6 Thermal Generating Stations

6.1 Introduction

The Island of Newfoundland relies heavily on existing thermal power sources to supply energy (33% in 2010). The Holyrood Thermal Generating Station (HTGS) and two CTs (110 MW) are currently used by Nalcor to satisfy load requirements. In both Options, thermal generation will be used to supplement the energy and capacity requirement to meet the reliability criteria.

The Infeed Option includes the addition of 520 MW of thermal generation using combustion turbines. This generation plan includes:

- Synchronous condenser conversion projects at HTGS for units 1 and 2 plus some life extension work to keep the plant running as synchronous condensers (2041).
- 7 - 50 MW new Combustion Turbines (CT).
- 1 - 170 MW new Combined Cycle Combustion Turbine (CCCT).

The Isolated Island Option is largely a thermal generation plan with the addition of 1,640 MW of CTs and CCCTs. The Isolated Island Option generation plan includes:

- Installation of environmental emissions controls at HTGS (electrostatic precipitators, scrubbers and low NOx burners).
- Life extension projects at Holyrood with eventual replacement of the units in 2033 and 2036 with 3 – 170 MW CCCTs.
- 9 - 50 MW new CTs.
- 7 - 170 MW new CCCTs.

The Infeed Option contains significantly less thermal generation than the Isolated Island Option. By 2067 there still will be some thermal generation emissions as the HTGS is decommissioned and 520 MW of CCCTs and CTs are added primarily as peaking units. The Isolated Island Option, with 1640 MW of new thermal and 510 MW of replacement thermal for HTGS, will emit significantly more greenhouse gases (GHG).

Exhibit 16, page 27, states that "….the current Provincial Government 25,000 tons per year limitation on SO_X emissions from the HTGS, have traditionally been included in generation planning studies."[53] The 25,000 tonnes per year limitation on SO_X emissions from HTGS commenced in 1991. To date, the only year that annual emissions exceeded 25,000 tonnes was in 1989, when the SOx emissions at HTGS totaled 25,900 tonnes[54]. However, if 0.7% sulphur content fuel continues to be used at the facility, this target will not be exceeded in the future even when the load factor is increased.

[53] Exhibit 16, Nalcor, "Generation Planning Issues 2010 July Update", July 2010
[54] Response to RFI PUB-Nalcor-17

Even though Nalcor has projected a capital cost of $603 million for an environmental equipment upgrade, this investment will not reduce GHG emissions, which are expected to increase as the load factor of the plant increases. Should the GHG emission standard change through public policy to a lower target, there is the risk that an oil fired facility such as HTGS may not be able to operate in the long term. The proposed pollution control upgrades for HTGS under the Isolated Island Option meet the Newfoundland and Labrador Energy Plan's commitment to address environmental concerns at HTGS.

6.2 Holyrood Thermal Generating Station

HTGS located on the south shore of Conception Bay, consists of three heavy fuel oil boilers for a combined net generating capacity of 466 MW. HTGS currently supplies approximately one third (up to 2,996 GWh annually) of the island's existing firm energy. The plant normally operates all three units during the highest customer demand periods of December through to March. HTGS production and operating factor can vary from year to year depending on the amount of hydraulic energy production, weather conditions, and industrial load requirements. HTGS Unit 3 generator is capable of synchronous condenser operation to assist in voltage control during the off peak season. HTGS Units 1 and 2 are over 40 years old and Unit 3 has exceeded 30 years of service.

As HTGS uses heavy fuel oil, it is a significant source of pollution emissions within Newfoundland and the amount of emissions is proportional to energy production. Nalcor has stated that environmental stewardship is one of its guiding principles as documented within the provincial energy plan (Focusing Our Energy: Newfoundland and Labrador Energy Plan).[55] HTGS does not currently employ environmental equipment to control SO_X or particulate emissions.

MHI's thermal specialists performed an assessment of the various options for HTGS and the planned CTs and CCCTs in meetings with Nalcor, a review of available documentation, and responses to RFIs.

6.3 Thermal Generation Options

Nalcor has investigated various options to upgrade or replace HTGS, which is approaching its end of service life. The initial screening study performed by AMEC[56] concluded that the HTGS life could be extended if capital investments were made for the refurbishment or replacement of critical plant equipment. Studies completed by Stantec[57] and Alstom[58] were made regarding the addition of pollution control equipment at HGTS in order to comply with the Government's directive on the addition of such equipment, if continued operation of the HTGS is required. Additional studies also concluded that CTs and CCCTs burning light fuel oil could be utilized on the island.

[55] Government of Newfoundland and Labrador, "Focusing Our Energy: Newfoundland and Labrador Energy Plan," 2007
[56] Exhibit 44, AMEC, "Newfoundland and Labrador Hydro, Holyrood Thermal Generating Station Condition Assessment & Life Extension Study", January 2011
[57] Exhibit 5-L-I, Stantec, "Precipitator and Scrubber Installation Study Holyrood Thermal Generating Station", November 2008
[58] Exhibit 68, SGE Acres, "Air Emission Controls Assessment – Holyrood Thermal Generating Station Final Report", February 2004

6.3.1 Isolated Island Option Thermal Plan

The Isolated Island Option expansion plan includes the continued operation of HTGS with the addition of pollution abatement equipment and life extension and upgrade investments to allow the operation of the plant to 2033 (units 1 & 2) and 2036 (unit 3). After this date the HTGS would be replaced with CCCT technology. The schedule and costs for the thermal capital works and retirements are outlined in Table 11.

Table 11: Isolated Island Option Thermal Plan

Isolated Island Option Thermal Plan			
Thermal Related Installations, Life Extensions & Retirements			
Year	**Description**	**Costs (millions)**	**Retirements**
2015	Holyrood ESP & Scrubbers	$582	
2016	Holyrood Life Extension (5-yr $20 M /yr)	$100	
2017	Holyrood Low NOx Burners	$20	
2019	Holyrood Upgrades	$121	
2022	170 MW CCCT (Greenfield)	$282	Hardwoods CT (50MW)
2024	50 MW CT (Greenfield) Holyrood Upgrades	$91 $9	Stephenville CT (50MW)
2027	54 MW CT (Greenfield)	$97	
2029	Holyrood Upgrades	$4	
2030	50 MW CT (Greenfield)	$103	
2033	Holyrood U1 Replacement - 170 MW CCCT Holyrood U2 Replacement - 170 MW CCCT	$346 $447	Holyrood Unit 1 (161.5 MW) Holyrood Unit 2 (161.5 MW)
2036	Holyrood U3 Replacement - 170 MW CCCT	$492	Holyrood Unit 3 (142.5 MW)
2042	50 MW CT (Greenfield)	$130	
2046	50 MW CT (Greenfield)	$141	
2049	50 MW CT (Greenfield)	$149	50 MW CT
2050	170 MW CCCT (Greenfield)	$477	
2052	170 MW CCCT (Greenfield)	$665	50 MW CT & 170 MW CCCT
2056	170 MW CCCT (Greenfield)	$534	
2063	50 MW CT (Greenfield) - 2 Units 170 MW CCCT (Greenfield)	$395 $818	2 x 170 MW CCCT
2064	50 MW CT (Greenfield)	$201	
2066	170 MW CCCT (Greenfield)	$645	170 MW CT
2067	170 MW CCCT (Greenfield)	$882	50 MW CT

6.3.2 Infeed Option Thermal Plan

Under the Infeed Island alternative the HTGS would be required to operate as is until at least 2017 then maintained in standby mode for power generation from 2017 to 2021. HTGS would primarily be operated in synchronous condenser mode from 2017 onwards. The schedule and costs for the thermal capital works and retirements for the Infeed Option are outlined in Table 12.

Table 12: Infeed Option Thermal Plan

Infeed Option Thermal Plan			
Thermal Related Installations, Life Extensions & Retirements			
Year	**Description**	**Costs (millions)**	**Retirements**
2014	50 MW CT	$75	
2017	Holyrood Units 1 & 2 Synchronous Condenser Conversion	$3	
2021	Holyrood decommissioning begins	$15	Holyrood Unit 1 (161.5 MW) Holyrood Unit 2 (161.5 MW) Holyrood Unit 3 (142.5 MW)
2022			Hardwoods CT (50 MW)
2024			Stephenville CT (50 MW)
2025			
2029	Holyrood decommissioning complete	$12	
2037	170 MW CCCT (Greenfield)	$373	
2039			50 MW CT
2041	Holyrood Synchronous Condensers decommissioned		Units 1, 2, and 3.
2046	50 MW CT (Greenfield)	$141	
2050	50 MW CT (Greenfield)	$152	
2054	50 MW CT (Greenfield)	$165	
2058	50 MW CT (Greenfield)	$179	
2063	50 MW CT (Greenfield)	$197	
2066	50 MW CT (Greenfield)	$209	
2067			170 MW CCCT

6.4 Holyrood Thermal Generating Station Pollution Control Equipment Upgrades

With the Isolated Island Option, Units 1 and 2 of the HTGS would continue operating until 2033, and Unit 3 until 2036, when the station would be replaced. The station would require various upgrades to continue operating as a generating plant, where most of these upgrades involve the addition of pollution control equipment including electrostatic precipitators, scrubbers, and low NOx burners required to meet Government's directive.

Nalcor has committed to install equipment to control SOx and particulates at HTGS if the Lower Churchill Project does not proceed[59]. This decision complies with the Newfoundland and Labrador Energy Plan by addressing environmental concerns at HTGS. HTGS currently meets SOx emission limits specified in the Certificate of Approval - AA06-025458B, and has only exceeded these limits once during heavy operation.

[59] Exhibit 68, SGE Acres Limited, "Final Report: Air Emissions Controls Assessment – Holyrood Thermal Generating Station", February 2004

Meetings with Nalcor staff have indicated that the upgrade to low NOx burners has been under consideration for many years, on the assumption that future regulatory requirements would mandate their replacement. It is standard industry practice in North America to invest in NOx burner upgrades, which have a small capital commitment when installed along with other major emission control upgrades.

The level of detail in the studies for the addition of pollution control equipment was adequate, and the related cost estimates are reasonable and in line with industry norms.

6.5 Holyrood Thermal Generating Station Life Extension

Life extension of the HTGS was reviewed under both options. The initial Holyrood Phase 1 Condition Assessment and Life Extension Study (non-intrusive analysis) completed by AMEC does not address life extension requirements for the Isolated Island Option. The study of the life extension of the plant for continuous operation until 2015, and synchronous condenser operation until 2041, was detailed. It thoroughly reviewed the main equipment and systems and developed a detailed list of requirements for a more in-depth analysis, inspections, the tests required, and estimated costs associated with this work in phase 2 of the study. The study concluded that HTGS is a relatively modern design, is well maintained, and is in good condition for its age.

The costs included in the study are mainly related to the inspections and tests for Phase 2 of the life extension study. The life extension costs themselves are high level, and subsequent study phases would need to be completed to provide more detailed line item costs for components such as the marine terminal, transformers, and switchyard.

Meetings with Nalcor and responses to the Board's letter of July 12, 2011 (Exhibit 28) indicate that values included in the 2010 Capital Budget of $100 million ($20 million per year from 2012 to 2016) for the Holyrood Life Extension for the Isolated Island Option were not based on detailed engineering.[60] However, the values do offer a conservative order of magnitude representation of the sustaining capital required for the plant.

The CPW inputs also include HTGS life extension costs for major overhauls for Boilers No. 1 – 3 in 2015 – 2019, steam turbine overhaul costs in 2015 and 2016, as well as other minor upgrades in years 2024 and 2029[61]. This cost estimate provides a reasonable order of magnitude for life extension work of the HTGS plant to 2033/2036.

Based on industry experience, even with life extension, operation beyond 50 years to a maximum of possibly 60 years, with reduced reliability, may not be practical.

[60] Exhibit 28, Board Letter – July 12th, 2011
[61] CE-39 MHI-Nalcor-1 CPWDetails

6.6 Holyrood Thermal Generating Station Replacement

For the Isolated Island Option, the HTGS plant replacement is planned to consist of three, 170 MW No. 2 low sulfur oil-fired CCCTs. The turbines would be installed in 2033 for Units 1 and 2, and in 2036 for Unit 3.

The cost for the first unit would be higher since there would be significant costs incurred for transmission connection, fuel supply, black start capability, etc. which would not be required for the 2nd and 3rd units. The resulting base cost estimate for the first unit included in Exhibit 5 Summary-Capital Costs Estimates is $273.9 million.

MHI used GTPro/Peace software, a well-known combined cycle heat balance and cost estimating program, to assess the plant installation costs in Nalcor's commissioned studies. The cost estimates and power output were found to be reasonable, with modifications applied to the cost for contingency and escalation.

6.7 Simple Cycle Combustion Turbines

CT installations on the island system in both options would have a nominal rating of 50 MW per unit and would be located either adjacent to existing thermal operations or at greenfield sites near existing transmission system infrastructure. Due to the high cost of operations, CTs are generally used for only short periods of time. Due to their low simple cycle efficiency, CTs are primarily deployed for system reliability and capacity support for peak demand. If required, CTs can be utilized to provide firm energy to the system.

The technology proposed and base value of $55 to $60 million for a 50 MW simple cycle No. 2 oil-fired CT installation appear reasonable and in compliance with industry estimates. The cost estimates are based on manufacturer supplied data.

6.8 Combined Cycle Combustion Turbines

A CCCT is more efficient than a simple cycle combustion turbine. A CCCT plant is essentially an electrical power plant in which combustion turbine and steam turbine technologies are used in combination to achieve greater efficiency than would be possible independently. The higher efficiency makes it possible for CCCTs to be competitive for intermediate or base load applications. One of the primary benefits of a CCCT plant is that it can be used as base load power generation. CCCTs are typically configured using larger units of 170 MW.

The Isolated Island Option includes seven greenfield[62] CCCT plant installations between 2022 and 2067. As discussed in Section 10 Volume 2, the CCCT Capital Cost study prepared by Hatch in 2008[63] was used to develop the base cost estimate for a 170 MW greenfield installations for both the Isolated

[62] Definition of greenfield is an undeveloped site, especially one being evaluated and considered for commercial development or exploitation.
[63] CE-46 Rev.2 (Public), Hatch, "PM0011 – CCGT Capital Cost Benchmark Study Final Report", December 2008

Island and Infeed Options. The base cost estimate for the installations was escalated on average by approximately 2% per year to arrive at values used in the CPW analysis. MHI considers this estimate to be reasonable for the study purposes intended.

6.9 Holyrood Thermal Generating Station Synchronous Condenser Conversion

The feasibility study for converting Units 1 and 2 to synchronous condenser operation, Exhibit CE-56 Rev. 1 (Public), covered the main aspects of the electronics, controls, and generator and steam turbine modifications required to allow operation of the generators as synchronous condensers. Unit 3 already has the capability to operate as a synchronous condenser, and therefore conversion is not required.

MHI has concluded that the chosen technology is appropriate and that the cost estimate is acceptable.

6.10 Holyrood Thermal Generating Station Decommissioning

A detailed site assessment study has not been completed for HTGS by Nalcor. As a result, costs allocated for decommissioning the station are high level estimates. Using decommissioning estimates available to MHI from other projects, MHI has determined that the estimate of $27.3 million used by Nalcor is reasonable.

It was noted in the response to RFI MHI-Nalcor-106 that Nalcor plans to continue using the Holyrood site for CCCTs. As a result, the site as a whole would not need to be remediated.

6.11 Thermal Assessment Key Findings

Key findings of MHI's review of thermal projects for both options are as follows:

- The thermal studies related solely to the Isolated Island Option were screening level studies, while there was a great deal more depth to studies of the Infeed Option. The level of detail of studies on upgrading the Holyrood Thermal Generating Station was found to be adequate, and the related upgrade costs are reasonable and in line with industry standards.

- Although the HTGS life extension costs for the Isolated Island Option are not based on detailed engineering studies, the estimates in the CPW analysis are conservative and representative of similar plants. This expenditure is needed to extend the life of the plant as a generating facility to 2033 for units 1 and 2, and 2036 for unit 3.

- Even with life extension under the Isolated Island Option, operating HTGS beyond 50 years, to a maximum of 60 years, with reduced reliability, may not be practical. There may come a point well before 2041 when the plant becomes unreliable to operate. The life extension plan and requirements under the Infeed Option are as follows:

    - 2010 to 2017 Electricity Generation
    - 2017 to 2021 Electricity Generation, as-required primarily on a standby basis
    - 2017 to 2041 Synchronous Condenser Operation – Units 1 and 2 converted to synchronous condenser mode by 2017. Unit 3 is already synchronous condenser capable.

- The technology and base costs assumed for the 50 MW CT and the 170 MW CCCT installations are reasonable. The technology and costs assumed for replacing HTGS using CCCTs under the Isolated Island Option are reasonable based on present utility plant retirements for plants built in the late 1960's and early 1970's.

- A detailed site assessment study for decommissioning the HTGS has not yet been completed by Nalcor. The costs of decommissioning the station are high level estimates, but they are considered reasonable when compared to similar recent projects.