Abstract

This paper will describe the existing Manitoba Hydro power system, and identify future hydro generation potential along with associated transmission required to deliver this generation to Manitoba load and export customers.

Introduction

As reported in earlier publications [1, 2, 3], Manitoba Hydro studied the possible development of new hydroelectric generation stations in northern Manitoba. Three sites were under consideration: Gull Rapids on the Nelson River, Notigi on the Rat River and Wuskwatim on the Burntwood River. Manitoba Hydro has recently completed construction of its newest hydroelectric station Wuskwatim G.S. on the Burntwood River. New outlet transmission facilities needed for the plant were completed in 2011. The plant is being commissioned in the summer/fall of 2012.

Manitoba Hydro is currently studying the possible further development of new hydroelectric generating stations in northern Manitoba. Two sites are under consideration: Keeyask G.S. and Conawapa G.S. both on the Nelson River. The necessary community consultation, engineering, economic and environmental studies are currently underway to enable decisions to be made on continuing development.

Existing Generation and Major Transmission System

Manitoba Hydro is a provincial Crown Corporation providing electricity to 537,299 customers throughout Manitoba and natural gas service to 265,961 customers in various communities throughout southern Manitoba [4]. Manitoba Hydro also has formal electricity export sale agreements with a number of electric utilities and marketers in the Midwestern U.S. and Canadian provinces of Ontario and Saskatchewan.

Nearly all electricity generated is from self-renewing waterpower. On average, about 30.5 billion kilowatt-hours of electricity are generated annually. Seventy-five percent is produced by five hydroelectric generating stations on the Nelson River; the remainder is generated at nine hydroelectric stations on the Winnipeg, Saskatchewan, and Laurie rivers; two thermal stations; and four diesel sites. The electricity is transmitted over nearly 65,000 miles of transmission and distribution lines.

Manitoba Hydro has 5,950 MW of generation (including 223 MW at recently built Wuskwatim; 99 MW of wind generation at St. Leon and 138 MW of wind generation at St. Joseph both in southern Manitoba) connected to its network. In 2011, the corporation supplied a provincial peak load of 4,261 MW [4]. The provincial peak load is growing at an average rate of about 1.5% per year (energy 1.6% per year).

The transmission system in Manitoba is interconnected to the transmission systems in the provinces of Saskatchewan and Ontario and the states of North Dakota and Minnesota by 12 tie lines. Of these, three 230 kV lines and one 500 kV line interconnect the Manitoba system to the United States, three 230 kV.
and two 115 kV lines interconnect to Saskatchewan, and two 230 kV lines and one 115 kV line interconnect to Ontario (Figure 1).

Figure 1: Existing Generation and Major Transmission System

**Wuskwatim Generation and Outlet Transmission Facilities**

The initial concept design of Wuskwatim and Gull (now named Keeyask) started in the 1990s. The project design was modified to have less effect on the environment, greater public and market acceptability, but at higher cost and lower generation capacity. Flooding was designed to be less than 1-km square at Wuskwatim. 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 2 shows a comparison of the flooded area for existing and potential hydro plants.

Construction of Wuskwatim Generation Station (Figure 3) started in April 2007 with the commissioning of a new Thompson Birchtree 230 kV Station and 28 mile long Thompson Birchtree – Wuskwatim 230 kV line to supply the construction power.

Other lines that needed to be built were: two 86 mile, 230 kV lines between Wuskwatim and Herblet Lake, and one 100 mile, 230 kV line from Herblet Lake to The Pas Ralls Island (Figure 4). A -60/110 MVAr continuous rating and a 10-second overload rating up to 165 MVAr Static Var Compensator (SVC) was installed at the Thompson Birchtree 230 kV Station to provide transient voltage control. In addition to connecting new generation to the system, the new facilities will improve the reliability of the overall transmission system.
**Riel Station Reliability Project**

D602F, a 500 kV line, now connects the Dorsey 500 kV AC Station, north of Winnipeg, to Forbes Station near Duluth, Minnesota in the U.S. A new station, Riel, is to be built just east of Winnipeg adjacent to the right of way of the 500 kV line (Figure 5).

The Riel Station currently under construction is located on the southeast Winnipeg periphery adjacent to major 230 kV and 500 kV transmission corridors, making it an ideal location for a new supply point for Winnipeg load.

The location minimizes the need for new transmission corridors into and out of Riel and reduces the amount of new west to east transmission across Winnipeg as it provides an alternate supply point to Dorsey, which is located on the northwest periphery of Winnipeg.

The project will include establishing the Riel Station site, installing 230 kV and 500 kV switch yards, installing a 1,200 MVA, 230 kV to 500 kV transformer bank, sectionalizing the existing Dorsey-Forbes 500 kV line, sectionalizing two existing 230 kV lines (Ridgeway-St. Vital lines R32V and R33V), and installing 500 kV line reactors.

The project will improve system reliability by adding an alternate terminal point for the 500 kV transmission line to the U.S., thereby preserving Manitoba Hydro’s system import capability if there is a major outage at Dorsey. The scheduled in-service date of the project is 2014.

**Bipole III Reliability Initiative**

Enhancement of the reliability and security of HVDC transmission lines and the Dorsey Converter Station has been under investigation for some time. The HVDC transmission lines, Bipoles I and II, are located on a common right-of-way corridor referred to as the Interlake corridor which is 562.5 miles in length (Figure 6).

1 Sectionalizing the existing Dorsey-Forbes line means cutting the line at Riel and terminating it at Riel to form a Dorsey- Riel line and a Riel-Forbes line.
Figure 6: Bipole III Transmission Route

The southern converters of Bipole I and II are both located in the Dorsey Converter Station. The Bipole I & II corridor and the Dorsey Station are vulnerable to rare, but severe weather events such as wind bursts, tornados and ice storms; that could cause extended outages and severe hardship to Manitoba Hydro customers and Manitoba. One such event occurred on September 6, 1996 when straight line winds associated with a microburst resulted in the collapse of 19 HVDC transmission towers north of the Dorsey Converter Station, resulting in the loss of the Bipole I & II lines for about 5 days.

Manitoba Hydro is advancing a western routed (west of Lake Winnipegosis and Lake Manitoba) Bipole III transmission line, running from a new converter station named Keewatinoow in the north located near Conawapa to Riel Converter Station near Winnipeg.

The Bipole III scheme includes (Figure 7):

- A ±500 kV HVDC transmission line, about 865 mile long, from Keewatinoow Converter Station to Riel Converter Station.
- A 2,000 MW converter station in the north (Keewatinoow C.S.).
- One 32.5 mile long 230 kV transmission line from Long Spruce to Keewatinoow.
- Four 17 mile long 230 kV transmission line from Henday to Keewatinoow.
- A 2,000 MW converter station at Riel.
- Sectionalizing of the Ridgeway-Richer 230 kV line into the Riel Converter Station.

Manitoba Hydro is continuing to evaluate the converter technology to be used for Bipole III [6]. A new technology, referred to as the Voltage Source Converter is available as an alternative to the existing Line Commutated Converter technology used for Bipoles I and II.

The ultimate rating of the converters is also being evaluated. Bipole III is planned to be operated at 2,000 MW initially. However provision for a larger rating is being studied to accommodate potential future Nelson River generation. The estimated in-service date for Bipole III is 2017.
Future Nelson River Generation Development

The planning is underway for two new generating stations, the Keeyask G.S. and the Conawapa G.S., on the Nelson River (Figure 8). The Keeyask G.S. will be located about 38 miles upstream from the existing Kettle G.S. (1,224 MW). The Conawapa G.S. will be located about 32 miles downstream from the existing Limestone G.S. (1,350 MW).
Future Keeyask Generation and Outlet Transmission Facilities

The 695 MW Keeyask Generating Station will require new outlet transmission facilities needed to connect the generating station to the Manitoba Hydro grid.

A new Keeyask Switching Station will be established to terminate seven new 138 kV lines including four unit lines (approximately 2 miles each) to receive the power from Keeyask Generating Station, and three 138 kV transmission lines (approximately 24 miles each) to convey the power to Manitoba Hydro’s existing Radisson Converter Station [5]. The 2,000 MW Bipole III, slated to be in-service in 2017, will increase the capacity of the Bipole I, Bipole II and Bipole III HVDC system to accommodate the Keeyask generation.

A construction power station will be built and fed primarily from a 138 kV transmission line with an approximate length of 14 miles tapped from existing line KN36. One of the Radisson-Keeyask lines will be constructed earlier than the other two, in order to serve as a back-up source of construction power. Station upgrades at the Radisson station will also be required. In addition to connecting new generation to the system, the new facilities will improve the reliability of the overall transmission system (Figure 9).

The in-service date for the first unit at Keeyask is anticipated to be September 2019. All of the transmission facilities will be in-service on August 2019.

Figure 9: Keewatinoow Converter Station

Future Conawapa Generation and Outlet Transmission Facilities

Conawapa Generating Station with a rating of 1,485 MW rating (net 1,395 MW) with an in-service date of 2024/25 will be connected into the Northern Collector System at Keewatinoow (Figure 10).
The past development of its hydroelectric generating plants on the Nelson River in northern Manitoba has allowed Manitobans to enjoy some of the lowest electricity rates in North America. Manitoba Hydro is exploring the feasibility of developing new northern hydroelectric generation sites and new interconnections to meet future load growth and new contracts to ensure that these low rates can be sustained in the future.

Figure 10: Conawapa G.S. and Outlet Transmission

**Future Transmission Interconnections**

As mentioned above, the transmission system in Manitoba is interconnected to the transmission systems in the provinces of Saskatchewan and Ontario and the states of North Dakota and Minnesota.

These interconnections allow for economic exchange of electricity as well as provide support during electric system emergencies. The interconnections are especially beneficial to Manitoba due to the characteristics of Manitoba Hydro’s predominantly hydraulic generation system. As well as exporting electricity surplus to Manitoba’s needs during periods of above median river flows, the interconnections allow Manitoba Hydro to import energy during periods of drought.

Manitoba Hydro has recently contracted with Minnesota Power (MP) to provide 250 MW over 15 years starting in 2020 and a firm sale of 100 MW to Wisconsin Public Service (WPS) commencing in 2021. Manitoba Hydro has also signed a term sheet with WPS to provide up to an additional 400 MW. The proposed power sales agreements will require new hydroelectric development in northern Manitoba (Keeyask and Conawapa) and a new transmission line between Canada and the United States. Studies are underway to determine the necessary transmission facilities needed to increase the firm Canada to U.S. transmission export capability.

There are number of options being studied at this time:

1. Winnipeg (Dorsey) to Fargo (Bison) - 500 kV Line and Fargo (Bison) to St. Cloud (Monticello) – 345 kV Line
This option would include two phases. First phase (year 2020) consists of a 75 mile long Winnipeg to U.S. border line and 160 mile long U.S. border to Fargo line. Phase 2 (2025) of the project would include addition of a second circuit of a 345 kV line to CapX2020 project from Fargo to St. Cloud (238 miles) (Figure 11).

2. Winnipeg (Dorsey) to Iron Range (Blackberry, Shannon, or new Iron Range Station) - 500 kV Line and Iron Range (Shannon) to Duluth (Arrowhead)– 345 kV - double circuit Line

This option would include two phases. First phase (2020) consists of a 140 mile long Winnipeg to U.S. border line and 210 mile long U.S. border to Iron Range line. Phase 2 (2025) of the project would include a double circuit 345 kV line from Iron Range to Duluth (50 miles) (Figure 12).

3. Winnipeg (Riel) – Iron Range (Shannon) 230 kV Line

This option (2020) which will be built as a minimum requirement for MP 250 MW sale consists of a 90 mile long Winnipeg to U.S. border line and 210 mile long U.S. border to Iron Range line (Figure 13).
Conclusions

Manitoba Hydro has over 5,000 MW of clean hydro electric energy potential to develop. This paper described future bulk transmission development that will be required to transfer this power to load centers in the most efficient way.

References


