the market –albeit not to the same extent.

**Table 3: Residential Energy Demand (PJ)**

	<b>CAGR[4] 1990 -2009 (Per cent)</b>	<b>Consumption 2009 (PJ)</b>
<b>Distillate Fuel (heating oil)</b>	-4.9	3.4
<b>Liquefied petroleum gases</b>	0.7	0.2
<b>Renewable energy</b>	-1.4	3.2
<b>Electricity</b>	1.6	13.4
<b>Total</b>	<b>-0.7</b>	<b>20.3</b>

Source: Statistics Canada 57-003, Report on Energy Supply and Demand in Canada

### **Commercial Energy Demand**

Commercial sector demand has a cumulative average annual growth rate over the last 20 years of more than 2 per cent. This growth has been driven by rising economic activity in the service sector – 2.2 per cent per annum – and by investment in commercial floor space.[5] Electricity has essentially maintained about a 55 per cent market share over the period from 1990 through 2009.

**Table 4: Commercial Energy Demand (PJ)**

	<b>CAGR 1990 -2009 (Per cent)</b>	<b>Consumption 2009 (PJ)</b>
<b>Distillate Fuel</b>	1.2	4.6
<b>Residual Fuel</b>	7.3	2.3
<b>Liquefied Petroleum Gases</b>	5.8	0.6
<b>Electricity</b>	1.8	9.1
<b>Other</b>	1.9	0.1
<b>Total</b>	<b>2.2</b>	<b>16.8</b>

Source: Statistics Canada 57-003, Report on Energy Supply and Demand in Canada

## Industrial Energy Demand

The industrial sector has seen a large drop in energy demand between 1990 and 2009. This reflects the closing of certain energy intensive manufacturing operations. For example, pulp and paper mills at Stephenville and Grand Falls closed down in recent years as did the paper machine at Corner Brook. Note that this demand in industrial energy use also took place while the offshore oil industry was growing rapidly.

**Table 5: Industrial Energy Demand (PJ)**

	<b>CAGR 1990 -2009 (Per cent)</b>	<b>Consumption 2009 (PJ)</b>
<b>Electricity purchases</b>	-4.3	6.8
<b>Liquefied petroleum gases</b>	2.4	0.3
<b>Refined petroleum products</b>	-1.0	26.1
<b>Coal and coke</b>	1.6	5.1
<b>Own generation – hydro</b>	1.3	1.3
<b>Renewables</b>	0.2	2.8
<b>Total</b>	<b>-1.3</b>	<b>43.1</b>

Source: Statistics Canada 57-003, Report on Energy Supply and Demand in Canada

### **2.2.2. Peak Demand**

According to Navigant, in 2010, the Island electricity system had a peak demand of 1,478 MW and an energy requirement of 7,355 GWh. Peak demand tends to take place in the winter months.

## **2.3. Electricity Supply**

### **2.3.1. Capacity**

The system must have enough capacity in reserve to meet peak load and to cover unexpected breakdowns and maintenance. The desired level of capacity depends on the nature of the electricity supply system. Systems that rely heavily on hydroelectricity often have lower levels of reserve margin requirements because hydro generation facilities are less likely to suffer unscheduled unavailability.

In 2009, developed public and private hydro capacity accounted for 6,782 MW out of total capacity of 7,667 MW. Table 6 shows energy capacity by type. Churchill Falls has been separated out because it will need to be considered separately when examining supply options for the Island.

**Table 6: Newfoundland and Labrador Electricity Generating Capacity 1990 – 2009 (MW)**

	<b>1990</b>	<b>2009</b>
<b>Holyrood (heavy fuel oil)</b>	500	490
<b>Internal combustion (diesel)-</b>		105
<b>Combustion turbines</b>	200	236
<b>Churchill Falls</b>	5,428	5,428
<b>Other Hydro</b>	1,200	1,354
<b>Wind</b>	0	54
<b>Total Capability</b>	<b>7,328</b>	<b>7,667</b>

Source: Statistics Canada 57-206, Electric Power Generating Stations

The island of Newfoundland has a total generating capacity of 2,074 MW. About 35 per cent of the island's electrical capacity comes from thermal-powered generation. The Holyrood Thermal Generating Station, which represents approximately 25 per cent of the island's electrical capacity, burns heavy fuel oil and is a significant emitter of greenhouse gases and other pollutants. It is mostly used in the winter to meet peak demand.

Newfoundland and Labrador's total wind capacity was 54 MW in 2009.

### **2.3.2. Electrical Energy Generation**

Electricity generation in 2009 was at about the same level as it was in 1990.

**Table 7: Newfoundland and Labrador Historical Electricity Generation 1990 – 2009 (TWh)**

	<b>1990</b>	<b>2000</b>	<b>2009</b>
<b>Hydro - Churchill Falls</b>	26.2	31.8	30.5
<b>Other Hydro</b>	8.1	10.0	5.1
<b>Petroleum</b>	2.0	1.0	1.1
<b>Wind</b>	-	-	0.1
<b>Total</b>	<b>36.3</b>	<b>42.8</b>	<b>36.8</b>

Source: Statistics Canada 57-003, Report on Energy Supply and Demand, 57-202, Electric Power Generation, Transmission and Distribution

Churchill Falls produced 33.8 TWh of electricity in 2010, of which 29.0 TWh was exported to Quebec. The remainder is sold to NL Hydro for use in Labrador, for export sales and for the Twin Falls Power Corporation to service the mining industry in Labrador West.

### **2.3.3. Inter-tie Capacities and Trade Patterns**

The Island of Newfoundland is currently isolated from other electrical grids. Newfoundland and Labrador's only interconnection is with Québec (three 735-kilovolt transmission lines). As mentioned earlier, NL Hydro sells 300 MW of recall power to a third-party marketing company for distribution via Quebec to Atlantic Canada.

However, pertinent to the potential for trade from Newfoundland, there is existing capacity for trade through Nova Scotia to New Brunswick and New England. In particular, through Nova Scotia there are connections between:

- Nova Scotia and New Brunswick (with capabilities of 350 MW from NS to NB and 300 MW from NB to NS)[6];
- New Brunswick and Quebec (1000 MW from QC to NB; 720 MW from NB to QC); and
- New Brunswick and New England (1,000 MW from NB to New England; 550 MW from New England to NB).

### **2.3.4. Transmission Technology**

This section provides some background information on existing transmission technologies. The vast majority of transmission lines in North America are alternating current (AC) lines [7]. AC transmission networks are designed to withstand various generator and transmission contingencies under continuously changing load conditions. As such these systems are ideal for transmission over short distances and for distribution.

Where large blocks of power must be transmitted over long distances, direct current (DC) lines are often used. These lines offer the advantage of being able to control the amount of power flowing over each line. Long distance bulk transmission and bulk consumption increases the cost of transmission.

Specific technologies can allow more power to be delivered over a line or to operate the lines more reliably. Some of these technologies can increase the capacity of existing lines, allowing greater trade without requiring new lines. Examples of such technologies include voltage support (capacitors, inductors) or flow control devices that can increase the power carrying capacity of individual transmission lines.

## **3. Electricity Demand – Outlook**

### **3.1. Projected Demand**

All projections are subject to uncertainty. However, long-term projections for future demand are vital to the electricity industry. Governments are expected to ensure there is a reliable supply at low cost. Given the long-lived nature of electricity assets and the long-lead time in bringing those assets into the supply pool, long-term planning is necessary.

From the perspective of the economic justification, the projected demand outlook is very important. The Muskrat Falls portion of the proposed project is tied to anticipated future electricity requirements on the Island of Newfoundland. In particular, Panel recommendation 4.2 focused on the assessment of alternatives to meet future requirements. A key risk in the consideration of alternatives is anticipated future requirements.

This section presents Nalcor's demand outlook for the Island and compares their views with recent outlooks for Newfoundland and Labrador by Natural Resources Canada (NRCan), the National Energy Board (NEB) and Environment Canada (EC). Note that most of these latter outlooks do not provide a separate outlook for the Island.

### **3.1.1. Comparison of projections**

Nalcor uses an econometric model that projects energy demand as a function of population, economic activity, housing and commercial building stock and efficiency gains. The projections for the key economic variables used in Nalcor's analysis are provided by the Department of Finance, Government of Newfoundland and Labrador.

According to Nalcor, the prevalence of electric heat as a primary driver of electricity demand and energy is expected to continue in view of recent and forward looking energy prices which impact equipment and fuel choice decisions for space heating.<sup>[8]</sup> The market share for electric heat is projected by Nalcor to increase from 59 per cent in 2010 to 66 per cent in 2029.<sup>[9]</sup>

According to Navigant other key assumptions to the forecast are:

- Island newsprint mill and oil refinery operations are maintained;
- Teck mine is expected to operate through 2013;
- The Vale nickel processing facility will be connected to the power grid and at full production by 2015; and
- There will be economic spin-offs resulting from the development of the Hebron oil field.

**Table 8: Comparison of Electricity Demand Projections (average annual growth rates, per cent)**



	1990 - 2009	2009 - 2020	2021 - 2030	2031-2064
<b>NRCan</b>	-0.8	2.1	0.7	N/A
<b>NEB</b>		2.1	N/A	N/A
<b>EC</b>		2.8	1.0	N/A
<b>Nalcor</b>		0.9	0.9	0.8

Sources: NRCan, Energy Outlook 2010 (unpublished); EC, Outlook 2011 (unpublished); NEB, Canada's Energy Future 2011; Nalcor, Presentation to Municipalities of Newfoundland and Labrador, May 5, 2011

Table 8 shows that Nalcor's demand projection is lower than other recent forecasts to 2020, but at the top end of the range in the period from 2021 to 2030.

Nalcor projects demand to continue to grow at 0.8 per cent per year beyond 2030. We cannot compare that projection with the other forecasts because they do not go out that far. Nalcor does not provide the source for this expected growth.

For the residential sector, EC expects no growth while NRCan is projecting growth of 0.8 per cent per year. NRCan sees growth driven by rising personal incomes and by electricity's increasing share of residential home heating.

Regarding the commercial sector, NRCan sees electricity demand growing by 0.8 per cent per year to 2030. This growth is driven by continuing growth in the service sector.

In the period to 2020, both NRCan and EC are projecting strong growth in industrial electricity demand. However, these forecasts do not distinguish Island demand from that of Labrador; therefore, it is not clear how much of this industrial demand growth would be for the Island.

Further to this, the following provides a bit more background on the outlook for mining and processing – a key industry and an important electricity consumer.

Growth in Newfoundland and Labrador's mining and mineral processing industry is expected to occur in two areas:

1. the mining of iron ore in Labrador West; and
2. the processing of nickel ore on the Island.

The current iron ore mines are expected to expand production over the next several years in response to growing demand in China. The Wabush iron ore mine is expected to produce 4 million tonnes of iron ore in 2011 and to expand to 5 million tonnes annually over the next 4 to 5 years. The Iron Ore Company of Canada is expanding production in Labrador West. Production is expected to reach 23.3 tonnes by 2013. Labrador Iron Mines Ltd. (LIM) is the most recent company to start production in Labrador. In 2011, LIM is

expected to deliver by rail to Sept-Iles 1 million tonnes of iron ore for shipment to Asia. Production is expected to reach about 2.5 million tonnes in 2012 and 3 million tonnes in 2013.

Several new projects are expected to be commissioned in the future. Tata Steel Ltd. of India, the world's seventh largest steel maker, and New Millennium Iron Corp. (a Canadian publically listed junior company) are expected to bring a major project into production in the near future in Labrador West.

Teck Resources (Canada's largest integrated miner) operates the underground copper-zinc mine at Buchans in central Newfoundland. An exploration program is under way to extend the life of the mine beyond 2014. A feasibility study of the nearby Boundary deposit is continuing.

A major consumer of electricity on the Island of Newfoundland will be Vale's hydrometallurgical smelter at Long Harbour on the Avalon Peninsula. The capital costs for the Long Harbour processing facility are now estimated at US\$2.821 billion. Start-up is still anticipated in the first half of 2013 by Vale.

In light of the above, it would seem likely that after the Vale smelter comes on stream there is no expectation for growth in the mining and processing sector on the Island - the growth in this sector is expected to take place in Labrador.

### **3.1.2. Risks to the Outlook**

The outlooks above are unanimous in calling for steady demand growth over the next 20 years. As with any outlook, there are risks.

On the upside, new offshore oil and gas projects may be developed that lead to more service sector growth than anticipated. Electricity-using technologies may be introduced that drive up electricity use (for example, electric cars, new consumer electronics). New mining on the Island may be found and developed or the pulp and paper industry may make a come back. Some of the above could take place against a back drop of rising prices for commodities such as iron ore, timber, crude oil and natural gas, which would make electricity more competitive. Tougher environmental regulation would also make electricity more attractive as an energy source than its competitors.

On the downside, much of the wealth generation in the last twenty years in Newfoundland and Labrador has come from the offshore oil industry. This industry is in decline and while the Hebron project is expected to provide a boost, its impact is expected to slow the decline – not reverse it. Population is not expected to grow over the forecast and the

mining and processing discussion suggests that after the Vale smelter, there is no expectation for further growth on the Island. If crude oil prices do not grow as expected then penetration rates for electricity in the residential sector may not continue.

This section has discussed the risks associated with the demand projections. The report returns to this issue in the context of analysing the options for meeting Island demand and in the context of analysing the profitability of the Muskrat Falls and Gull Island projects.

### **3.2. Transmission**

The Project does not include the transmission lines to carry the power to the Island nor from the Island to Nova Scotia. However, the costs associated with these transmission projects are an important input to the economic analysis of the Project.

Nalcor has indicated that it would construct a 1,100 km HVdc Labrador Island Link (LIL), which would provide 900 MW of power transfer capacity between Labrador and the Island. According to Navigant, this is the only technically feasible option, due to the long distance that must be covered, the fact that water will be crossed, and the weakness of the Island electrical system.

Similarly, Nalcor has indicated that all Muskrat Falls volumes would flow to Nova Scotia through the proposed Maritime Transmission Link between the Island of Newfoundland and Nova Scotia. The Maritime Link would represent an alternate route for clean hydro-electric power from Labrador to Nova Scotia, New Brunswick and the US North-east.

According to Nalcor, the Maritime Link will have 500 MW of capacity, a construction start in 2013, an in-service date of 2016 and a construction cost of \$1.2 billion.

## **4. Evaluation of Supply Alternatives**

As indicated above, Panel recommendation 4.2 expressed the concern that Nalcor had failed to demonstrate that the Muskrat Falls project was the best option for meeting the Island's future electricity demand and recommended that the Government of Newfoundland and Labrador and Nalcor commission an independent analysis of alternatives.

Prior to the release of the Panel's report, Nalcor commissioned Navigant to "review the reasonableness" of Nalcor's analysis of Island supply options. Most of the options that Nalcor asked Navigant to assess were ones the Panel subsequently identified as needing further examination.

This section summarises the Navigant study. It also examines the specific recommendations made by the Panel and for each one identifies the response offered by Nalcor and/or Navigant plus a short commentary. The section closes with concluding comments on supply alternatives.

## **4.1. Nalcor's Supply Alternatives**

The Navigant report indicates that Nalcor evaluated generation options under two broad alternatives:

- Isolated Island alternatives; and
- Interconnected Island alternatives.

Isolated Island alternatives involve keeping the island of Newfoundland separate from Labrador. Possibilities for meeting demand under this scenario would include development of other renewable resources on the island and improving the island's Holyrood facility by way of equipment refurbishment (costing \$200 million) and the installation of pollution control equipment (costing \$600 million). Under this alternative, further investments in new thermal generation capacity may be necessary.

The Interconnected Island alternatives would involve building a link between Labrador and the Island crossing the Strait of Belle Isle. There are two proposed installations available under this alternative – Gull Island and Muskrat Falls. Nalcor selected Muskrat Falls as being the least cost option under this alternative.

As indicated earlier, the tool Nalcor uses for comparing alternatives relies on a concept called Cumulative Present Worth (CPW), which is a present value of all incremental utility capital and operating costs incurred by the utility to reliably meet a specific load forecast given a set of reliability criteria. Where the CPW of one set of supply options is less than the CPW of an alternative set, it is the one with the lowest CPW that is chosen. In other words, the supply option that has the lowest CPW is considered by this methodology to be the lowest cost option.

Nalcor used the CPW concept and a specific planning tool to identify the lowest cost combination of investments to meet Island forecast demand under the Isolated Island constraint.

### **4.1.1. Scope of the Navigant Review**

Nalcor engaged Navigant to review the reasonableness of:

- The long-term Island supply options considered by Nalcor;
- Nalcor's assumptions associated with Island supply options; and

- The process that Nalcor followed to screen and evaluate the supply options.

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

- Whether the Interconnected Island alternative represents the least cost supply option that also fulfills the additional requirements of security of supply and reliability, environmental responsibility, and risk and uncertainty; and
- The accuracy of the rate projections.<sup>[10]</sup>

The inputs for Navigant's review included financial and engineering models, reports and discussions with Nalcor management and personnel, the province's 2007 Energy Plan, and Island supply option evaluation criteria used by Nalcor (such as, security and reliability, and cost to rate payers).

It is important to note that Navigant was not asked to review the financing decision for Muskrat Falls nor was it to include possible revenues and costs associated with exports.

#### **4.1.2. Demand Projections**

The same demand forecast was used for both alternatives. Navigant reviewed Nalcor's demand forecast, which was discussed earlier, including the conservation and demand management assumptions and found the methodology and the demand and energy growth forecast to be reasonable.

#### **4.1.3. Isolated Island**

According to the Navigant study,<sup>[11]</sup> the key elements of the Isolated Island alternative are the development of limited renewable resources in the near-term, pollution abatement, life extension improvements at the Holyrood plant, replacement of the Holyrood plant and the continued development of thermal power resources over the planning period (to 2067).

Table 9 shows the major investments that, according to Navigant, would need to take place over the planning period.

**Table 9: Isolated Island Generation Investment Plans and costs**

<b>Investment</b>	<b>Megawatts</b>	<b>Capital Costs 2010\$ millions</b>	<b>Year</b>
Wind	25	58	2014
Island Pond Hydro	36	166	2015
Holyrood Upgrades	N/A	800	2015 – 2017
Portland Creek Hydro	23	98	2018
Round Pond Hydro	18	127	2020

CCCT[12]	170	273	2024
Combustion turbine (CT)	50	65	2024
CT	50	65	2027
Wind Renewal	50	116	2028
Holyrood replacement; Additional Thermal	N/A	N/A	2030 - 2067
<b>Total</b>	<b>424</b>	<b>1,768</b>	

Source: Navigant, Independent Supply Decision Review, Sept 14, 2011

Navigant reviewed and assessed the cost assumptions for all of the above investments and found them all to be reasonable. Navigant also reported on and found reasonable Nalcor's assumptions about projected retirements, operating cost and heat rates for the various units.

Navigant reviewed the projected costs for the Holyrood life extension upgrades and pollution control investments that total over \$800 million as per Nalcor documents. The pollution control equipment is expected to be about \$600 million. The pollution control investments are required for the plant to conform to the Province's energy policy with respect to emissions affecting air quality.

Nalcor's planning model software program takes the factors discussed above, such as capital and operating costs, heat rates, and expected generation output, and calculates CPW for different combinations of investments in order to arrive at the minimum cost combination.

Navigant reviewed the model inputs and found them to be consistent with those presented by Nalcor in exhibits to the Public Utilities Board.

For the Isolated Island option, Nalcor imposed some constraints. Wind power was constrained to 80 MW – this issue is examined later in the context of the Panel's recommended options. Another constraint introduced by Nalcor was the requirement for pollution abatement equipment, in accordance with the province's energy policy.

Based on the assumptions, inputs and analysis briefly described above, the CPW for the Isolated Island option was calculated by Nalcor to be \$8,810 million in constant 2010 dollars.

#### **4.1.4. Interconnected Island**

According to the Navigant study, the Interconnected Island alternative would include two major new facilities: the 824 MW Muskrat Falls generation facility and the 1,100 km High Voltage direct current (HVdc) Labrador – Island Transmission Link from Muskrat Falls to the Avalon Peninsula.

This alternative would provide the capability to displace the Holyrood plant and meet provincial growth requirements for years to come. In addition, this alternative would interconnect the Island with the regional North American power grid. The major components of the Interconnected Island alternative, including their cost and timing, are presented in the table below.

**Table 10: Interconnected Island Generation Investment Plans and costs**

<b>Investment Description</b>	<b>Megawatts</b>	<b>Capital Costs 2010\$ millions</b>	<b>Year</b>
CT	50	65	2014
Muskrat Falls	824	2,206	2017
HVDC Island Link	N/A	1,616	2017
Holyrood Standby	N/A		2017
Holyrood Shut down	N/A		2021
Thermal units for reliability support only	N/A	N/A	2030 - 2067
<b>Total</b>	<b>874</b>	<b>3,887</b>	

Source: Navigant, Independent Supply Decision Review, Sept 14, 2011

Navigant reviewed and assessed the cost assumptions for all of the above investments and found them to be reasonable.

Nalcor ran its utility planning model and arrived at a CPW for the Interconnected Island case of \$6,652 million in constant 2010 dollars. This is \$2,158 million less than the CPW for the Isolated Island case. In other words, the net present value of all incremental capital and operating costs for Muskrat Falls and the Island link is about \$2.2 billion dollars less than the net present value of the costs of the next best alternative, according to Nalcor's assumptions, inputs and constraints.

#### **4.1.5. Nalcor's Sensitivity Analysis of Results**

The Navigant report described the following sensitivity analyses that were run by Nalcor and Navigant. A sensitivity analysis is meant to examine the impact on the results when certain key variables are changed. It is commonly used to check the sensitivity of the results to the different assumptions that go into the analysis.

The following table shows the CPW

**Table 11: Sensitivity Results: CPW Difference  
between Alternatives**



Supply Option	2010 \$ millions
Reference Case	2,158
High fuel Costs	2,806
Federal loan guarantee	2,758
Carbon pricing	2,655
+200 MW Wind in Isolated Island	1,717
750 GWh of CDM[13] saving in Isolated Island	1,283
Muskrat Falls & Link 25% higher capital costs	1,183
Low load growth	752
Low fuel costs	120

difference between alternatives for each scenario.

Source: Navigant, Independent Supply Decision Review, Sept 14, 2011

For every scenario examined, the Interconnected Island remains the lower cost option. The fact that the Interconnected Island alternative is the lower cost option under a wide range of assumptions about the key variables lends credibility to the original conclusion that the Interconnected Island alternative is the lower cost option.

Each scenario is briefly described below. Commentary and analysis of key options are provided in section 4.2 of this report.

### High/Low fuel costs

Nalcor/Navigant relied on PIRA[14] to provide different oil price trajectories. They did not provide the actual price forecasts for the high, low or reference cases. However, Navigant indicates that the reference case is similar to the most recent forecast by the US Energy Information Administration. Fuel prices impact the operating cost of fossil fuel-fired turbines. Since the Isolated Island alternative relies more heavily on fossil fuel power, the Isolated Island alternative becomes relatively more expensive under the high oil price scenario. Under the low oil price scenario that Navigant considered, there is little difference in costs between the two alternatives.

### Federal loan guarantee

The loan guarantee would have the effect of lowering the interest rate on the debt for Muskrat Falls and the Labrador-Island link thereby reducing the cost of the Interconnected Island alternative.

### Introduction of carbon pricing

Navigant stated that due to continuing uncertainty of federal regulation of atmospheric emissions, Nalcor chose not to include any impact from possible carbon pricing in its reference case. Nevertheless, Nalcor and Navigant decided to address the possibility. In particular, they estimated the impact of carbon pricing coming into effect in 2017. According to Navigant, the carbon price forecast was based on projections developed by the US Department of Energy as an analysis of the Waxman-Markey legislation.

Higher carbon prices serve to raise the cost of producing electricity using fossil fuels and therefore raise the cost of the Isolated Island alternative.

### **200 MW increase in wind in Isolated Island**

According to Navigant, this case involved an incremental 100 MW of wind in 2025 and a further 100 MW in 2035. Navigant and Nalcor indicate that the isolated system cannot effectively handle more wind early in the forecast.

### **Pursuit of conservation and demand management programs in Isolated Island**

Nalcor and Navigant explored two conservation and demand management program sensitivity cases. The upper estimate is provided in Table 11. The calculation assumes that the 750 GWh of savings are achieved by 2031 at a cost of about \$60 per MWh saved.

### **Higher capital costs for Muskrat Falls and the Island Link**

This scenario reflects the impact of 25 per cent higher capital costs for Muskrat Falls and the Island Link. This raises the cost of the Interconnected Island.

### **Low load growth**

The low load growth case reflects a 50 per cent reduction in the annual load growth starting in 2015, after Vale's Long Harbour operation reaches full production.

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

### **Combining Sensitivity Cases**

Navigant reported that they did not run any combination sensitivity cases. They provided no explanation for this.

#### **4.1.6. Navigant's Conclusions**

Navigant concluded that the CPWs for the generation expansion alternatives are a fair representation of the costs that would be incurred under the Interconnected and Isolated Island scenarios. Based on the above analysis of all relevant costs, Navigant further concluded that the \$2.2 billion CPW preference for the Interconnected Island alternative is a reasonable estimate of the expected cost difference between the two alternatives<sup>[15]</sup>.

#### **4.2. NRCan Comments on Navigant's Analysis of Supply Alternatives**

NRCan was able to do a rough verification of the reported CPW results with some additional assumptions. In theory it should be possible to take the investment schedule, the demand and oil price outlooks, heat rates, capacity factors and calculate the net present value of the costs of the different options. Nalcor/Navigant provided all of the above information except the capacity factors by plant.<sup>[16]</sup> The capacity factor is needed to calculate electricity output as well as the fuel costs to run the plant.

NRCan was able to replicate the results using reasonable in-house estimates of capacity factors. Annex 8.1 provides more details.

Navigant analysis indicates (and the NRCan analysis supports the conclusion) that under the given assumptions about demand growth, oil prices, investment and operating costs, the Interconnected Island alternative gives a lower CPW cost than the Isolated Island alternative. The Navigant sensitivity analysis also indicates that the Interconnected Island alternative has a lower CPW cost than the Isolated alternative under a variety of options. Given time and data constraints, NRCan was not able to corroborate these results.

NRCan examined the impact on the two options under the scenario that demand growth remains flat after the coming on-stream of the Vale smelter. Under this no growth scenario, the CPW of the Isolated Island option is 2010\$ 800 million less than the Interconnected Island alternative.

There are two reasons for this result. The first is that lower demand means that less capacity is needed. In the Isolated Island case, it means that a 170 MW combined-cycle combustion turbine is not built – thereby saving its capital and associated operating costs. The second reason is that operating costs for the system as a whole are less in the Isolated Island because generation is directly tied to burning fossil fuels – less generation means less fuel which means lower operating costs.

For the Interconnected Island, operating costs are virtually insignificant and the major capital cost is incurred up front with the building of the hydroelectric station and the transmission facilities. There is no way to reduce costs in the face of unexpected lack of demand growth under this option – they are sunk costs at that stage.

It might bear repeating in the context of this discussion about the low demand growth option that the CPW analysis focuses entirely on the incremental economic costs required to meet Island demand. This kind of analysis does not take account of environmental costs and benefits. Also, it ignores possible revenue impacts. Thus, while the Interconnected Island alternative cannot effectively lower costs in the face of lower domestic demand, it can offset the impact somewhat on the revenue side by looking for higher revenues from export sales. While the CPW concept cannot incorporate this, project cash flow analysis is able to do so. The paper discusses project cash flow and export revenues in section 5. Environmental issues are discussed in section 6.

### **4.3. Panel Supply Options**

The Panel recommended that an independent analysis of economic, energy and broad-based environmental considerations of alternatives be conducted to address the question, “What would be the best way to meet domestic demand under the ‘No Project’ option, including the possibility of a Labrador-Island interconnection no later than 2041 to access Churchill Falls power at that time, or earlier, based on available recall.” The Panel recommended that the analysis of supply alternatives should address the following considerations:

- why Nalcor’s least cost alternative to meet domestic demand to 2067 does not include Churchill Falls power which would be available in large quantities from 2041, or any recall power in excess of Labrador’s needs prior to that date, especially since both would be available at near zero generation cost (recognizing that there would be transmission costs involved);
- the use of Gull Island power when and if it becomes available since it has a lower per unit generation cost than Muskrat Falls;
- the extent to which Nalcor’s analysis looked only at current technology and systems versus factoring in developing technology;
- a review of Nalcor’s assumptions regarding the price of oil till 2067, since the analysis provided was particularly sensitive to this variable;
- a review of Nalcor’s estimates of domestic demand growth (including the various projections to 2027 in the EIS (2007, 2008, 2009 and the 0.8 percent annual growth to 2067 provided at the hearing);

- Nalcor's assumptions and analysis with respect to demand management programs (compare Nalcor's conservative targets to targets and objectives of similar programs in other jurisdictions and consider the specific recommendations, including the use of incentives to curtail electric base board heating, from Helios Corporation, among others);
- the suggestion made by the Helios Corporation that an 800 MW wind farm on the Avalon Peninsula would be equivalent to Muskrat Falls in terms of supplying domestic needs, could be constructed with a capital cost of \$2.5 billion, and would have an annual operating cost of \$50 million and a levelized cost of power of 7.5 cents per kilowatt-hour; and
- whether natural gas could be a lower cost option for Holyrood than oil; and potential for renewable energy sources on the Island (wind, small scale hydro, tidal) to supply a portion of Island demand.

These alternatives and Navigant/Nalcor's views on them are described and discussed in more detail below.

#### **4.3.1. Churchill Falls Power Recall Post 2041**

The Panel concluded that Nalcor did not adequately consider Churchill Falls recall power, which would be available starting in 2041, in its assessment of the need for the project.

Nalcor concluded that recall power from Churchill Falls would not be a viable alternative to the Lower Churchill project since the agreement with Hydro-Québec will not expire until 2041. According to Nalcor, ratepayers on the Island would be subjected to fuel price volatility, and Nalcor would be exposed to risks associated with environmental non-compliance until this time.

Nalcor further noted that there is uncertainty surrounding the terms for availability of supply from Churchill Falls, given the fact that Nalcor is not the sole shareholder. Recall power that would be available, under that agreement, is presently sold to third parties. Furthermore, this power is loaded, which means that it must be used and cannot be returned. Therefore, if this power were used to back up other renewable energy sources, it would be lost when the other sources were providing electricity.

Navigant concurs with Nalcor's rejection of deferring the in-service date of the link until 2041 and using Churchill Falls as a supply option for the Island. Reasons cited by Navigant include the rising cost of fuels until 2041, as well as capital costs associated with early replacement of the Holyrood facility with an oil-fired combined cycle combustion turbine in 2017. Navigant estimates these cost to be \$1.7 billion more than Nalcor's base Interconnected Island alternative.

**NRCan Comments**

The Navigant analysis and conclusions are based on Nalcor's domestic demand growth assumptions. Nalcor's demand growth assumptions are consistent with other demand forecasts. However, if the anticipated demand growth fails to materialize, for example, then the Churchill Falls recall option could be less costly than the Muskrat Falls option. However, there would be a cost to the Province as it would have to give up the revenues it is currently earning from the 300 MW of recall power (see section 2.1.2).

**4.3.2. Use Gull Island Power to meet Island Demand**

The Panel suggested that Gull Island may be a preferable option to Muskrat Falls. This idea is based on the lower per unit costs of Gull Island compared to Muskrat Falls.

Navigant considered this option. It was argued that because island requirements represent a much lower proportion of the Gull Island output and in the absence of confirmed export transmission via Quebec or new large industrial load in Labrador, the financial returns for the Gull Island project selling only to the Island would be unacceptably low. In order to provide the same rate of return as projected by Navigant/Nalcor, the purchase price for power from Gull Island would have to be approximately 60 percent higher than power from Muskrat Falls.

**NRCan Comments**

Gull Island would not appear to be a lower cost option for the Island. The Navigant analysis of the Gull Island appears reasonable. Gull Island is lower cost than Muskrat on a per unit basis. However, it is a much bigger and more expensive project. An argument for Gull Island, therefore, relies on offsetting these larger capital costs with export revenues. This reliance on export revenues could represent a large additional risk to rate payers. In other words, rate payers may only be able to benefit from Gull's lower per unit costs if Gull is able to produce and sell to its potential. If prices are weak or access is limited, rate payers could face much higher prices.

**4.3.3. Combining Small Hydro and Other Renewables**

The Panel recommended that the potential for other renewable energy sources on the Island be explored, such as smaller-scale wind, small-scale hydro, and tidal. In particular, the Sierra Club Atlantic suggested that the province's moratorium on small-scale hydro could be lifted.

Nalcor and Navigant considered a variety of supply alternatives involving other forms of renewable electricity generation, including small-scale hydroelectric facilities (run-of-river), tidal power, biomass, and solar power.

Tidal, solar and biomass generation were all excluded by Nalcor as possible supply alternatives. Tidal was excluded due to its unproven commercial viability. Solar generation was not considered to be an appropriate supply alternative due to the low insolation rates in Newfoundland and Labrador – a result of the province's high latitude and cloudy conditions. Biomass was not considered due to the limited access to biomass through Newfoundland and Labrador's existing forest industry.

Nalcor concluded that alternative hydro developments on the Island would not be sufficient to meet future demand and would therefore require continued reliance on the Holyrood facility. Nalcor also stated that small-scale hydro developments would not allow for storage, and would therefore be unable to respond to fluctuations in energy demand.

Nalcor intends to expand wind generation in the province, but as a complement to other sources of power.

Taken together, Nalcor estimated that the cost of small scale alternative power generation would be more than double the cost of the Muskrat Falls facility. Nalcor also noted that large scale integration of these sources would not be technically feasible.

Navigant concluded that the exclusion of biomass, solar, and wave and tidal power by Nalcor was reasonable. In regards to other smaller-scale hydroelectric developments, Navigant referenced a series of proposals that were submitted in 1992/93 pertaining to small hydro development. The price per MWh for these projects was deemed to be sufficiently high for Navigant to determine that Nalcor's rejection of this alternative was reasonable. In this regard, Navigant noted that the expected cost of power from these smaller-scale hydro facilities would be approximately 20 per cent higher than wind power.

As mentioned in the discussion of large-scale wind development, Navigant believes that wind power could be expanded on the Island.

### **NRCan Comments**

Regarding small hydro, Nalcor/Navigant indicated that small hydro should be avoided because it is more expensive than wind. According to Nalcor, there are factors that limit wind power to only about 80 MW. It would seem reasonable, therefore, to consider small hydro as a source of power after the wind potential has been reached.

Regarding the other potential renewable sources, while it is true to say these are unproven technologies, the period under consideration is to 2060. It is possible that these technologies will become economic in that time frame. A possible long-term strategy for meeting electricity requirements could involve taking interim measures in the near term while developing strategies to research higher risk renewable options for the medium term.



#### **4.3.4. Oil Price Assumptions**

The Panel suggested that the independent analysis review the oil price assumptions. Navigant examined this issue and their results are described in section 4.1.5. Navigant found that under a low oil price scenario, there is little cost difference between the two alternatives.

##### *NRCan Comments*

It was impossible to verify Navigant's results since they did not provide their oil price assumptions. It would appear, based on NRCan's rough calculations, that the Project is the low cost option under a wide range of oil price assumptions.

#### **4.3.5. Review Nalcor's estimates of domestic demand growth**

According to the Panel, Nalcor indicated in the EIS that by 2027, an additional 582 MW of generating capacity would be required. This projection was reduced in 2008 to an additional peak capacity requirement of 531 MW by 2027. In 2009, the projection was further reduced to an additional requirement of 244 MW by 2027.

As indicated above, Navigant reviewed Nalcor's demand projections for the period and found them reasonable.

##### *NRCan Comments*

Section 3 discusses the demand outlook in detail. The report returns to this issue in section 4.4.

#### **4.3.6. Aggressive Demand Management**

During the Panel's public review process, Helios Corporation and Sierra Club Atlantic pointed to demand side management as a viable alternative for the Island. Helios Corporation noted that Newfoundland and Labrador is significantly under-spending on conservation and demand management compared to other provinces, and that other regions are aiming towards zero load growth. The Panel recommended that Nalcor's assumptions surrounding demand management be reassessed, and that programs such as the use of incentives to curtail electric base board heating should be considered.

Referring to a study conducted by consulting company, Marbek, concerning conservation and demand management in Newfoundland and Labrador, Nalcor concluded that the maximum reduction in energy consumption that could be achieved with demand management between 2007 and 2027 is 12 per cent. Nalcor suggested this would not result in sufficient savings to negate the need for the project. According to Nalcor,

Newfoundland and Labrador customers have not had sufficient experience with conservation and demand management and therefore participation in these programs has typically been low.

Navigant has indicated that there may be more opportunity for investment in CDM than Nalcor has incorporated in its electricity market outlook. Navigant has also indicated that while such opportunities likely exist, CDM would not be sufficient to negate the need for the project.

### **NRCan Comments**

It would appear that there is more potential for CDM than Nalcor has incorporated in its demand outlook. Whether CDM could be used in combination with other options to mitigate the project is discussed in section 4.4.

#### **4.3.7. Large-scale Wind Development**

A number of participants in the Panel's review process suggested that Nalcor should consider a large-scale wind development as an option for meeting domestic demand. In particular, the possibility of developing an 800 MW wind farm on the Avalon Peninsula, situated on the Island, was noted as an alternative to the Muskrat Falls hydro project. It was suggested that such a project would have a capital cost of less than \$2.5 billion, annual costs of \$50 million, and a real levelized cost of power of 7.5 cents per KWh.

Sources such as the Canadian Wind Atlas and the North American Wind Atlas were cited, which state that Newfoundland and Labrador has significant wind resources, and that the province is in fact one of the windiest places in North America. According to the Canadian Wind Atlas, wind turbines could be erected at almost any location on the Island and would be expected to have a higher energy output than similar facilities that are currently being installed in Quebec.

Nalcor indicated that they have studied the potential for wind development and concluded that, since wind is an intermittent resource, it could not be relied upon to provide power at the times when it is needed. As a result, wind facilities would need to be backed up by more reliable sources of power. Nalcor stated that they would plan to expand wind generation in the province as a complement to more reliable sources of power. Nalcor also noted that such developments would not be pursued unless the province had access to a larger load base than is presently the case.

Navigant concurs that Newfoundland and Labrador have abundant wind resources, and suggested that Nalcor could consider the addition of 100 MW of wind power on the Island in 2025, and again in 2035. Navigant stated that this incremental 200 MW of wind power

by 2035 should be considered as an upper limit. Ultimately, Navigant concluded that no amount of wind generation could eliminate the need for the firm capacity provided by a facility such as Holyrood or a replacement thermal facility.

### **NRCan Comments**

It is widely accepted that for wind penetration levels up to 10 per cent there is no need for changes in the way the electricity system in a particular jurisdiction is managed and balanced. Any penetration levels over 10 per cent would require gradual changes, including advanced monitoring and balancing capabilities and additional firm reserve capacity. There is a lengthy debate about how much reserve should be put in place in terms of MW of reserve for each 100 MW of variable capacity, but the widely accepted view is that about 6-8 per cent would be sufficient (i.e. 6 to 8 MW firm capacity for each 100 MW of variable capacity).

In that light, it is difficult to understand Nalcor's argument that the system can only support up to 80 MW – this would represent about 250 GWh. Given that annual Island generation is expected to reach 9,000 GWh when the Vale smelter comes on stream in 2016, the 10 per cent penetration levels above would suggest that a 300 MW wind project delivering about 900 GWh could be manageable.

The 800 MW wind farm that the Panel suggested be considered would not likely be feasible in an Isolated Island option. This level of power equates to about 25 per cent of Island power. Such a penetration rate for wind energy would be unprecedented for an isolated system, given current experience. Penetration levels higher than 10 per cent have been experienced in other countries (i.e. Denmark, Spain), but specific conditions about the level of electrical grid integration in these countries and the way the electrical grid is managed in neighbouring countries have facilitated the integration. This is not currently an option for the Island. This could be an option under the Interconnected Island alternative.

#### **4.3.8. Conversion of Holyrood to Natural Gas**

Through the public participation opportunities associated with the Panel's review, Grand RiverKeeper Labrador Inc. suggested that Nalcor had not considered the alternative of converting the existing oil fired facilities at Holyrood to natural gas, which could be obtained from offshore developments. The Panel recommended that an analysis of supply alternatives should include the question of whether natural gas could be a lower cost option for Holyrood than oil.

In response to this suggestion, Nalcor stated that this alternative was hypothetical and that no business case for the transportation or marketing of natural gas has presently been identified. As such, Nalcor expressed the view that the natural gas industry will not likely exist on the Island within the foreseeable future. Furthermore, Nalcor expects the price of natural gas to increase in the future.

Navigant reviewed this option and found Nalcor's argument to be reasonable. Nalcor and Navigant both cited a 2001 Gas Pipeline study by the Government of Newfoundland and Labrador. According to Navigant, this study indicated that the sustainable economic extraction rate needed to support a submarine natural gas transportation system off-shore of Newfoundland would be approximately 700 Bcfd (billion cubic feet per day). Navigant quoted the study as follows:

*“Delivery of gas for domestic [provincial] use such as for power generation, industrial, commercial and residential is not economically feasible without integral development of delivery to Eastern Canada and the U.S.”*

Navigant also identified liquefied natural gas (LNG) as a possible fuel that could be used on the Island – an option that the Panel did not specifically suggest. In particular, Navigant explored the feasibility of a LNG regasification facility that would serve a 500 MW natural gas-fired combined-cycle combustion turbine (CCCT). The regasification facility would require capacity of about 84 million cubic feet per day, if sized to meet the peak demand of the natural gas-fired power plant. This would be a very small facility by normal standards - for example, the Canaport LNG facility in New Brunswick has a capacity of about 1.2 billion cubic feet per day.

Navigant estimated the capital cost of 84 million cubic feet per day facility would be about \$1 billion. There would also be a cost associated with building the new natural gas power plant. The commodity costs for LNG would also need to be taken into account. According to Navigant the commodity costs for LNG are likely to be tied to world LNG prices and not North American natural gas prices. Further, Navigant expects world LNG prices to track crude oil prices for the foreseeable future. Therefore there would be only a modest discount between the LNG commodity costs and the fuel oil costs that Nalcor is already paying to run Holyrood and other combustion facilities.

Navigant concluded that there is, therefore, currently no clear economic advantage to using LNG due to the capital requirements for LNG-facilities, as well as the expected long-term relationship between the world price of LNG and crude oil.

## **NRCan Comments**

The 2001 Gas Pipeline study cited above was actually recommending that the Province build the infrastructure to take natural gas from the Newfoundland offshore to the Island and then connect the Island with Nova Scotia and its natural gas facilities. The study argued the project was feasible and could be profitable under a number of assumptions including a crucial one that there was sufficient natural gas supply potential from the other offshore projects. Under current and future expected natural gas prices it seems unlikely that this project would be feasible.

The industry is currently using the natural gas it is producing for reinjection in order to maintain the productivity of existing offshore oil projects and to produce electricity on the Hibernia platform. At some point in the future, some portion of this gas will be available for other uses. It is unclear at this point when it will be available and what its best future use is likely to be.

With respect to LNG, it would not appear to be a lower cost option than the Project. It is certainly the case that world LNG prices are not similar to North American natural gas prices. It is unclear how or whether these prices will converge and what their relationship will be to that of crude oil. Under current conditions and expectations, LNG prices are not expected to fall significantly compared to anticipated crude oil prices. Thus, the Navigant analysis and conclusions would appear reasonable.

#### **4.4. NRCan Comments on Alternatives**

It is unlikely that the Panel's suggested alternatives would mitigate the need for the project. The Navigant analysis shows fairly conclusively that these options will not be sufficient to meet future anticipated requirements at a comparable cost to Muskrat Falls and the Labrador-Island link.

The 800 MW wind project would represent about 20 per cent of Island demand and seems too ambitious for the Isolated Island alternative. Such a high proportion has only been achieved in Denmark, which has access to large amounts of back-up hydro-electric power. This would obviously not be the case in an Isolated Island scenario.

It appears there is a certain amount of untapped small hydro available. However, it is not sufficient, even in combination with, say, 300 MW of wind power and increased CDM, to produce power at a lower cost or to meet the long-term anticipated growth in electricity demand.

There are a few concerns to note with respect to the Navigant/Nalcor analysis. The analysis examined and discussed all the above options in a piece-meal fashion. It did not look at combinations of the different options. Nor did it consider the possibility of incorporating a combination of options in order to delay the project and its large capital costs.

In scenarios where demand does not grow beyond 2020 or 2030, NRCan's analysis indicates that the Isolated Island alternative could be 2010\$ 800 million (in net present value) less costly than the Interconnected Island alternative. The \$800 million amount represents a risk to the Project. That is, it is the net present value of the additional cost that would be borne by rate payers and taxpayers in this scenario compared to the No Project option.

A strategy to mitigate this risk would be to invest in more wind power, small hydro and CDM in the near term. This strategy would delay the large capital costs of the Project and allow time for other experimental technologies – such as solar and tidal – to become more cost-effective. A decision on the Project could then be delayed until the Holyrood plant is nearer the end of its useful life.

The risk of the above strategy, on the other hand, would be that the demand does indeed materialize as forecasted and that Muskrat is needed to meet the higher demand. In this case, some relatively expensive energy has been brought on stream that the analysis above suggests would not be competitive with Muskrat and that could be stranded or require support from the rate-payer and/or taxpayers.

It should be noted that this analysis is focused entirely on how best to meet future Island electricity requirements at the lowest possible cost. This analysis does not consider the benefits of linking the Island with the Mainland. To provide just a few examples:

- With Muskrat Falls linked to the Island, the wind potential of the Island can be more fully utilized since it would have Muskrat's additional 834 MW as back up;
- The environmental and health issues associated with the Island's fossil-fired plants is not considered here nor are the potential benefits to Nova Scotia and New Brunswick from another relatively clean power source; and,
- The potential economic benefits from export sales are not a consideration in this part of the analysis.

We turn to some of the above issues in the next sections.

## **5. Project Cash Flow Analysis**

This section will provide information and analysis on the project from the perspective of project cash flow analysis. Project cash flow analysis is a standard approach used by financial analysts to assess a project's profitability. This section will report on and critique work done by Nalcor and Navigant in respect of what project cash flow analysis tells us about the benefits from these two projects. NRCan's analysis takes explicit account of the transmission projects required to get Muskrat power to market.

There is some important context to this analysis. The Panel report indicated that Nalcor had failed to justify the Project in either economic or in energy terms. The Panel recommended (4.1) that the Newfoundland government and Nalcor undertake a separate review of the projected cash flow of both Muskrat and Gull Island to ascertain whether there really would be a net benefit from each of these components and to ascertain the extent of the benefit.

The following sections summarise the information provided by Nalcor and reports on NRCan's attempts to replicate and extend Nalcor's results using the assumptions provided to the Panel. The task was challenging because Nalcor did not provide all the information necessary to replicate their results. It was therefore necessary to reverse-engineer certain information in order to calculate certain key variables such as assumed export prices, Quebec transmission costs and the Muskrat Falls netback price.

## **5.1. Nalcor's Project Cash Flow Analysis**

Nalcor reported that they use a discounted cash flow modeling technique which involves estimating and projecting net future cash flows on an annual basis. Key inputs to the financial model include project-specific variables such as market prices, the sales portfolio, and capital expenditures as well as macro-economic assumptions such as exchange rates, interest rates and inflation.

Project financing assumptions including capital structure, debt terms and an equity target rate were developed by Nalcor with the assistance of outside experts, Pricewaterhouse Coopers. The primary outputs of the model include project net present value and the internal rate of return. If the net present value is positive and the internal rate of return exceeds the equity target rate of return, the investment opportunity may be attractive, according to Nalcor, provided risks are deemed acceptable and capital for investment is available.

For the analysis of both projects, Nalcor assumed a 7.3 per cent borrowing rate for a borrowing term of 30 years, and a US-Canada dollar exchange rate of 0.964.

### **5.1.1. Muskrat Falls**



The table below summarizes Nalcor's project-specific assumptions for Muskrat Falls.

**Table 12: Muskrat Falls Project Cash Flow Assumptions**

<b>Capital Cost:</b>	2010\$2.5 billion
<b>Schedule:</b>	In service date: 2017 (construction start: late 2011)
<b>Debt/Equity:</b>	59/41
<b>Revenue:</b>	Newfoundland and Labrador domestic market, Nova Scotia, New Brunswick and New England markets
<b>Market Access:</b>	via Labrador – Island Transmission Link, Maritime Transmission Link, NSPI/Emera transmission system and rights
<b>Energy Sold:</b>	Average production from Muskrat Falls: 4.9 TWh/yr

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

**Table 13: Muskrat Falls Portfolio**

	2017	2020	2030	2040
<b>Market volumes to NL &amp; export (GWh)</b>	3,713	3,729	3,843	3,900
<b>Av. Price (\$/MWh)</b>	72	86	111	133

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

Based on the above assumptions, Nalcor found that the return on equity for Muskrat Falls is 9.2 per cent. Since Muskrat Falls power is partially directed to domestic sales, this rate of return is consistent with the Province's policy of providing low cost power to the Island while ensuring a reasonable rate of return for producers, and is slightly higher than the Public Utility Board's 2011 rate of return on equity for regulated assets of 8.38 per cent.

The Panel asked Nalcor to consider various sensitivity tests. The first test included a combined 10 per cent increase in capital cost and no export sales. Nalcor thought this scenario unrealistic since Emera has committed to provide 330 MW of firm transmission access on the Maritime Transmission Link and beyond to the New England market. Notwithstanding Nalcor's view on the lack of realism, Nalcor ran the test and found that Muskrat Falls would provide a return on equity of 6.8 per cent.

The second sensitivity analysis requested by the Panel included a 10 per cent increase in capital costs and an assumption that only half the export sales would be achieved. Nalcor was equally concerned with the realism of this scenario. Nevertheless, they found that under these assumptions, the project would earn a return on equity of 7.5 per cent.

### **5.1.2. Gull Island**

The table below summarizes the key project-specific assumptions for Gull Island that were

used by Nalcor in its analysis and reporting to the Panel.

**Table 14: Gull Island Project Cash Flow Assumptions**

<b>Capital Cost:</b>	2010\$ 3.9 billion
<b>Schedule:</b>	In service in 2021 (2014 construction start)
<b>Debt/Equity:</b>	70/30
<b>Revenue:</b>	Portfolio of New Brunswick, Ontario, New England and New York markets
<b>Weighted average market price</b>	PIRA forecast
<b>Market Access:</b>	via HQT system, includes OATT and upgrade costs <sup>[17]</sup>
<b>Energy Sold:</b>	Average production from Gull Island: 11.8 TWh/yr

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

**Table 15: Gull Island Portfolio**

	<b>2021</b>	<b>2030</b>	<b>2040</b>
<b>Market volumes to NL &amp; export (GWh)</b>	10,950	10,950	10,950
<b>Av. Price (\$/MWh)</b>	94	124	151

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

Based on the above assumptions, Nalcor finds that the return on equity for Gull Island is 12.6 per cent, which exceeds Nalcor's target return on equity for Gull of 12 per cent.

The Panel asked Nalcor to consider a scenario where capital costs were 10 per cent higher, sales volumes 20 per cent lower and prices were 10 per cent lower. Nalcor indicated that this scenario was not realistic. In particular, Nalcor indicated the 20 per cent reduction in sales volumes was unrealistic because of Nalcor's strategy of securing firm market access. This issue, according to Nalcor, would be addressed in the decision process leading up to Project Sanction, and a decision to proceed with Gull Island "will be made only upon completion of that review."<sup>[18]</sup> Notwithstanding Nalcor's view on the lack of realism, they ran the test and found that the return on equity would drop to 6.2 per cent.

## **5.2. Comments on the Nalcor Project Cash Flow Analysis**

NRCAN was not able to immediately reproduce the internal rate of return results for both projects using the assumptions provided by Nalcor to the Panel. If the costs and prices reported above were used, the internal rate of return would be much higher than reported

by Nalcor. It appears that the average portfolio price reported above is the average wholesale price in the target markets and so presumably includes transportation tolls and transmission losses. Nalcor did not provide assumed tolls or losses.

Another important factor that is implicit in the above analysis is the annual projected sales volume. The reported sales presumably incorporate assumptions about capacity factors – these are not explicitly reported. Also, in the case of the Muskrat project, Nalcor's reported volumes are considerably below potential even taking into account a reasonable capacity factor. It was assumed that the reported volumes are net of the export volumes promised to Emera in exchange for Emera building the Maritime Link.

### **5.3. NRCan Project Cash Flow Analysis**

As indicated above, Nalcor's analysis did not explicitly account for the costs of either the Labrador-Island or the Maritime Links. The economic benefit of the Muskrat project in particular depends on the cost of moving electricity through these transmission systems to market.

There are different approaches that could be followed in order to account for these costs. One approach might be to explicitly include whatever costs and assumptions are contained in the agreement between Nalcor and Emera regarding cost sharing for the transmission projects. The difficulty with this approach is that the analysis then becomes an assessment of a particular agreement – who wins and who loses under certain assumptions - rather than an independent economic analysis of the Gull Island and Muskrat projects themselves. That approach has not, therefore, been followed here.

Another approach, and one that has been followed here, is to treat the Labrador-Island and Maritime transmission links as two separate projects that are providing a service and that need to earn a reasonable rate of return. With this approach, it is possible to calculate an average toll per MWh for electricity passing through the links that is sufficient to earn that rate of return. This assumption removes any implicit economic benefit or cost associated with the links that could be included in Nalcor's assumptions about prices and volumes.

#### **5.3.1. Key Assumptions**

In NRCan's analysis, each link was assumed to charge a toll on electricity passing through it sufficient to earn an 8 per cent rate of return. This is slightly less than the rate of return Navigant indicated was reasonable for Muskrat Falls in the context of a 50 year supply agreement to the Island.

In order to calculate project rates of return it is necessary to make assumptions about sales and prices. Nalcor provided information on assumed Muskrat volumes and a corresponding netback price to Island consumers. It also supplied information on total sales from Muskrat and the average wholesale price.

Using the above information, it was possible to calculate assumed sales from Muskrat through the two links. It was also possible to estimate the export volumes from Muskrat. For export prices, it was assumed that a portion of exports were for firm sales to Nova Scotia at the same price as the delivered price to the Island. For the remaining exports, the 2010 annual average export price from Quebec in constant real dollars was used as a proxy.

With respect to the firm sales to Nova Scotia and the delivered price to the Island, these prices will appear to be high relative to the average electricity rates paid by rate payers in Newfoundland and Nova Scotia. These high delivered prices do not necessarily imply substantially higher electricity rates for consumers because of the way electricity rates are established. Regulators establish rates based on overall system costs. Muskrat costs will be rolled in with all other costs and electricity rates established based on total system costs. The overall system price has not been calculated but it would be expected to be lower than the delivered prices associated with the Muskrat Falls production.

There are a few important constraints to the system that will impact the analysis. Firstly, as has been indicated earlier, Gull Island's production is meant for exports via the Quebec system. This means that Gull is not meant to feed domestic Island demand nor is it meant for sales through the Maritime Link. However, Churchill Falls power might be available and it was assumed for this analysis that it could be made available for sale to the Island and for exports through the Links.

Two other important constraints are the respective capacities of the Labrador-Island Link (900 MW) and the Maritime Link (500 MW). These capacities mean that they would carry (assuming a 65% load factor) about 7,000 GWh per year and 4,000 GWh per year, respectively. Note that Muskrat Falls is expected to account for 4,900 GWh on average over the forecast period – that leaves a maximum of 2,100 GWh of additional power from Churchill Falls. These capacity constraints have an impact on the project's ability to both meet projected Island demand requirements as well as provide sufficient power to make the Maritime Link economic.

### **5.3.2. Key Findings**

The following provides results of the NRCan cash flow analysis of the Muskrat Falls and Gull Island projects, respectively. More details on project-specific assumptions and the calculations can be found in Annex 9.2.

## Key findings - Muskrat Falls

The Muskrat Falls project is primarily designed to meet anticipated Island requirements. However, excess volumes are available for export through the Maritime Link.

1. Muskrat Falls earns a return on equity of about 6 - 9 per cent –this rate of return is consistent with the Province's policy of providing low cost power to the Island while ensuring a reasonable rate of return for producers, and is close to the Public Utility Board's 2011 rate of return on equity for regulated assets of 8.38 per cent.
2. The delivered price to Island consumers (i.e., including the estimated toll for the Labrador Island link) is calculated to be about 2010\$ 107/MWh. As indicated above, this price should not be confused with the rates that would actually be paid by Island consumers.
3. This rate of return assumes an average delivered price to Nova Scotia of about 2010 \$ 68/MWh, which incorporates a portion of firm sales priced at the same price paid by Island consumers and the remainder at a price consistent with average Quebec export prices in recent years (held constant real).
4. By 2048, Muskrat is no longer able to meet both domestic requirements and provide Nova Scotia with the 950 GWh per year (less line losses), as agreed; it is assumed other power sources are found to meet domestic needs until the agreement with Nova Scotia expires in 2051.
5. In 2052, it is assumed that all Muskrat power is going to meet domestic needs.<sup>[19]</sup>
6. The analysis also looked at a low demand growth scenario where Island demand does not grow beyond 2030. In this scenario, excess Muskrat capacity is assumed to be sold through the links. However, export sales are assumed to be less profitable than sales to the Island and consequently the rate of return on equity for Muskrat falls to 6 per cent.

## Key findings - Gull Island

Nalcor indicated that the target rate of return on equity for Gull is 12 per cent. NRCan's analysis corroborates that target under certain assumptions. The analysis of Gull Island is more straight-forward than for Muskrat Falls since all Gull Island volumes are meant for export from the Province through Quebec.

1. Gull Island earns a rate of return on equity of between 7 and 14 per cent based on assumed average export prices of between 2010 \$65/MWh and 2010 \$83/MWh, line losses of 5 per cent and an average toll including system upgrade costs through Quebec of 2010 \$40/MWh.
2. The price range lies within the recent (10 years) historical export prices for electricity sales from Quebec to the US. The 2010 average export price was near the bottom of

the range at \$54/MWh<sup>[20]</sup>, while at the upper end of the range the 2005 price was \$93/MWh.

3. The average toll (2010 \$40/MWh) was imputed by NRCan based on numbers provided by Nalcor to the Panel. The Gull Island cost for moving electricity through the Quebec system to Ontario, New Brunswick and New England is expected to be higher than the current average toll of \$15/MWh since system upgrades would be required.
4. The projected rates of return assume that an average of 10,950 GWh per year can be moved through the Quebec system to markets beyond Quebec at a time when Quebec is also expected to increase its exports to these same markets.
5. If Nalcor can gain access to the Quebec system at Nalcor's assumed cost, then this analysis indicates that at the upper end of the assumed price range Gull would exceed Nalcor's target rate of return for Gull of 12 per cent. At the lower end of the price range, the project would not meet Nalcor's target.

## **6. Environmental Impacts**

To supplement NRCan's economic analysis, Environment Canada has conducted an evaluation of the ecological goods and services (EG&S) associated with the predicted impacts of the Project. The Project is expected to generate environmental and associated economic benefits through the displacement of greenhouse gas and air pollutant emissions from fossil-fuel based electricity sources. Notably, the Project is expected to replace the 490-MW heavy-fuel-oil-fired Holyrood Thermal Generating Station and meet future growth in provincial electricity demand. Using Nalcor's estimates, the overall greenhouse gas emission reductions will range from 160 to 520 million tonnes over 50 years of operation. The Project is also expected to result in reductions in sulphur oxides, nitrogen oxides, particulate matter and mercury. The actual reductions will depend on the source of electricity being displaced.

## **7. Conclusion**

This economic analysis was developed in order to inform decision making under the *Canadian Environmental Assessment Act*. The key economic issue examined by the report concerns whether the project in its entirety, or the Muskrat Falls or Gull Island components individually, would provide an economic benefit while representing the least-cost option for supplying power to the Island of Newfoundland.

The report examined the two alternatives for supplying power to the Island, namely the Interconnected Island (i.e., Muskrat Falls and the Labrador-Island Link) and the Isolated Island (i.e., the no project option). Given Nalcor's assumptions about demand growth, oil prices, investment and operating costs, the Muskrat Falls alternative was found to be lower cost than the Isolated Island alternative. The assumptions were found to be reasonable and the demand projection was consistent with other recent forecasts.

Under most of the sensitivity analyses the Project was found to be the lowest cost option except under a low demand growth scenario in which case either Churchill Falls recall power or some combination of enhanced wind power, small hydro, CDM and fossil-fired power would be a lower cost option.

This analysis examined the question of whether the project in its entirety, or the Muskrat Falls or Gull Island components individually, would provide an economic benefit to Newfoundland and Labrador.

NRCan's analysis found that the rate of return on equity for Muskrat Falls and Gull Island are 6 - 9 per cent and 7 – 14 per cent, respectively. The return on Muskrat Falls is consistent with the Province's policy of providing low cost power to the Island while ensuring a reasonable rate of return for producers, and is close to the Public Utility Board's 2011 rate of return on equity for regulated assets of 8.38 per cent. With respect to Gull Island, if Nalcor can gain access to the Quebec transmission system at Nalcor's assumed cost, then this analysis indicates that at the upper end of the assumed price range Gull would exceed Nalcor's target rate for Gull of 12 per cent. At the lower end of the price range, the project would not meet Nalcor's target.

It is important to recognise the limited scope of this analysis compared to the wider implications of the Lower Churchill project. This analysis and conclusions have focused predominantly on the economics of the project and its ability to meet Island demand at the lowest cost while reducing greenhouse gas emissions within Newfoundland and Labrador. However, the project may also be perceived as being nationally important. The project will increase the amount of clean power in our national portfolio and will likely displace the use of power generated by burning fossil fuels, such as the burning of coal in Nova Scotia. Connecting the Island of Newfoundland to the North American grid brings benefits that cannot be easily captured in a least cost or project rate of return analysis. While this report has touched on some of this, these larger benefits are not readily monetized and therefore are really beyond the scope of this report.

## **8. Annex**



## **8.1. NRCan Analysis of Island Supply Options**

### **Assumptions used in all scenarios**

- For the existing electricity sources, Navigant provided no information on their phase-out; therefore, the following assumptions were made:
  - For Isolated Island, these sources are replaced at the end of their economic life;
  - For Interconnected Island, these sources are not replaced at the end of their economic life (because Muskrat provides more than enough power). In other words, all thermal generation projects, Fermeuse and St. Lawrence wind projects are not replaced.
- Non-dispatchable sources: Star Lake and Exploits Generation, assumed historical capacity factor of 13 per cent. Corner Brook Pulp and Paper feeds its entire generation capacity to the grid.
- Assumed demand growth of 2.5 per cent per year between 2012 and 2016 to meet electricity requirements for the Vale smelter.
- Unless otherwise stated, demand growth from 2016 to 2067 is 0.64 per cent per year (this is the growth rate projected by Nalcor).
- For NPV calculations, an 8 per cent discount factor was used.

### **Scenario #1: Attaining CPW using estimated capacity factors**

- Capacity factors were adjusted to meet growing demand and to attain a CPW close to the CPW reported in Navigant document.
- Beyond 2030 additional capacity was added to meet demand:
  - Isolated Island:
    - Holyrood replacement: 3 CCCT at 170 MW each are built in 2033.
    - CT 50 MW thermal generation is added in 2060.
  - Interconnected Island:
    - CCCT 170 MW unit is added in 2039.

**Scenario #2: Demand stays flat post Vale smelter construction. Demand reaches a peak of 8.6 TWh/year in 2015 and remains flat to 2067.**

Isolated Island:

- Projects not included:
  - Thermal: 170 MW CCCT unit.
- NRCan Capacity factors used except for....

- Holyrood capacity begins at 40 per cent and declines as it reaches the end of its useful life. Rising demand due to the Vale smelter is met through increased production from new small hydro projects on the Island.
- There is surplus supply throughout the entire forecast period (2010-2067).
- **CPW: \$5.18 billion.**

## Interconnected Island:

- Holyrood capacity factor is at 48 per cent but declines until shutdown and replacement by Muskrat in 2017.
- **CPW: \$6 billion.**

Source Type	Project Name	NPV - CAPEX (millions \$)	NPV – OPEX <sup>1</sup> (millions \$)	MW	Production Start - End	Capacity Factor (CF) (%)	CF Annual Growth rate (%)
Hydro Projects	Island Pond	118	5	36	2016 - 2067	67	-
	Round Pond	65	3	18	2021-2067	67	-
	Portland Creek	52	4		2019-2067	67	-
Wind Projects	Fermeuse (replace)	19	-	27	2009-2067	23	-
	St. Lawrence (replace)	20	-	27	2008-2067	23	-
	Project 1	59	9	25	2014-2033	23	1.1
	Project 2	70	8	50	2029-2048	23	1.1
Thermal Generation	Greenfield Unit 1 CCCT	124	1,010	170	2023-2052	40	1.1
	Holyrood Replacement 3 X CCCT	149	2,875	510	2034-2067	70	1.1, CF capped at 90%
	Greenfield CT #1	26	151	50	2025-2049	20	1.1
	Greenfield CT #2	22	129	50	2028-2052	20	1.1
	Greenfield CT #3 <sup>2</sup>	3	33	50	2061-	85	1.1, CF capped at 90%

<b>Existing Projects</b>	Holyrood Units 1,2,3	452 <sup>3</sup>	3,113	466	- 2033	34	2010 – 2021: decline rate 0.5% 2022 – shutdown: decline rate 2%
	Hardwoods CT	-	173	55	- 2022	13	1.1
	Stephenville CT	-	195	55	- 2024	13	1.1
<b>Total CAPEX</b>	CPW of \$8.9 billion						

Notes:

1. OPEX includes fuel costs where applicable.
2. Greenfield CT #3 to meet demand post 2030 (not provided by Navigant).
3. Holyrood CAPEX includes the addition of electrostatic precipitators, scrubbers and NOX burners. 2015-2017

Source Type	Project Name	NPV - CAPEX (millions \$)	NPV – OPEX <sup>1</sup> (millions \$)	MW	Production Start - End	Capacity Factor (CF) (%)	CF Annual Growth rate (%)
<b>Hydro Projects – Muskrat Falls</b>	Muskrat Falls	2,051 <sup>2</sup>	116	824	2017 - 2067	67	-
	Labrador – NFLD Island Link	1,473 <sup>2</sup>	127		2017-2067		
<b>Thermal Generation</b>	Greenfield CT	48	167	50	2015-2039	13	1.1
	Greenfield CCCT <sup>3</sup>	47	610	170	2040-2067	65	1.1
<b>Existing Projects</b>	Holyrood Units 1,2,3	-	1,647	466	- 2021, standby after 2017	48	Declines 3% until close (2021)
	Hardwoods CT	-	173	55	- 2022	13	1.1

	Stephenville CT	-	195	55	- 2024	13	1.1
<b>Total CAPEX</b>	CPW of \$6.7 billion						

Notes:

1. OPEX includes fuel costs where applicable.
2. Debt/Equity ratio of 59/41. Debt interest rate: 8.8 per cent for duration of 30 year loan.
3. Greenfield CCCT to meet demand post 2030 (not provided by Navigant).

## **8.2. NRCAN Project Analysis of Muskrat and Gull**

### **Muskrat - Base Case**

Internal Rate of Return: 7.4%

Capital Costs (2013-2016): \$2.9 billion

	2017	2020	2030	2040	2060	2067
<b>Muskrat Volumes (GWh)</b>						
<b>Muskrat Domestic Volumes (Navigant)</b>	1,900	2,044	2,606	3,322	4,900	4,900
<b>Muskrat non Emera Export Volumes (Navigant)</b>	1,813	1,685	1,237	578	0	0
<b>Muskrat Emera export volumes</b>	950	950	950	950	0	0
<b>Total Muskrat Export Volumes</b>	2,763	2,635	2,187	1,528	0	0

<b>Total Muskrat Volumes</b>	4,663	4,679	4,793	4,850	4,900	4,900
<b>Links</b>						
<b>LIL remaining capacity after Muskrat</b>	2,433	2,417	2,303	2,246	2,196	2,196
<b>MIL remaining capacity after Muskrat</b>	1,179	1,307	1,755	2,414	3,942	3,942
<b>Domestic sales (net of line losses)</b>	1,805	1,941	2,475	3,156	4,655	4,655
<b>Emera export sales (net of line losses)</b>	874	874	874	874	0	0
<b>Remaining Export sales (net of line losses)</b>	1,668	1,551	1,138	532	0	0
<b>Price assumptions (\$/MWh)</b>						
<b>Muskrat Domestic Netback price (Navigant P51)</b>	87	93	113	138	205	235
<b>LIL Toll</b>	34	36	43	53	79	90
<b>Muskrat Delivered Domestic Price</b>	123	130	159	193	287	330

<b>Price for Firm delivered power for Emera volumes</b>	123	130	159	193	287	330
<b>Assumed non-Emera Export price</b>	75	79	97	118	175	201
<b>ML Toll</b>	71	75	91	111	166	190
<b>Total NetBack Revenues (\$)</b>	101,301,613	124,958,813	233,210,786	414,947,500	952,230,013	1,093,812,968
<b>Muskrat Development Costs (\$)</b>						
<b>CAPEX</b>	0	0	0	0	0	0
<b>Muskrat Loan repayment</b>						
<b>Principal repayments</b>	128,872	159,205	322,073	651,555	2,666,524	4,366,602
<b>Interest payments</b>	123,546,682	123,516,349	123,353,481	123,023,999	121,009,029	119,308,952
<b>OPEX</b>	14,000,000	14,856,912	18,110,493	22,076,590	32,804,651	37,682,232
<b>Net Cash Flow</b>	-36,373,941	-13,573,653	91,424,739	269,195,356	795,749,808	932,455,182

**Muskrat - Low Growth Case**

Internal Rate of Return: 5.8%

Capital Costs (2013-2016): \$2.9 billion

	<b>2017</b>	<b>2020</b>	<b>2030</b>	<b>2040</b>	<b>22060</b>	<b>2067</b>
<b>Muskrat Volumes (GWh)</b>						
<b>Muskrat Domestic Volumes (Navigant)</b>	1,900	2,044	2,606	2,606	2,606	2,606

<b>Muskrat non Emera Export Volumes (Navigant)</b>	1,813	1,685	1,237	1,237	1,237	1,237
<b>Muskrat Emera export volumes</b>	950	950	950	950	0	0
<b>Total Muskrat Export Volumes</b>	2,763	2,635	2,187	2,187	1,237	1,237
<b>Total Muskrat Volumes</b>	4,663	4,679	4,793	4,793	3,843	3,843
<b>Links</b>						
<b>LIL remaining capacity after Muskrat</b>	2,433	2,417	2,303	2,303	3,253	3,253
<b>MIL remaining capacity after Muskrat</b>	1,179	1,307	1,755	1,755	2,705	2,705
<b>Domestic sales (net of line losses)</b>	1,805	1,941	2,475	2,475	2,475	2,475
<b>Emera export sales (net of line losses)</b>	874	874	874	874	0	0
<b>Remaining Export sales (net of line losses)</b>	1,668	1,551	1,138	1,138	1,138	1,138
<b>Price assumptions (\$/MWh)</b>						



<b>Muskrat Domestic Netback price (Navigant P51)</b>	87	93	113	138	205	235
<b>LIL Toll</b>	34	37	45	54	81	93
<b>Muskrat Delivered Domestic Price</b>	124	131	160	195	290	333
<b>Price for Firm delivered power for Emera volumes</b>	124	131	160	195	290	333
<b>Assumed export price</b>	75	79	97	118	175	201
<b>ML Toll</b>	61	65	79	97	144	165
<b>Total NetBack Revenues (\$)</b>	125,104,390	149,090,523	257,801,639	314,258,760	427,408,334	490,957,827
<b>Muskrat Development Costs (\$)</b>						
<b>CAPEX</b>	0	0	0	0	0	0
<b>Muskrat Loan repayment</b>						
<b>Principal repayments</b>	128,872	159,205	322,073	651,555	2,666,524	4,366,602
<b>Interest payments</b>	123,546,682	123,516,349	123,353,481	123,023,999	121,009,029	119,308,952
<b>OPEX</b>	14,000,000	14,856,912	18,110,493	22,076,590	32,804,651	37,682,232
<b>Net Cash Flow</b>	-12,571,164	10,558,057	116,015,593	168,506,616	270,928,129	329,600,041

**Gull Island – High Price Case**

Internal Rate of Return: 12.9%

Capital Costs (2017-2020): \$4.9 billion

The Loan repayment schedule reflects the economic life of the project, which is assumed to be 100 years for this calculation. The toll is imputed from Nalcor's response to the Panel's Information Request of March 21, 2011.

	2021	2030	2040	2060	2067
<b>Gull Island - 2250 MW</b>					
<b>Market Volumes (GWh) (Nalcor)</b>	10,950	10,950	10,950	10,950	10,950
<b>Volumes less 5% line losses</b>	10,403	10,403	10,403	10,403	10,403
<b>Average Portfolio price (\$/MWh)</b>	94	124	151	224	258
<b>Toll</b>	50	59	72	108	124
<b>Netback Price</b>	44	65	79	117	134
<b>Gross Revenue</b>	460,483,771	671,631,822	817,099,792	1,214,167,308	1,394,696,585
<b>CAPEX - Development Costs (\$)</b>	0	0	0	0	0
<b>Loan repayment</b>					
<b>Principal repayments</b>	262,010	493,987	999,339	4,089,848	6,697,384
<b>Interest payments</b>	251,183,749	250,951,772	250,446,420	247,355,911	244,748,375
<b>OPEX</b>	15,154,050	18,110,493	22,076,590	32,804,651	37,682,232
<b>Net Cash Flow</b>	193,883,962	402,075,570	543,577,443	929,916,898	1,105,568,594

#### **Gull Island - Low Price Case**

Internal Rate of Return: 6.5%

Capital Costs (2017-2020): \$4.9 billion

	2021	2030	2040	2060	2067
<b>Gull Island - 2250 MW</b>					
<b>Market Volumes (GWh) (Nalcor)</b>	10,950	10,950	10,950	10,950	10,950
<b>Volumes less 5% line losses</b>	10,403	10,403	10,403	10,403	10,403
<b>Assumed export price (\$/MWh)</b>	81	97	118	175	201

<b>Toll</b>	50	59	72	108	124
<b>Netback Price</b>	31	37	45	67	77
<b>Gross Revenue</b>	323,366,843	386,453,311	471,084,430	700,006,682	804,087,643
<b>CAPEX - Development Costs (\$)</b>	0	0	0	0	0
<b>Loan repayment</b>					
<b>Principal repayments</b>	262,010	493,987	999,339	4,089,848	6,697,384
<b>Interest payments</b>	251,183,749	250,951,772	250,446,420	247,355,911	244,748,375
<b>OPEX</b>	15,154,050	18,110,493	22,076,590	32,804,651	37,682,232
<b>Net Cash Flow</b>	56,767,034	116,897,059	197,562,081	415,756,272	514,959,651

### **8.3. Definition of Terms**

1. Base load (or base load demand): A minimum amount of power that a utility or distribution company must make available to its customers.
2. Capacity factor: A ratio of the actual energy produced in a given period to the maximum possible.
3. Cogeneration: The simultaneous generation of electricity and useful thermal energy (e.g. steam) in one process and from the same source. Types of cogeneration units/systems include condensing steam turbines, combined cycle gas turbines, etc.
4. Electricity generation: The process of generating electric energy by using other forms of energy such as natural gas, wind, hydro, etc.
5. Energy source: The primary source that provides the power that is converted to electricity. Energy sources include coal, petroleum, gas, water, uranium, wind, sunlight, geothermal, and other sources.
6. Generating capacity: The maximum power capability of producing electricity.
7. Grid: An interconnected network for delivering electricity from suppliers to consumers.
8. Kilowatt (kW): A unit of energy power equivalent to 1000 watts. One gigawatt is equal to one million watts (10<sup>9</sup>).
9. Kilowatt hour (kWh): A unit of energy equivalent to 1000 watts of power expended in one hour. 1 kWh is equal to 3.6 megajoules (MJ).
10. Line losses: Energy loss from transmission of electrical energy across power line and in distribution systems.
11. Megajoule (MJ): A unit of measure for energy consumption equal to one million joules (10<sup>6</sup>); and gigajoule is equal to one billion joules (10<sup>9</sup>).
12. Renewable energy: An energy source which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are naturally replenished.

[1] See pages 9 – 12, Connections – An Energy Strategy for the Future, Economic Council of Canada 1985

[2] *Energy Plan*, page 48.

[3] Statistics Canada, Spending Patterns in Canada, Catalogue no 602-202

[4] CAGR – cumulative average annual growth rate.

[5] Floor space is a variable that has been developed and is maintained by Informetrica Limited, Ottawa.

[6] Transfer capability to and from Nova Scotia is constrained by the import and export limits of the Nova Scotia electricity system.

[7] Electricity Industry Issues Table Foundation Paper, prepared for the Electricity Industry Issues Table, 1999 (unpublished).

[8] Nalcor response to Panel Information Request March 21, 2011. April 1, 2011.

[9] Navigant, Independent Supply Decision Review, Sept 14, 2011, page 33.

[10] Navigant, Independent Supply Decision Review, Sept 14, 2011, page 15.

[11] Navigant, Independent Supply Decision Review, Sept 14, 2011, page 13.

[12] Combined cycle combustion turbine

[13] Conservation and Demand Management (CDM)

[14] Petroleum Intelligence Research Associates

[15] Navigant op cit. Page 55

[16] Capacity factor is used to convert capacity to electricity output. For example, a 500 MW combined cycle combustion turbine burning natural gas has, according to Nalcor/Navigant's assumptions a heat rate of about 7mmBtu/MWh. Therefore, the unit operating at 100% capacity would use:

$500 \text{ MW} \times 7 \text{ MMBtu per MWh} \times 24 \text{ hours} \times 1 \text{ Mcf per MMBtu} = 84,000 \text{ Mcf/day}.$

If the plant were operating at 50 per cent capacity then it would use 50 per cent of 84,000 Mcf/day or 42,000 Mcf/day.

[17] HQT and OATT refer to the Hydro Quebec transmission and open access transmission tariff.

[18] Nalcor Response to Panel Information Request March 21, 2011, page 11.

[19] Navigant, page 52

[20] NEB, *Monthly Electricity Exports and Imports*, December 2010.

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