Preparing for the Next Generation at Manitoba Hydro

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Abstract

Manitoba Hydro's current and future generation mix is described. The present system is approximately 95% hydro, and 5% thermal. Planned additions and retrofits of grid-connected generation are mainly single cycle combustion turbines (SCCTs), fuel switching from coal to natural gas, with some alternate energy projects in Demand Side Management and System Efficiency Improvements. Manitoba Hydro is also studying the possible development of new hydroelectric generating stations in northern Manitoba. Manitoba Hydro's views on sustainable generation projects, co-operation and possibly partnerships with Cree Nations are also discussed.

Sommaire

La génération mixte actuelle et future de Manitoba Hydro est décrite. En ce moment, la génération est approximativement 95% hydro et 5% thermale. Les ajouts et modifications planifiés à la génération « reliée à la grille » sont principalement des turbines à combustion à cycle simple, le passage du charbon au gaz naturel, avec quelques projets en "Demand Side Management" et en amélioration de l'efficacité des systèmes. De plus, Manitoba Hydro étudie la possibilité de développer de nouvelles centrales hydroélectriques au nord de la province. Le point de vue de Manitoba Hydro sur des projets de génération durables, et sur la coopération, et possiblement un partenariat, avec les premières nations Cris sont aussi discutés.

1.0 Introduction:

Manitoba Hydro is studying the possible development of new hydroelectric generating stations in northern Manitoba. Three sites are under consideration: Gull Rapids on the Nelson River, Notigi on the Rat River and Wuskwatim on the Burntwood River. The necessary community consultation, engineering, economic and environmental studies are currently underway to enable decisions to be made on continuing development. The projects had been modified to have less effect on the environment, greater public and market acceptability, but higher costs and lower generation capacities. No final decision has yet been made regarding which, if any, sites will be developed.

2.0 Resource Planning Process:

Manitoba Hydro's resource planning process starts with development of a menu of resource options. The range of power resource options includes demand side management, efficiency improvements for existing plants, plant life extensions for existing thermal units, new hydro plants, extra-provincial imports, new coal burning plants, combustion turbines, micro turbines, fuel cells, co-generation, wind, and solar and bio-mass options. Also included in the resource planning procedure are load forecasts including various sensitivities such as low, medium, high demand levels; interest, escalation and exchange rate predictions and the cost of fuel such as natural gas and coal.

3.0 Planning criteria for supplying the load have two components:

Capacity: A firm capacity is required including a minimum of 12% reserve over the forecast peak domestic load demand.

Energy: The dependable energy resource must be adequate to supply forecast load energy under a repeat of the lowest historic flows.

Examination of the base Manitoba load and contractual export sales compared to annual dependable energy dictates that new resources must come on line by the year 2019 at the latest. Other factors in considering new resources are overall system economics, domestic electricity prices, market opportunity, financial criteria including borrowing requirements, risks and uncertainties, system reliability, environmental impacts such as bio-physical, socio-cultural and economic, affected community acceptance, and public and political acceptance.

4.0 Existing Generation:

Currently Manitoba Hydro has a total generation capacity of 5200 MW. Hydro constitutes 95% of this and the remaining generation is coal fired. Total import capability through interconnections amounts to about 2450 MW. Committed Manitoba projects include “Power Smart” programs (282 MW by 2011), system efficiency improvements (80 MW by 2001), new interconnection (200 MW by 2002) and combustion turbine under construction (280 MW by 2002). It is also proposed that the Selkirk G.S. (132 MW) be converted to gas by 2005, and Brandon G.S. Unit #5 (105 MW) license be renewed by 2006.

5.0 Future Hydro Potential:

There are three hydro options considered and these are all low impact projects. Major re-designs of Wuskwatim and Gull would minimize their environmental impacts. Flooding would be less than 1-km square at Wuskwatim, Gull would be in the order of 48-km square, and Notigi Plant would have no flooding as the water control structure already exits. When partial development (at 235 m forebay level) of Wuskwatim is compared to full development (at 243.2 m forebay level), the estimated flooded area drops by 90% and average annual energy is about 25% less. Figure 1 shows a comparison of the flooded area for existing and potential hydro plants.

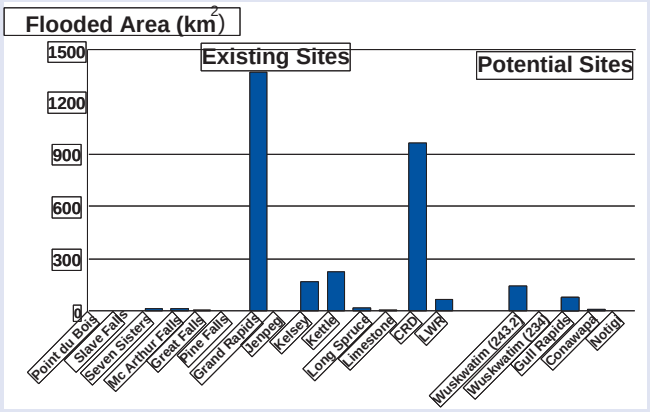

Figure 1: Comparison of Existing and Potential Hydro Sites

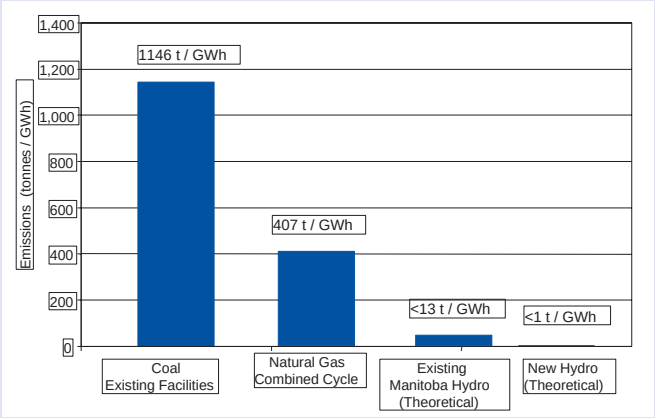

Figure 2: Comparison of Emission Intensities

- tonnes of CO2 equivalence per unit of energy

- the new hydro estimate represents the average emission for the undeveloped Manitoba sites

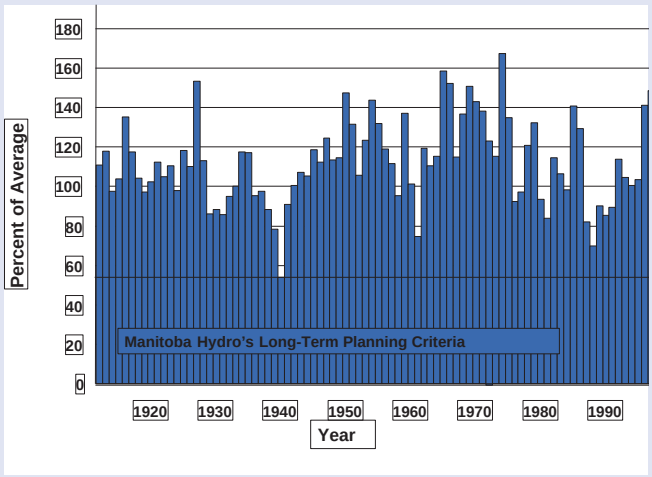

Figure 4: Historic variability of water supply: Churchill/Nelson River Drainage Basin

Methyl mercury production due to flooding would be minimal and Green House Gas (GHG) emissions would essentially be zero. Figure 2 shows a comparison of emission intensities per GWh energy produced for coal and gas fired generation in relation to existing and new hydro plants in Manitoba.

The re-designed generation projects have less environmental effects, higher costs, lower generation capacities, greater public and market acceptability.

Manitoba Hydro has a potential of 600 MW at Gull and 1300 MW at Conawapa (and possibly 1900 MW more) on Nelson River. We also have 100 MW at Notigi and 200 MW at Wuskwatim (and possibly 650 MW more) on Burntwood River. Other potential from partially developable hydro sites in the province amounts to about 4000 MW.

Potential projects considered include three smaller or mid range hydro plants as described above. Construction cost including the transmission cost would be in the order of $0.5 B for Notigi, $1 B for Wuskwatim, $3 B for Gull [1]. Additional CTs with a generation capability of 140-280 MW would cost about $0.1-$0.2 B. A larger hydroelectric plant at Conawapa would cost about $5 B including transmission to the load centers in the south.

Historic variability of water supply in the Nelson and Churchill Rivers Drainage basin (Figure 3) over the last 80 to 100 years shows a range of percent average flow from a low of 55% to a high of 160% (Figure 4).

Manitoba Hydro's long term planning criteria must consider the lowest historical level for power resource planning, but plant structures including the spillways must be designed for maximum flood conditions.

Figure 5 shows the Manitoba Hydro hydraulic system with respect to the elevation levels along with the existing plant locations indicated. Figure 6 shows the annual average energy potential. Figure 7 shows an illustrative view of Burntwood and Nelson Rivers areas in reference to the potential new generation.

6.0 Transmission Access:

Manitoba Hydro is experiencing strong growth in its export sales, while provincial requirements are growing steadily. Export revenues have grown almost 50 percent in the past four years from $250 million in 1996 to $376 million in 2000. Regulatory changes in the U.S. market, coupled with a burgeoning economy and a lack of new generation and transmission in the U.S. have meant steadily increasing prices for wholesale electricity.

Manitoba Hydro has been able to benefit from these changes, and now has the ability to market to 35 export customers, compared to the seven export customers it had in 1996. (Figure 8). With domestic electricity consumption in Manitoba growing slowly but steadily, this means that over time the utility will have less and less available energy to sell on the export market. If it wants to maintain its current level of sales, it will

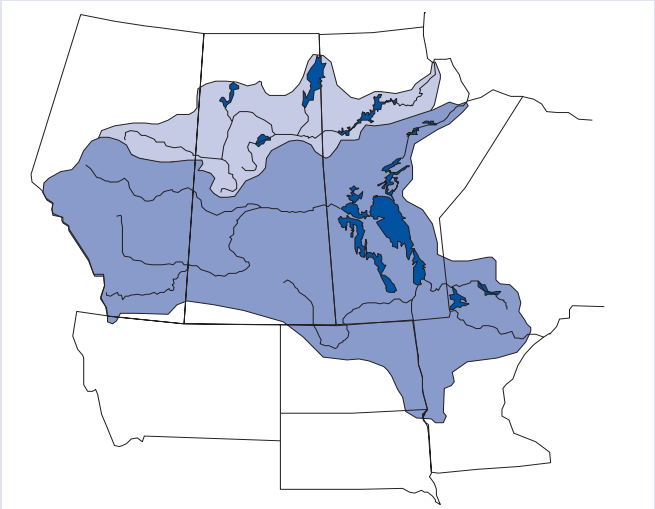

Figure 3: Churchill/Nelson River Drainage Basin

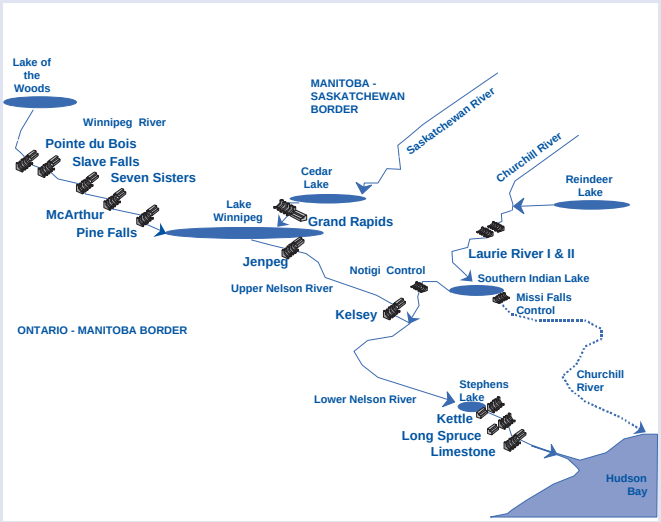

Figure 5: Manitoba Hydro System

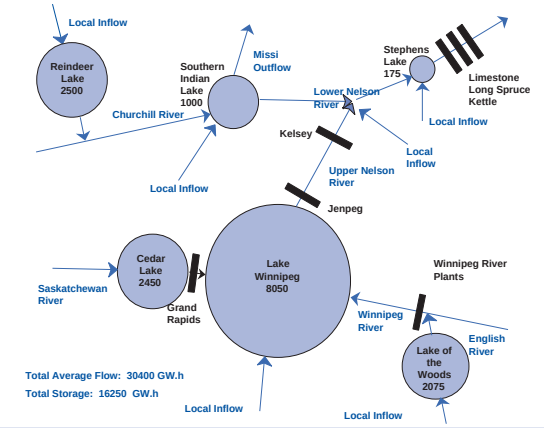

Figure 6: Annual Average Energy

Figure 8: Manitoba Hydro's Export Marketplace

have to build new sources of generation.

Strong export sales have been a key reason that electricity rates in Manitoba have not risen for four years (for industrial customers, the rates have remained stable for 9 years).

Figure 9 shows the generation and interconnection capability for Manitoba Hydro's immediate vicinity in western Canada and in mid west U.S. A number of east - west interconnection schemes were studied in the past such as the Manitoba - Ontario connection which included new generation in northern Manitoba with a north - south HVDC line. This project had an estimated cost of $2 B (Figure 10). Another east - west scheme studied was 500 kV HVDC multi terminal concept which covered Manitoba, Saskatchewan and Alberta, also known as western grid, as shown in Figure 11.

There has also been a number of north - south interconnection studies in the past to the States of Minnesota, North Dakota, Nebraska and Wisconsin. One current project which is approved and under construction is a 230 kV connection between western Manitoba and central North Dakota with a transmission line length of 200 km and a cost of $55 million (Figure 12). This project will re-establish Manitoba Hydro's import capability to 500 MW, it will also increase the import and export capabilities by 200 MW. The in service date for this project is fall of 2002.

Figure 13 shows Manitoba Hydro integrated system. Figure 14 shows the existing dc system including the route for a possible third dc line between north and south. Overview of the system including the connections to the neighbouring provinces of Ontario and Saskatchewan and connections to the U.S. are schematically shown in Figure 15.

7.0 Agreements in Principle:

The work on these potential hydroelectric generating stations represents a fundamental change in Manitoba Hydro's relationship with Cree Nations. Early in the process, the Corporation began working with potentially affected Cree Nations communities to identify and reduce possible negative impacts and maximize local opportunities. Manitoba Hydro is engaged in a collaborative planning process with the Nisichawayasihk (formerly Nelson House) Cree Nation with respect to the Notigi and Wuskwatim projects and with the Tateskweyak (formerly Split Lake) Cree and War Lake First Nations on Gull project. The proposed planning process includes joint investigation of possible environmental impacts, consultation on design, discussion about business opportunities, including the possibility of equity participation by the First Nations in the projects. Consultation is also under way with regulators, environmental community, unions and other interested parties [2,3].

In late 2000, that process led to a historic agreement in principle between Manitoba Hydro and the Tateskweyak Cree First Nation and potentially other Cree Nations within the Split Lake resource management area. This agreement would provide the opportunity to invest in the proposed Gull Generating Station. The agreement in principle was approved by a community wide recent vote, just as any final agreement

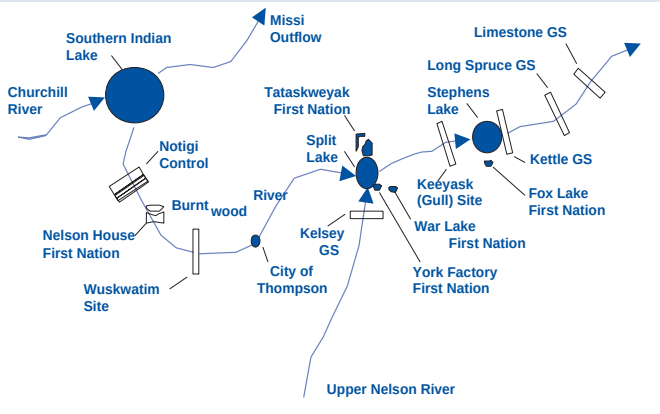

Figure 7: Potential New Generation - illustrative view of Burntwood/ Nelson River area

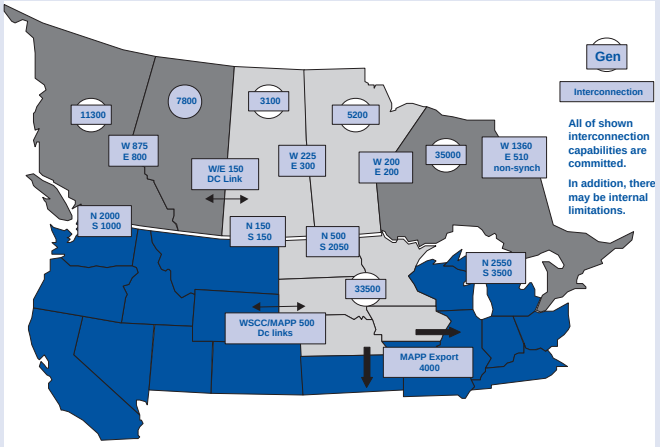

Figure 9: Generation and Interconnection Capability (MW)

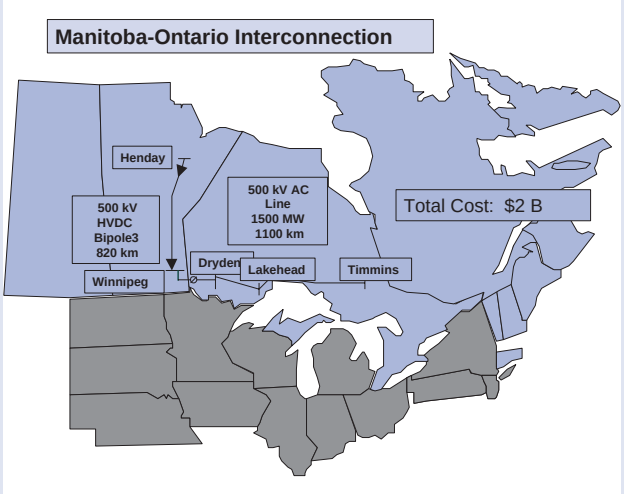

Figure 10: Transmission Expansion studied in the past.

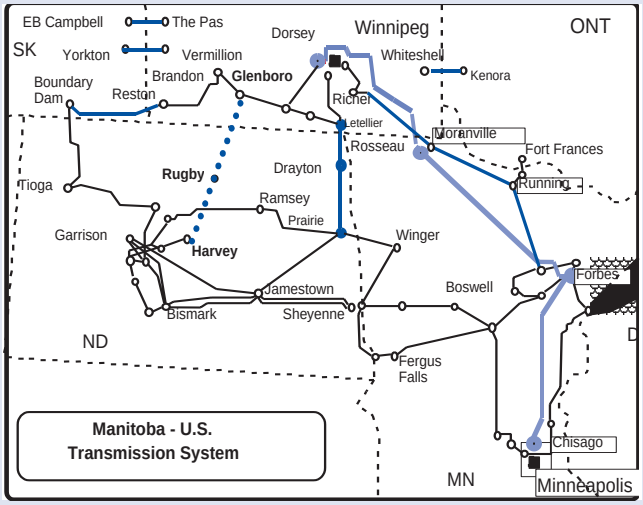

Figure12: Manitoba - U.S. Transmission System

would be subject to a community vote. A similar agreement in principal was approved by the Nisichawayasihk Cree Nation (NCN) in the summer of 2001. Manitoba Hydro announced the signing of an Agreement in Principle with the NCN regarding possible future development of two hydroelectric generating station projects [4].

While Manitoba Hydro continues to study the three potential projects, no decision has been made to proceed with the construction. Once a decision is made, a public review will be held and environmental licensing by provincial and federal agencies would be required. Finally, approval must then be received from the provincial government. Final project development agreements would also have to be negotiated with any affected Cree Nations.

The earliest any construction is expected to begin is 2004, with the earliest in service date for Notigi being 2008, for Wuskwatim in 2009 and Gull Rapids, 2011.

8.0 Demand Side Management:

These are projects supported by the Corporation which are also known as "Power Smart" initiatives. They include energy surveys and audits; the introduction, promotion and in some cases partial subsidy projects such as use of energy-efficient appliances; weather stripping doors and windows; installing energy-efficient showerheads; insulating basement walls; installing programmable thermostats; use of block heater timers; use of energy efficient lights in residential and commercial buildings; and the use of energy efficient drives and other equipment in industrial plants.

The projected energy savings currently achieved in this category is 188 MW of power and 444 GWh/year of energy. It is projected that total savings of 299 MW of power and 983 GWh/year of energy would be achieved by year 2011.

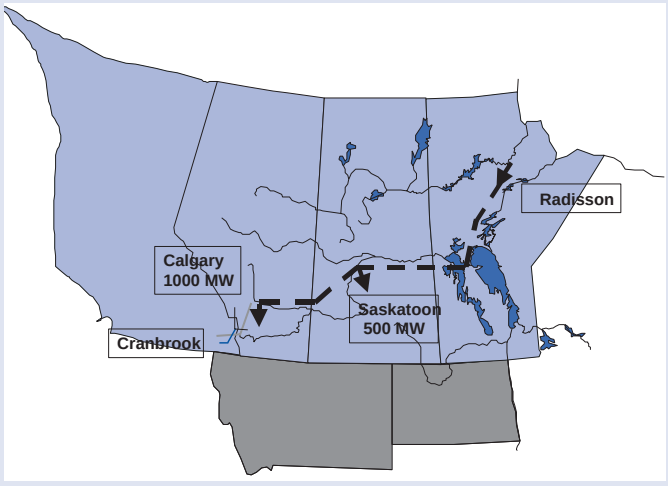

Figure 11: Western Grid - 500 kV HVDC Multi-terminal 1825 km line

Figure 13: Manitoba Hydro integrated system

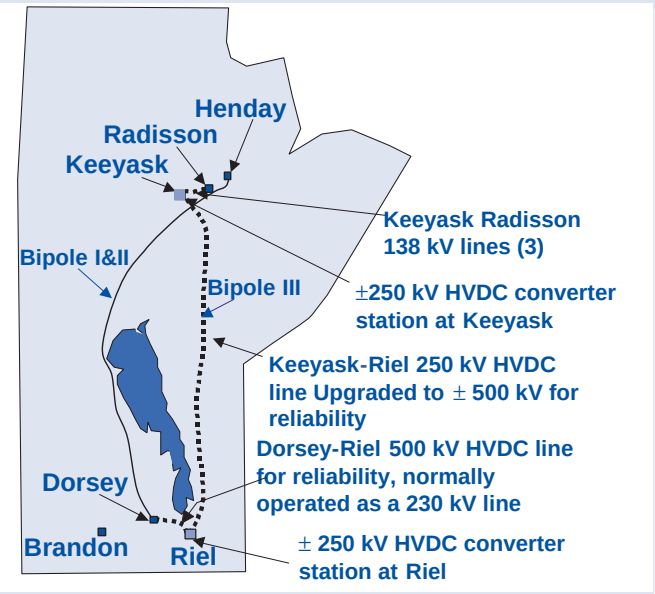

Figure 14: DC system

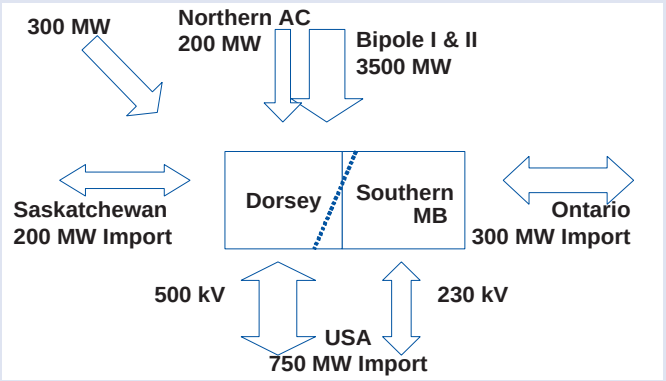

Figure 15: System overview

9.0 Supply Side Efficiency Improvements:

These are proposed and achieved efficiency improvements to existing generators either initiated based on a benefit versus cost basis or during scheduled maintenance and outages. To date, 31 MW of capacity in total has been added to the system. There are various projects under consideration which will bring the total up to 80 MW.

One such example is Winnipeg Hydro's Pointe Du Bois Project. Winnipeg Hydro is a sister utility which owns and operates two hydraulic plants on the Winnipeg River. One is Pointe Du Bois (69 MW) built in 1911 and the other is Slave Falls (71 MW) built in 1931. These plants supply 45% of energy requirements and 30% of peak demand for Winnipeg Hydro's 96,000 customers. In 1995, KGS Group was retained by Winnipeg Hydro to conduct a preliminary engineering study comparing plant redevelopment versus plant rehabilitation. The study concluded that the old plant could be successfully rehabilitated, using the compact Straflo turbine technology, for a total cost of approximately $100 million less than the cost of building a new plant (estimated at $310 to $380 million in 1995 dollars) [5]. The total replacement of the original turbine generators was estimated to increase the plant capacity from 69 MW to 134 MW. Waterpower is a major source of renewable electrical energy, and the rehabilitation of Pointe du Bois G. S. would nearly double the plant's output with no major impact on the environment.

The Straflo Demonstration Project was approved in 1996 and construction commenced in 1998 and was completed in fall of 1999. This project saw the replacement of one existing 3.5 MW Francis turbine generator (1911) with a new 8.4 Straflo turbine generator. The turbine runner is shown on the cover page of this issue during the installation.

A decision on the replacement of additional turbines will be based upon an in-depth engineering and economic analysis and study of alternatives by KGS Group.

10.0 Acknowledgements:

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11.0 References:

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About the author

Hilmi M. Turanli received his B. Sc. and M. Sc. degrees (both in Electrical Engineering) from the Middle East Technical University, Ankara, Turkey in 1976 and 1980, respectively. He was granted his Ph. D. degree from the University of Manitoba in 1984.

He was with the Electrical Engineering Department, University of Manitoba working on a special research project for Manitoba Hydro. Later, he taught for the Department of Electrical Engineering at the University of New Orleans as an Assistant Professor. He also worked as a consultant for Louisiana Power and Light Company.

In June 1986, Dr. Turanli started working for Manitoba Hydro. Currently he is the Interconnections & Grid Supply Studies Engineer in the System Planning Department. His research interests involve the digital simulation of power-electronics circuits, HVDC transmission, and power system planning.

Dr. Turanli is a Professional Engineer registered in the Province of Manitoba. He is a Senior Member of IEEE. He is the author or co-author of several published technical papers. In March 2001, he was designated as a Fellow of Engineering Institute of Canada.