Following are explanations of why each of the above projects is required for the safe, reliable operation of the Holyrood Generating Station while allowing Hydro to meet its mandate for service at least cost.

1. Upgrade Vibration Monitoring Equipment, Units 1, 2 and 3

This project involves the upgrade of the Bently Nevada 3300 series Turbine Supervisory Instrumentation (TSI) system to the 3500 series for the synchronous condensing part of the plant only. The modules that monitor the future synchronous condenser part of the plant and associated diagnostic software will be removed and replaced with the upgraded system. The removed modules will be used as spares for the existing system that monitors the steam turbines in anticipation they will last until the turbines are no longer required for generation. As well, the upgrade will utilize the existing probes. The primary driver for the upgrade is that the existing system technical support from the vendor is limited in that it provides for only repair or exchange of failed components, replacement parts are not available. Operating a 3600 rpm turbine and generator without reliable and accurate vibration monitoring for alarms and tripping is unacceptable for safety and reliability reasons.

2. Install Variable Frequency Drives on Forced Draft Fans

This proposal is a two-year project for the addition of six variable frequency drives (VFDs) on the forced draft (FD) fan motors in the Holyrood Generating Station. The proposal includes the cost to design, procure, install and commission all six VFDs. It also includes the structural steel platform design and installation to mount the six VFDs, the removal of the existing inlet vane and tuning to the control system for this new equipment. This proposal is justified on energy efficiencies with VFDs over the existing inlet vane arrangement to provide cost savings of $7.7M over a four year period.

3. Install Fire Protection Upgrades

The purpose of this project is to implement measures to reduce the likelihood that fuel originating from the No. 6 fuel oil system which in excess of 40 years old will feed an existing fire at the Holyrood Thermal Generating Station (Holyrood). These measures include the installation of concrete curbing around Unit 1 and Unit 3 fuel-pumping skids, the installation of an automatic fuel shut-off valve on the 16 inch diameter No. 6 fuel oil supply pipe from the tank farm, and the application of fireproofing on the pipe supports that carry the indoor section of the 16 inch diameter fuel supply pipe. By implementing these measures at Holyrood, the station will be in a better position to quickly recover from a fire. FM Global, Hydro's insurer, has noted their concern with risk associated with the No. 6 fuel oil systems at

Project Title: Install Variable Frequency Drives on Forced Draft Fans

Location: Holyrood

Category: Generation - Thermal

Definition: Other

Classification: Justified

Project Description:

This project will involve the design, procurement, installation, and commissioning of six variable frequency drives (VFD) units to the existing system at Holyrood. This will enable the six forced draft fan motors to directly adjust the airflow into the boilers as necessary. The ability to directly manipulate the airflow will remove the need for some elements of the existing forced draft system so they will be removed as well. It will also require programming of the Foxboro control system to utilize the new variable speed capabilities of the motors. The budget for the project is shown in Table 1.

Table 1: Budget Estimate

Project Cost:*($ x1,000)*	2013	2014	Beyond	Total
Material Supply	453.9	1,285.0	0.0	1,738.9
Labour	53.9	43.4	0.0	97.3
Consultant	21.0	0.0	0.0	21.0
Contract Work	90.0	523.0	0.0	613.0
Other Direct Costs	37.7	25.5	0.0	63.2
Interest and Escalation	41.1	276.1	0.0	317.2
Contingency	0.0	506.7	0.0	506.7
TOTAL	**697.6**	**2,659.7**	**0.0**	**3,357.3**

Operating Experience:

The generating units at Holyrood have a range of operation between 20 to 105 percent of their maximum capacity rating (MCR). Generally, the units are not operated below 40 percent as these operating levels are highly inefficient. As a generating unit nears 100 percent of its MCR, the efficiency of the constant speed fan motors becomes higher. A majority of each year is spent with the generating units operating at loading levels which are less than its maximum. Regardless of operating level, the forced draft fan motors operate at full speed (1189 RPM) and consume the full 1120 kW of energy on a continuous basis.

Project Title: Install Variable Frequency Drives on Forced Draft Fans **(cont'd.)**

Project Justification:

The installation of VFDs onto the forced draft fan motors at the Holyrood thermal plant will yield significant energy and cost savings for Hydro. This project will yield an average annual fuel savings of $4.7 million while the Holyrood plant is generating electricity when compared to the status quo of constant speed fan motors. The project will cost $3.36 million and will commence in 2013 and be completed in 2014. A detailed analysis shows that the project will pay for itself within less than one year of being put into service in 2014.

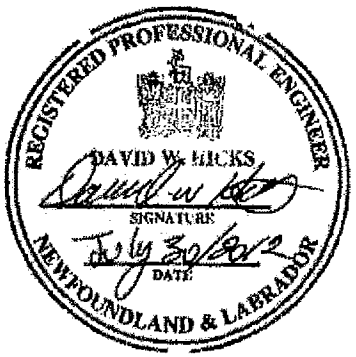
Future Plans:

None.

Attachments:

See report entitled "Install Variable Frequency Drives on Six Forced Draft Fans" located in Volume I, Tab 2, for further project details.

A REPORT TO
THE BOARD OF COMMISSIONERS OF PUBLIC UTILITIES



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System Planning

Install Variable Frequency Drives on Forced Draft Fans

Holyrood Generating Station

June 2012

newfoundland labrador hydro
a nalcor energy company

SUMMARY

The installation of variable frequency drives (VFD) onto the forced draft fan motors at the Holyrood Thermal Plant will yield significant energy and cost savings for Hydro. These savings are achieved by allowing the forced draft fan motors to operate at varying speeds which align with the intake air requirements of the generating units. Currently, the motors operate at a constant speed (1,189 RPM) and energy usage (1,120 kW) which is independent of the air requirements of the generating units. Airflow to the boilers of the generating units is regulated via a mechanical inlet vane which restricts the amount of air pushed in by the fans. The intake fan motors remain at maximum speed but the inlet vane controls the air flow to ensure an appropriate volume of air is supplied to the generating unit.

This project will yield an annual savings of $2.2 million while the Holyrood plant is generating electricity when compared to the status quo of constant speed fan motors. The project will cost $3.4 million and will commence in 2013 and be completed in 2014. A detailed Cost Benefit Analysis shows that the project will pay for itself in less than one year of being put into service in 2015.

TABLE OF CONTENTS

1 INTRODUCTION

The Holyrood Generating Station is a thermal generating plant with three generating units which produce 500 MW for the Island Interconnected System. The thermal generating system uses many systems and sub-systems to generate electricity using the force of high pressure steam to rotate each generator's turbine and generator.

This steam is produced inside an oil-fired boiler which uses a combustion reaction to superheat water. This combustion reaction requires specific amounts of fuel and air. The air supply system for the Holyrood oil-fired boilers is comprised of intake fans powered by 4,160 V motor units which pull air in from outside, ductwork to transport the air to the boiler, and an inlet vane to control the volume of air entering the boiler.

The intake fans are connected to 4,160 V motor units which operate at a constant speed. Operating these motors at a constant speed results in a constant energy usage from each motor as their speeds cannot be adjusted. If a generating unit requires less than 100 percent airflow the inlet vane is adjusted to limit the airflow from the intake fans into the ductwork and boiler. This results in the 4,160 V motors operating at full capacity in situations when maximum airflow is not required by the generating units. For example, if a generating unit required 50 percent airflow the intake motors would continue to run at 100 percent while the inlet vane would be placed into the 50 percent airflow position. These motors consume 1,120 kW of energy when they are operated. Currently at the Holyrood Thermal Plant there are two 4,160 V motors for each of the three generating units for a total of six motors.

There are motor drive units available which can vary their operating speed to directly match the needs of a system. These motor drive units are known as VFD and they are more energy efficient than constant speed motors as they can lower their operating speed to match system needs. A lower operating speed will lower the energy usage of the motor which can

yield significant savings when compared to constant speed motors. Constant speed motors can be converted to variable frequency operation with the installation of a VFD.

This project will involve the design, procurement, installation, and commissioning of six VFD units to the existing system at Holyrood. This will enable the six intake fan motors to directly adjust the airflow into the boilers as necessary. This work will require adding structural enhancements to mount the 3,800 kg VFD equipment to the existing motors. The ability to directly manipulate the airflow will remove the need for the inlet vanes so they will be removed as well. It will also require programming the Foxboro control system to utilize the new variable speed capabilities of the motors.

The reduction in energy usage from installing VFDs with the intake fan motors at Holyrood will yield a cost savings to Hydro. These savings will be presented in this proposal.

2 PROJECT DESCRIPTION

This project will procure and install VFD on each existing forced draft fan motor at the Holyrood Thermal Plant. The VFD units to be installed weigh 3,800 kg and will require appropriate structural enhancements at the plant. The six inlet vanes in the current system will be removed. Finally, the Foxboro control system will be configured to properly utilize the VFD-enhanced motors.

Six VFDs will be procured and installed at the Holyrood Thermal Plant. The minimization of downtime for the generating units will be a priority during project execution. Each generating unit will require two VFDs (one for each forced draft fan motor) and therefore the project will install the VFDs in sets of two per unit.

3 JUSTIFICATION

At the Holyrood Thermal Plant there are a number of support systems which are used in the generating of electricity. These support systems consume electricity themselves. The forced draft fan motors are one of these support systems.

The current configuration for these forced draft fan motors involves their operating at maximum output whenever the generating unit they are connected to is in operation. There are a number of instances throughout the year when the generating unit is not operating at its maximum capacity rating (MCR). If a generating unit is operating both forced draft fan motors connected to it are operating at maximum speed. If the generating unit is not operating at 100 percent MCR then there is wasted production from the forced draft fan motors as they are constant operating speed motors.

Upgrading the forced draft fan motors with VFDs will yield operational savings based on the motors directly matching the air intake requirements of the generating units which will reduce the amount of energy used by the forced draft fan motors. These savings are discussed in Section 3.4.2.

3.1 Existing System

As discussed previously, the supply of air to the boilers of the generating units at the Holyrood Thermal Plant is a key part of the generation process. The current system has six intake fans driven by 4,160 V constant speed motors. Each generating unit has two forced draft fans. These fans supply air to the oil-fired boiler which produces steam for the generating units.

These fan motors operate at a constant speed of 1,189 RPM and consume 1,120 kW of energy. The supply of air to the boiler is controlled via inlet vanes which control the amount of air being supplied by the intake fans. Each intake fan has a corresponding inlet vane

connected to it. The forced draft motors on Units 1 and 2 were replaced in 1991 and Unit 3 has the original motors from 1977. All motors currently installed are constant speed motors.

3.2 Operating Experience

The Hydro methodology for the Island Interconnected System is to operate its hydraulic units on the island at maximum capacity and import as much power as possible to the Avalon Peninsula. Due to transmission line limits and other factors, the level of imported power is not adequate to meet the full load requirements of the Avalon Peninsula. Holyrood units are placed online for operation to meet this deficiency and to meet any peak loading requirements that occur throughout each day. As the ramp-up time on a thermal generating unit is slow, thermal units are base loaded at 40 percent of their MCR to ensure they are ready and available when needed while minimizing ramp-up time.

The generating units at Holyrood have a capability range of operation between 20 to 105 percent of their MCR. Generally, the units are not operated below 40 percent as these operating levels are highly inefficient. The following table describes the typical operating levels for the generating units at Holyrood.

Table 1: Generating Unit Operating Levels

Operating Level (% MCR)	Amount of Time at this Level Per Year
Offline	10%
40	50%
50	10%
60	10%
70	10%
>80	10%

As a generating unit nears 100 percent of its MCR, the efficiency of the constant speed fan motors becomes higher. However, it is clear that a majority of the year is spent with the generating units operating at loading levels which are less than its maximum. Regardless of operating level, the forced draft fan motors are operating at full speed (1,189 RPM) and consuming the full 1,120 kW of energy on a continuous basis.

3.2.1 Environmental Performance

This project will not alter the environmental performance of the Holyrood Thermal Plant. Installing VFDs will result in the motors not using as much energy throughout the year, but will not impact the consumer demand for energy from the generating units.

3.2.2 Industry Experience

The installation of variable frequency drives on large voltage motors is an established industry practice.

3.2.3 Anticipated Useful Life

The anticipated useful life of the forced draft fans and motors is for the remaining life of the plant. This VFD system will be used as long as the plant is used to generate electricity. The manufacturer of the variable speed drives will support the VFD equipment for 20 years.

3.3 Development of Alternatives

This proposal will analyze two alternatives. The first alternative is for the forced draft fan motors to remain at status quo. The second alternative is the installation of six variable frequency drives along with the removal of the inlet vane control from each intake fan system.

3.4 Evaluation of Alternatives

The time period considered for the evaluation of these alternatives is from 2013 to 2016. For the status quo, the energy and maintenance costs of the fan motors are considered for two years. For the installation of VFDs the new system is assumed to be placed in service at the end of 2014.

The cost of energy of operating the existing constant speed fan motors for four years was calculated to be $10.3 million. This represents the status quo cost. The cost for the same period of time for the VFD upgrade was calculated to be $5.9 million and this assumes the

VFD upgrades come online in January of 2015.

The difference in favor of the VFD upgrade is $4.3 million. This savings is realized in two years (2015 and 2016) for an average annual savings of $2.2 million. These figures are presented in Section 3.4.2.

3.4.1 Energy Efficiency Benefits

This project will yield energy efficiency benefits primarily through the reduction in energy usage by operating constant speed fan motors at full capacity even when the generating units do not require full capacity airflow. VFDs will operate the fan motors at the precise level required to supply sufficient air to the boilers of the generating units.

3.4.2 Economic Analysis

The analysis conducted for this proposal is a present value calculation for the period ranging from the estimated in-service date of the VFD system (January 2015) until the assumed in-service date of the Labrador Infeed (2017). This present value analysis shows an anticipated difference of $4.3 million for the two alternatives of status quo and the addition of VFDs.

The analysis involves an improvement in the efficiency of the forced draft fan systems. The VFD based system will consume less energy than the existing system. Energy consumption numbers for both systems were received from Siemens. The cost of consumed energy is calculated based on the amount of fuel consumed at Holyrood. The cost is calculated based on the formula:

Cost = MW * hours * barrels of oil/MWh * cost per barrel of oil

The analysis also uses a projection of production at Holyrood from the 2012 System Operation Holyrood Production Forecast. The cost of a barrel of oil is based on the Nalcor

Energy Corporate Planning Forecast from January 2012. The summary of this analysis is shown in Table 2.

Table 2: Net Present Value Analysis

Install Variable Frequency Drives on Six Forced Draft Fans **Alternative Comparison** ***Cumulative Net Present Value*** ***To The Year*** **2016**		
Alternatives	**Cumulative Net Present Value (CPW)**	**CPW Difference between Alternative and the Least Cost Alternative**
Status Quo	10,278,019	4,343,355
VFD	5,934,664	0

To test the results of the present value analysis a sensitivity analysis was conducted for two factors. The assumed price of fuel and the energy consumption rate of the VFDs were tested independently to discover what the values for each would have to be to make status quo the preferred alternative. The cost of fuel at Holyrood would have to be less than 40 percent of the forecasted value for the status quo to become the preferred alternative. The energy improvement of the VFDs would have to be less than 40 percent of the value provided by Siemens for the preferred alternative to shift to the status quo.

The projected budget for this work is presented in Section 4.1 and is $3.4 million. Once operational the VFDs will yield an average annual fuel savings of $4.7 million to Hydro while the Holyrood Thermal Plant is generating electricity. The project pays for itself less than one year of being put into service.

4 CONCLUSION

The installation of VFDs on the forced draft fan motors at the Holyrood Thermal Plant will reduce energy costs and yield operational savings of $4.7 million per year. The payback period for the $3.4 million project budget is less than one year.

4.1 Budget Estimate

The budget estimate for this project is shown in Table 3.

Table 3: Project Budget Estimate

Project Cost:*($ x1,000)*	**2013**	**2014**	**Beyond**	**Total**
Material Supply	453.9	1,285.0	0.0	1,738.9
Labour	53.9	43.4	0.0	97.3
Consultant	21.0	0.0	0.0	21.0
Contract Work	90.0	523.0	0.0	613.0
Other Direct Costs	37.7	25.5	0.0	63.2
Interest and Escalation	41.1	276.1	0.0	317.2
Contingency	0.0	506.7	0.0	506.7
TOTAL	**697.6**	**2,659.7**	**0.0**	**3,357.3**

4.2 Project Schedule

The anticipated project schedule for this project is shown in Table 4.

Table 4: Project Schedule

Activity		**Start Date**	**End Date**
Planning	Determine Outage Period, Gather Equipment Data	January 2013	March 2013
Design	Design Structural Components, VFD parameters	April 2013	July 2013
Procurement	Tender and Procure Structural Work Tender and Procure VFD Equipment Tender and Award Electrical Contract	July 2013 May 2013 October 2013	September 2013 June 2013 December 2013
Construction	Install Structural Components	October 2013	November 2013
	Install VFD, Remove Inlet Vane	May 2014	July 2014
Commissioning	Foxboro Tuning, VFD Operation	July 2014	August 2014
Closeout	Documentation Closeout	September 2014	December 2014