V2 draft

Introduction

Newfoundland and Labrador Hydro (NLH) is vested with the responsibility to plan the Island's power grid to ensure that there are sufficient resources in line to meet expected demand, commensurate with the established reliability criteria. Consistent with this mandate, each and every year NLH initiates an internal planning process to review the requirement for, and timing of, new electric power generation capability for the interconnected electricity network on the Island of Newfoundland. This analysis evaluates approved power system planning criteria against the latest long term forecast for electricity demand and prepares a least cost generation expansion plan utilizing identified supply resources. The analysis commences with the Planning Load Forecast (PLF) and then shifts to generation expansion analysis power grid expansion and production costing.

Planning Load Forecast

This review utilizes the 2010 Planning Load Forecast (PLF) as prepared by the Market Analysis section of the NLH System Planning department. NLH maintains econometric models for utility electricity demand on the Island of Newfoundland which are updated and reforecast every year. Utility demand represents the requirements of Newfoundland Power and NLH's island rural interconnected customers. Econometric analysis consists of multivariate regression equations that model various domestic and commercial electricity requirements as a function of population, income or gross domestic product (GDP), prices, housing and commercial stock, weather, and efficiency gains. Modeling for the Island grid encompasses a 35 year historical period from the late 1960s to the present using historical data. Each year, a 20 year forecast for the provincial economy is provided by Department of Finance, Government of NL and consists of projections on GDP, population, personal income, housing starts, etc. An important consideration for local electricity demand forecasting purposes is that NLH has the Department of Finance adjust total provincial GDP to exclude resource revenues accruing to interests external to the Province (i.e. the gross value (and swings) of oil production are essentially excluded from GDP. *subject to check*)

Electricity prices are generated through an internal iterative analysis of generation expansion analysis and projected NLH revenue requirements to derive wholesale and retail prices based on the expansion sequence. Local fuel oil prices for NL, including residential fuel and Holyrood heavy fuel oil, are derived from services received under a retainer contract with the PIRA Energy Group. In contrast with econometric based utility forecasts, NLH's direct industrial customers (North Atlantic Refining, Kruger, Teck, IOC, Vale) are contacted directly and production expectations and associated power requirements both short and long term are evaluated.

The Island load forecast is extended beyond the 20 year forecast horizon based initially on the average growth in energy for the last five years in the forecast. For the 2010 PLF, this is the period from 2024 to 2029 and primarily reflects ongoing basic economic growth. The annual growth in energy is subsequently reduced in 5 to 10 year intervals to reflect growing maturing

market saturation for electricity in heating markets but with an underlying modest economic growth.

Generation Expansion Analysis

To prepare a least cost generation expansion plan for any given load forecast, NLH uses Ventyx's Strategist software. Strategist is an integrated strategic planning computer program that allows modeling of the current and future generation system and that performs, amongst other functions, generation system reliability analysis, production costing simulation and generation expansion planning analysis. Given the current generation system, available resource options, a load forecast and other inputs, as will be described, algorithms within Strategist will evaluate all of the various combinations of resources and produce a number of generation expansion plans, including the least cost plan, which supplies the load forecast within the context of the power system reliability criteria.

The outcome of the generation planning analysis is a metric called Cumulative Present Worth (CPW), which is the present value of all incremental utility capital and operating costs incurred by NLH to reliably meet a specific load forecast given a prescribed set of reliability criteria. Where the cost of one alternative supply future for the grid has a lower CPW than another, the option with the lower CPW will be recommended by NLH, consistent with the provision of mandated least cost electricity services. From a financial planning perspective, the supply future with the lowest CPW will translate into the lowest overall revenue requirements that would be recovered from ratepayers based on established regulated cost of service principles. When NLH states that Muskrat Falls is the least cost option for the Island, it says so in this generation planning context: the electricity supply future with Muskrat Falls power delivered across a transmission interconnection from Labrador will have a lower CPW than a supply future for an isolated Island grid that entails a continued and progressive reliance on thermal power. It should be noted that production costing and the derivation of a CPW is with respect to the marginal and incremental utility costs for the power system and do not include the existing fixed and common costs associated with generation production across alternate expansion cases. Fixed and common costs would refer to operating and maintaining (O&M) expenses for the existing fleet of hydro plants and associated capital charges for such assets. Such existing and fixed common costs are accounted for when a full revenue requirement analysis is required for NLH that would effectively combine the existing and future rate base elements.

Generation Expansion Analysis – Reliability Criteria

At the generation level, NLH has long-established and approved criteria related to the appropriate reliability for the total Island system and it is these criteria that determine the timing of generation resource additions. These criteria set the minimum level of reserve capacity installed for the power system to ensure an adequate generation supply for firm load. Short-term deficiencies may be tolerated where a deficiency is determined to be of minimal incremental risk. Hydro's system planning criteria are:

Capacity: The Island Interconnected System should have sufficient generating capacity to satisfy a Loss of Load Hours (LOLH) expectation target of not more that 2.8 hours per year.

Energy: The Island Interconnected System should have sufficient generating capability to supply all of its firm energy requirements with firm System capability[1].

Generation Expansion Inputs

In preparing to carry out a generation expansion exercise, the inputs into the Strategist model are reviewed and updated as required. Key inputs and parameters are as follows:

1) Time period of study – The time period that the study will cover must be defined and all other inputs must be developed to cover this period. The time period for the 2010 expansion analysis was extended to 50 years in order to cover the economic life for the Labrador – Island transmission system.
2) Planning Load Forecast (PLF) – As described earlier, an annual load forecast of peak demand and energy for the Island interconnected grid is prepared.
3) Load shape – Hourly load shapes for each month of the year are required. Hydro uses one week to represent each month with inputs developed by NLH based on hourly system load readings.
4) Escalation Series – Current escalation rates for capital and O&M are developed annually within NLH based on external projections received from the Conference Board of Canada and Global Insight. NLH develops weighted cost indices for its core plants and uses projections on various producer price indices from Global Insight to drive its escalation indices.
5) Heavy Fuel Oil and distillate market prices– NLH has a retainer services contract with the PIRA Energy Group of New York, a leading international supplier for energy market analysis and forecasts, and oil market intelligence in particular. NLH regularly updates its long term projections for the beginning of each expansion analysis. Such fuel oil market based price forecasts are used in production costing for the existing Holyrood and combustion turbine (CT) thermal plants, plus for any new combined cycle combustion turbines (CCCTs) that would be constructed in future periods. .
6) Discount Rate – The generation expansion analysis for 2010 used a discount rate of 8.0 percent, reflecting NLH's projection for its weighted cost of capital as of January 2010. All costs are modeled in current (as spent) Canadian dollars, and the results discounted to the base year of 2010.
7) Capital Cost Estimates – Capital costs estimates for a portfolio of alternative generation assets are collected together for inputs based on formal feasibility studies and estimates as developed by consultants and NLH's Project Execution and Technical Services (PETS) Department.

[1] Firm System capability for the hydroelectric system is the energy capability of the system under the most adverse three-year sequence of reservoir inflows occurring within the historical record. Firm energy for the thermal resources (Holyrood) is based on energy capability adjusted for maintenance and forced outages.

8) Power Purchase Agreements (PPAs) – The annual power purchase expense incurred by NLH under existing PPAs, and future PPAs as applicable, are accounted for.
9) Service Life/Retirements – The service life and retirement dates for existing and new generation asset must be defined for the Strategist expansion analysis as thermal plant replacement is an important component of generation planning and costing. Service lives are defined internally with NLH Operations and PETS departments.
10) O&M Costs – Non-fuel operations and maintenance costs (O&M) for the resource projects are derived from NLH feasibility studies and its own extensive operating experience. These O&M costs are comprised of fixed expenditures related to asset maintenance and variable costs driven by production output.
11) Thermal Heat Rates – Per unit fuel consumption of existing and future thermal generation sources are important inputs in production costing. The heat rates utilized in Strategist reflect a combination of NLH's operating experience, plus external studies and estimates.
12) Existing hydroelectric and wind energy – The monthly and annual average and firm energy production forecasts for all of the existing hydroelectric plants and wind farms are updated by NLH Operations to incorporate the latest historical data and operational factors. Production forecasts from new renewable plants are based on engineering studies and/or estimates.
13) Asset Maintenance Scheduling – Outages schedules to accommodate annual maintenance for each existing and future generation asset must be included in the Strategist analysis. Such maintenance scheduling is largely based on NLH operational experience.
14) Forced Outage Rates – All generation production units have an associated involuntary forced outage rates leading to the unavailability of a generating unit. The forced outage rates used by NLH are based on its own operations experience and/or industry norms as tabulated by the Canadian Electrical Association.
15) Generation Unit Capacities – the installed and net capacities of existing and future generation assets are reviewed and updated based on operational experience or external inputs as applicable.
16) A general framework for environmental externality costing mechanisms for CO_2, NO_X, SO_X and SO_2 atmospheric emissions are provided for but not yet included in base CPWs owing to prevailing uncertainties regarding the timing, scope, and design associated with possible future regulatory initiatives in this regard.
17) Energy efficiency is integrated into NLH's PLF through the use of an efficiency trend variable. The success associated with utility sponsored energy efficiency remains modest and is taken as a subset of efficiency trends in the load forecast process.

Generation Expansion Plans – Isolated Island Option versus Labrador Interconnection Option

In order to compare the utility costs associated with the Island's power supply under a continuation of the existing Isolated Island option, in contrast to utility costs incurred where the Island grid is supplied with energy from the Muskrat Falls facility on the Churchill River across, a high voltage direct current (HVdc) transmission interconnection to Labrador, two parallel

generation expansion analyses were carried out. All inputs for both options were updated using the same data or sources as applicable. NLH decided to analyse the same PLF under both alternatives for reasons of CPW comparability, but also because the per unit economics of the Labrador option would be more unfavourably positioned. This latter view derives from the observation in the presence of long term stable power rates, which are declining in real monetary terms, some additional load growth would typically be encouraged.

Isolated Island Expansion Plan

All baseload thermal units are defined to be CCGT's utilizing No. 2 distillate fuel oil. These units are judged to be more economic than a continuation of s ingle cycle heavy fuel oil units as presently exist at Holyrood – a conclusion reinforced by consideration of atmospheric emissions and the potential costs and penalties related thereto. Local offshore natural gas was not considered as a thermal fuel supply for the simple reason that there is no existing commercial production of offshore gas, and nor are there yet any plans on the horizon for such resource development. Under such a circumstance, it would not be responsible for NLH to assume a future natural gas supply that may never materialize. Some consideration has been afforded liquefied natural gas (LNG) procured on international markets but engineering and costing have not been advanced. NLH observes that in international markets, long term firm supplies of LNG to utilities tend to be priced against oil. Nuclear options have not been considered for the Isolated Island option due to provincial law that forbids the construction of such power supply within the province. NLH has not considered the use of coal fired generation due to environmental liability considerations.

The Isolated Island expansion plan proceeds with known and feasible hydroelectric and wind renewables on the Island up to 2020 to meet load growth. Thereafter, to the end of the study period, outside of replacing the three wind farms, all new generation plant is thermal, representing a combination of CTs and CCGTs, whether to accommodate incremental load growth relative to reliability requirements or for thermal unit replacements. The first large scale replacements for the isolated island alternative are of course for the three Holyrood oil-fired units in the 2033-2036 period. In the interim, Holyrood would have required expensive environmental and life extension capital programs. The generation expansion sequence for the Isolated island alternative is presented in Table 1 below.

Labrador HVdc Interconnection and Muskrat Falls expansion Plan

For the Labrador Interconnection alternative, the HVdc transmission link is brought into service for January 2016 as commissioning proceeds on the generating units at the Muskrat Falls hydroelectric plant for a commercial in-service target of mid-year. This transmission interconnection has a capacity to supply 900 MW of power and energy from Labrador to the Island and is essentially treated by Strategist as an unrestricted thermal supply source. Thus it can displace Holyrood and meets the Island's incremental load growth for years to come.

Initially, NLH plans to keep Holyrood 'hot' as the Labrador HVdc interconnection and power supply is integrated into the existing power system operations on the Island. After a year or two, Holyrood will go 'cold' and NLH would expect, by the 5th year, to commence dismantling

the majority of the thermal plant. The existing generators at the Holyrood plant will be retained for synchronous condenser operation for power grid voltage stability purposes. Following the commissioning of the Labrador HVdc, the island's additional capacity additions are driven by the requirement to conform to the capacity reliability criterion referenced above. CTs would normally be used exclusively for such planning purposes, but there can be circumstances where Strategist may call on other resources depending on the extent and cost to address the capacity criterion violation. The generation expansion plan for the Labrador HVdc Interconnection Muskrat Falls supply is also contained for review in Table 1 below.

In the Labrador Interconnection alternative, the in-service capital cost of the HVdc transmission asset itself is modelled as any other generating capital item for production costing purposes. The price for energy sourced to Muskrat Falls is an input to the Strategist Labrador supply expansion plan. An important outcome from the technical Strategist analysis is the identification energy requirements from Labrador across the Labrador HVdc Interconnection. Once Holyrood is removed as a supply source in the modeling environment, Strategist will identify the replacement energy for Holyrood and all incremental load growth going forward, up to the capacity of the LIL, as being available from Labrador. Once this Energy Over the Infeed (EOI) requirement has been identified, it is priced by assuming that a Power Purchase Agreement (PPA) is in place between Nalcor Energy and NLH. The price at which Nalcor sells energy to NLH is that price which provides Nalcor Energy will a return to capital consistent with returns in the regulated utility sector. Nalcor Energy had calculated that the cost out price for Muskrat Falls energy, assuming 100% equity, and a threshold return on equity of 11% assuming firm power, was $75.82 /MWh in 2010$ (escalating at 2% annually). When analyzing a circumstance where the only customer for Muskrat Falls is NLH for supply to the Island, with the remainder of the energy production potential spilled, the power purchase value for NLH was maintained at $76 /MWh so that island ratepayers would not be penalized for Muskrat Falls costs spread over less energy production. For this so-called Spill Case, with Nalcor supplying only the Island at $76 /MWh (escalating) the resulting return to capital of 8.4% was observed. This return is consistent with the applicable return on equity for Newfoundland Power in 2011. On this basis, Nalcor Energy believes that the proposed PPA price applicable for NLH and Island ratepayers is reasonable.

The CPWs

As noted, the generation expansion analysis for 2010 used a discount rate of 8.0 percent that reflecting Hydro's projection for its long run weighted cost of capital. All costs are modeled in current (as spent) Canadian dollars, and the results discounted to the base year of 2010. The CPW associated the isolated island is $8,810 million (2010$) and for Labrador Infeed is $6.652 million, for a least cost preference for the Labrador Interconnection option of $2,158 million

(2010$). The least cost[2] generation expansion plan under the 2010 PLF is shown below in Table1.

	Table 1: 2010 PLF Strategist Generation Expansion Plans	
	Isolated Island	**Labrador HVdc Interconnection and Muskrat Falls**
	PLF 2010	**PLF 2010**
2010		
2011		
2012		
2013		
2014	25 MW Wind	50 MW CT
2015	36 MW Island Pond Holyrood ESP & Scrubbers	
2016	Holyrood Upgrade	
2017	Hoyrood Low Nox Burners	Hoyrood Unit 1 Syn Condenser 900 MW Labrador Interconnection
2018	23 MW Portland Creek	
2019	Holyrood Upgrade	
2020	18 MW Round Pond	
2021		
2022	170 MW CCCT	
2023		
2024	50 MW CT Holyrood Upgrade	
2025		
2026		
2027	50 MW CT	
2028	Replace 2 Existing Wind Farms (~50 MW)	
2029	Holyrood Upgrade	
2030	50 MW CT	
2031		
2032		

[2] For Hydro, the term "least cost" refers to the lowest Cumulative Present Worth/Value (CPW) of all capital and operating costs associated with a particular incremental supply source (or portfolio of resources) over its useful economic life, versus competing alternatives or portfolios. CPW concerns itself only with the expenditure side of the financial equation. *The lower the CPW*, the lower the revenue requirement for the utility and hence, the lower the electricity rates will be. By contrast, the term Net Present Value (NPV) typically refers to a present value taking into account both the expenditure and revenue side of the financial equation, where capital and operating expenditures are negative and revenue is positive. The alternative with *the higher NPV* has the greater return for the investor. What CPW and NPV have is common is that that they are both techniques of discounted cash flow analysis. Outside of that, CPW and NPV are conceptually and numerically different values.

2033	Holyrood Replacement (2 units) 170 MW CCCT 170 MW CCCT	
2034	Replace 2014 Wind Farm (~25 MW)	
2035		
2036	Holyrood Replacement (3rd unit) 170 MW CCCT	23 MW Portland Creek
2037		170 MW CCCT
2038		
2039		
2040		
2041		
2042	50 MW CT	
2043		
2044		
2045		
2046	50 MW CT	50 MW CT
2047		
2048	Replace 2 Existing Wind Farms (~50 MW)	
2049	50 MW CT	
2050	170 MW CCCT	50 MW CT
2051		
2052	170 MW CCCT	
2053		
2054	Replace 3rd Wind Farm (~25 MW)	50 MW CT
2055		
2056	170 MW CCCT	
2057		
2058	50 MW CT	50 MW CT
2059		
2060		
2061		
2062		
2063	50 MW CT 170 MW CCCT	50 MW CT
2064	50 MW CT	
2065		
2066	170 MW CCCT	50 MW CT
2067	170 MW CCCT	
CPW $ MM	$8,810	$6,652