A History of Electric Power Development in Manitoba

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Abstract

Today, with deregulation in the power industry occupying a good deal of public attention, this article presents the history of power development in Manitoba. Winnipeg was probably the only place in North America where competition between the private company and the municipal utility for customers was possible using the same power poles. This situation prevailed from 1912 to 1955. Manitoba is well endowed with rivers with significant hydroelectric power sites. The paper outlines the history of development up to and including the development of the Nelson River in the late 1960's. This involved the diversion of the Churchill River into the Nelson River and the regulation of Lake Winnipeg. The largest capital expansion program in the history of the utility was undertaken during this period and involved moving the power from the north using direct current transmission at +/-500 kV. The various stages of evolution and consolidation of the power industry are covered, with Manitoba Hydro ending up as the only utility in Manitoba serving all the citizens at a uniform rate.

Sommaire

De nos jours, avec la déréglementation de l'industrie énergétique qui reçoit une bonne part de l'attention du public, cet article présente un historique du développement de l'énergie au Manitoba. Winnipeg était probablement le seul endroit en Amérique du Nord où la compétition entre des compagnies privées et les services publics municipaux utilisant les mêmes poteaux électriques était possible. C'était le cas de 1912 à 1955. Le Manitoba regorge de complexes hydroélectriques. Cet article dresse un historique du développement hydroélectrique, des débuts jusqu'au projet de la rivière Nelson à la fin des années 60. Durant ces années-là, il y eut diversion de la rivière Churchill vers la rivière Nelson et la régularisation du Lac Winnipeg. Le plus grand programme d'expansion dans l'histoire du service public a été entrepris durant cette période et a exigé le transport de l'énergie du Nord par des lignes de transmission de courant à plus ou moins 500kV. Les différentes étapes de l'évolution et de la consolidation de l'industrie énergétique sont discutées, avec Manitoba Hydro devenant le seul service public au Manitoba offrant aux citoyens l'électricité à un taux uniforme.

1.0 Early History

Electric Arc Lamps were first seen in Winnipeg, Manitoba in March 1873, just three years after the Province of Manitoba was formed. This was six years before Edison invented the incandescent lamp. It was not long after this that a newly incorporated company received a contract to install arc lamps in the City. This was the beginning of several business ventures by a variety of new companies, and when electric trolley conveyance was demonstrated in 1891, it was the Winnipeg Electric Railway Company (WECO) that received the franchise from the City. This company built a thermal generating station on the banks of the Assiniboine River. It purchased its last competitor in the mid nineties. With a rapidly growing city and the demand for more uses of electricity, WECO looked to the Winnipeg River for hydroelectric development.

It was not the first company to develop a hydro plant in Manitoba. This was done by a company in Brandon some 120 miles west of the City of Winnipeg. They developed a plant on the Minnedosa River (now known as the Little Saskatchewan River) but the flow was such that the plant could only operate for a maximum of eight months of the year. The plant served the City of Brandon using an 11 kV wood pole line. The plant was dismantled in 1924.

2.0 Development of the Winnipeg River

At the beginning of the 20th century, WECO examined the possibility of a development on the Winnipeg River. The consultants that they engaged selected the Pinawa Channel, which is a channel parallel to the Winnipeg River, partially bypassing the Seven Sisters Falls site. It required the construction of a weir to divert the water into this channel with some enlargement of the intake. To build a hydroelectric plant in the wilderness with horses was a remarkable achievement. There were no roads or railways; access was by river or winter road. Construction started in 1902 and the first power was delivered using a 60 kV steel tower line to Winnipeg in 1906. The output of the plant was 22 MWs.

The WECO had a monopoly on the supply of electric power and was charging twenty cents per kWhr, which did not sit very well with some of the aldermen of the City. The company did lower its rate to 10 cents per kWhr when the Pinawa plant was completed. One alderman in particular, Alderman John Wesley Cockburn, managed to get the water rights for the Pointe du Bois site on the Winnipeg River and when the City Charter was amended to permit it to float a bond issue for the development of a hydroelectric site, he transferred the rights to this site to the City. The citizens of Winnipeg voted in favor of developing Pointe du Bois with the promise of power at 3 cents per kWhr. A railway was constructed from the nearest CPR line at Lac du Bonnet. This involved building bridges over the Winnipeg River and the Pinawa Channel. This site was developed into what is now the oldest plant still operating on the Winnipeg River. It has a 46-foot head and is rated at 78 MW. The first power was delivered in October 1911. The rate was set at 7 and cents per kWhr. This sparked a vehement protest from the citizens who had been promised 3 cents. The public outcry resulted in City Council lowering the rate for power to 3 and 1/3 cents per kWhr, which the private company met. This rate remained in use until 1968.

The delivery of power from the City's plant caused a mad scramble to connect customers. It was not uncommon for the City to begin construction of a line on the opposite side of the street on a Saturday morning to supply an industrial customer on Monday morning. The multitude of lines eventually resulted in a judicial decision in 1912 to require both utilities to share the same poles. This arrangement continued until the power industry was rationalized in 1955.

3.0 Rural Electrification

The settlements in rural parts of the province also wanted to share in the benefits of this new form of energy. It spawned a multitude of entrepreneurs; all charging what they thought was reasonable. In order to rationalize this, the Government created the Manitoba Power Commission in 1919 and undertook to sell power to the municipalities, much the same as Ontario was doing, but by 1933, when the depression forced many municipalities into financial difficulties due to residents not paying their electric utility bills, they amended the legislation to permit the Commission to sell directly to the customer and do away with the so called middle man. The growth of consumption required Winnipeg to complete the second half of Pointe du Bois, a project they commenced in 1919 as they had a contract to supply the Commission with its requirements. The WECO also undertook to develop a new site at Great Falls on the Winnipeg River with a capacity of 132 MW. This was the first use of propeller type turbines and resulted in some interesting developments. The admission of air to the draft tube to reduce cavitation was first used at this plant and was soon to be the norm.

The growth in the twenties required the City and WECO to seek new sites for development on the Winnipeg River. The City received the license to develop Slave Falls [1], while WECO received the license to develop Seven Sisters, with a reservation of 35 MW for the Power Commission. The contract that the City had with the Government to supply the Commission was terminated in 1935 when the Company supplied the power from its Seven Sisters Plant. With the

Figure 1: Slave Falls Plant (Source: Manitoba Hydro)

simultaneous development of two sites, nobody foresaw the crash of 1929, and the result was rather catastrophic. The City actually ran its Slave Falls plant with only two units installed on a one-shift basis and incurred a deficit. Units three and four were installed by 1938. The Company shut the three units installed at Seven Sisters down and defaulted on the bond interest. In one respect it was provident that this surplus capacity was available when the 1939 war broke out. It made it possible for the Province to assist in the war effort. However, the growth in the war years required the City to develop a water heater control program, which shut the water heater load off at noon and again during the evening peak, using carrier current injected frequencies into the residential feeders. These were picked up by relays installed in each household. These measures to control the peak demand, along with the use of thermal generation from the Amy Street standby plant that was installed in 1924, resulted in the City meeting its firm load requirements. This thermal plant was built as a result of the loss of all transmission from the Pointe du Bois plant due to a very severe windstorm. It was combined with a central heating system to supply central heat to the downtown city area. Three electric boilers, in addition to the coal-fired boilers, were installed. The operator of these boilers had a recording totatalizer of the Winnipeg Hydro load at his workstation. His job was to utilize all the spare capacity in the system as load on the electric boilers with a resulting saving in coal for the central heating plant. This resulted in a very high load factor on the City's two hydro plants.

The supply of some defense industry load during off peak hours, by arrangement with the WECO, further helped the City to meet its firm load requirements.

Even before the war ended, the City received permission from the Wartime Prices and Control Board to order the steel for the extension of the Slave Falls Plant, which was commenced in 1945. The plant with a total of eight units was completed in 1948. The transmission voltage was raised to138 kV - the first use of this voltage in Manitoba. Meanwhile the WECO undertook the completion of the Seven Sisters Plant to a capacity of 150 MW by raising the head and excavation in the tailrace. This utilized the full flow of the river. The retirement of the Pinawa Plant occurred in 1951.

The Government undertook a study of farm electrification in 1942 and with the completion of the war, commenced this program. The growth of the farm and rural load made it evident that someone had to add new capacity to meet these requirements. The private company would not invest in a new plant unless they received an agreement from the Province for a long-term commitment. The City was in a similar position. Without a guarantee, they were reluctant to commit the necessary funds for expansion of either of the two remaining hydro sites on the Winnipeg River.

4.0 Birth of The Manitoba Hydro Electric Board

This stalemate resulted in the Government creating the Manitoba Hydro Electric Board and the development of the Pine Falls site on the Winnipeg River. The City protected its position during the rather prolonged negotiations on how the power industry should be rationalized, by installing two thermal units of 15 and 25 MW capacity in the Amy Street thermal plant it built in 1924.

The plan for reorganization of the power industry, proposed by the Government, was turned down by the citizens of Winnipeg in a referendum. As a result, the Government forged ahead with its plans and bought the WECO and sold the load in the City, formerly supplied by the Company, to the City in exchange for the City load outside the City boundaries. It also agreed to leave the two City plants at Pointe du Bois [2] and Slave Falls with the City, but undertook to develop all future generation needs for the Province and entered into a cost sharing agreement with the City in 1955, based on the peak demand of the City load and the Provincial loads. The latter soon outdistanced the City load, due to the farm electrification program. Thus the competition for customers in Winnipeg by the two suppliers of power came to an end.

An interesting development occurred in January of 1957, when Manitoba Hydro Electric Board received a letter of intent from INCO to supply power for their new nickel mine being developed at Thompson Manitoba. This was a wilderness location, but the Hudson Bay Railway was some 50 miles away to the south. A hydro site on the Nelson River named Kelsey was available some 60 miles away and Manitoba Hydro undertook to develop this site on the Nelson. The schedule was very demanding, requiring power by 1960. This involved building a railway into the site, building dikes on perma-frost, and building the final earth and rock fill closure dam under a hoarding in the wintertime. The INCO estimated load required four units, but in anticipation of growth in the new town at Thompson, a fifth unit was added, and unit Number 7 was installed by 1972. This five-unit plant rated at 160 MW supplied an isolated load, including two arc furnaces rated at 18 MW each. Special governor characteristics were developed to handle the sudden loss of this furnace load, and governor development tests were run on the Pine Falls plant using electric boilers at the Paper Mill, close by, to simulate the condition of the loss of a furnace under load conditions. These tests were run with the help of Woodward Governor engineers to validate the anticipated governor performance. They are reported in a paper at the 1961 meeting of the AIEE and are recorded in the Transactions of the Institute. INCO placed limits on the amount of load that could be dropped; however very shortly after the tests, but before the instrumentation had been removed, an interruption of greater than one furnace occurred, and the governor performance for control of the machines was superb.

This first plant on the Nelson River was a good experience for future developments.

5.0 Formation of Manitoba Hydro

By 1961 the Government again moved to rationalize the power industry by an amalgamation of the Manitoba Power Commission and the Manitoba Hydro Electric Board. The new organization was called Manitoba Hydro.

With the growth of load in the fifties, the newly created Manitoba Hydro was struggling to stay ahead of the demand. It completed the last two sites on the Winnipeg River at Pine Falls and McArthur Falls and constructed a thermal generating station at Brandon, and another at Selkirk, while it studied its options for more hydro development on the Saskatchewan and Nelson rivers. The decision was made in 1960 to develop the Grand Rapids four-unit site with a capacity of 479 MW on

Figure 2: Pointe du Bois Plant (Source: Manitoba Hydro)

Figure 3: Kelsey Generating Station (Source: Manitoba Hydro)

the Saskatchewan River where it empties into Lake Winnipeg. This was, and still is, the largest head in Manitoba at 120 feet. The decision was made to use Kaplan units. The site was unique, in that it was built on a porous limestone foundation. This required extensive grouting, and became the largest grouting program ever encountered by any geophysical consultant. One sinkhole under the powerhouse location required approximately 6,000 cubic yards of grout.

6.0 Nelson River Sites

While this construction was progressing, studies were underway on future Nelson River sites. The Federal Government participated in these studies, which involved the future development of the northern Manitoba rivers for supplying the growing electrical load of the province. The outcome of these studies was an announcement in February 1966 of an agreement between the Federal Government and the Province of Manitoba to proceed to the Northern Sites for the future power requirements of the province. This agreement required Manitoba Hydro to build a 1272 MW power plant at the Kettle Rapids site [4] on the Nelson River, control Lake Winnipeg for storage for this and future Nelson River plants, and divert the Churchill River into the Nelson at a point above Kettle. The license from the Provincial Government to undertake these projects provided for four feet of storage on Lake Winnipeg and ten feet of storage on South Indian Lake, the reservoir for the Churchill River flow. The Federal Government agreed to lend the Province money, which the Federal Government would use to build a DC transmission line from the Nelson River Kettle site to a point near Winnipeg. Atomic Energy of Canada was the federal agency assigned to build the line. This loan was to be repaid by Manitoba Hydro when the load growth was sufficient to carry the financial burden of the line. In the meantime the interest was accumulating and being charged to the line capital account. This loan was discharged in 1992 when Manitoba Hydro bought the line and the accumulated debt.

To supply power to the construction site of the Kettle Plant, a 138 kV line was constructed from Kelsey [3] in 1966. In 1997, the Kelsey station was connected to the southern system by construction of a 230 kV line from Kelsey to Grand Rapids.

This present and future system expansion required additional revenue. As a consequence of this, the first rate increase in 57 years went into effect in July 1968.

7.0 Interconnection with the United States Utilities

This ambitious construction program with the many unknowns caused the Utility to look at alternatives to meet its load requirements in 1970. One option was the addition of another thermal unit at the Selkirk Plant, and an option on a shaft was actually bought. Another, which proved to be the preferred option, was to interconnect with the three utilities south of the border, namely Otter Tail Power, Northern States Power, and Minkota Power Cooperative Inc. and buy capacity for the winter of 1970. This alternative was pursued successfully and a 230 kV line was constructed after receiving approval from the National Energy Board. This line permitted the purchase of 90 MW of capacity for the winter of 1970. It also permitted the export sale of surplus energy, which proved to be very beneficial to all parties.

The first unit of the Kettle Plant [4] came on line in 1970, however the DC transmission terminal equipment was not ready. The two completed DC lines, approximately 900 km in length were used as a temporary 230 kV line with a reactor hung on at approximately the mid point at Grand Rapids to inject this power into the 230 kV system. It meant that Manitoba not only had the US utilities to support the Manitoba System, but the first unit at Kettle also improved the reserve and energy position. Long Spruce came on line in 1976 associated with the second bipole of the DC transmission Line. The converter station, named Henday was located at the site of the future Limestone plant to facilitate the conversion of this plant to DC. All Nelson River plants are interconnected with 230 kV transmission lines. The Limestone Plant came into service in 1990. There are still several sites on the Nelson and other rivers in the north to develop. Wuskwatim, on the Burntwood River, which carries the diverted Churchill River into the Nelson, is on the verge of being developed. The largest site in Manitoba is on the Nelson at Conawapa below Limestone and is being considered for a sale of power to Ontario Power Generation. A fourth interconnection, rated at 230 kV, has been added to the US system from the western part of the Manitoba system.

8.0 Interconnections

The first Interconnection from the Manitoba Hydro system was with Ontario Hydro's isolated Northwest system in 1957. This was followed by an interconnection with Saskatchewan Power Corporation in 1960 between their Estevan Plant and Brandon. This was initially operated at 138 kV, but designed to be raised to 230 kV, which was accomplished in a few years. With the completion of the first 6 units of the 12 unit Kettle plant, Manitoba had a surplus of generation and negotiated a sale to Ontario Hydro commencing in 1972, but by this time the Northwest Region of Ontario Hydro was interconnected with their main system. This meant there would be a circulation of power around the Great Lakes unless phase shifting transformers were installed on this interconnection. Two 200 MVA phase shifting transformers with a 180 degree shift capability were installed to supply two new 230 kV lines to the Ontario System. This rather large angle was determined by test of an isolated machine on the tie line to Ontario and the Manitoba system tied to the US system.

A second 230 kV line was constructed between Saskatchewan and the Manitoba system in 1973.

The operation of the first tie to the US proved so successful that another utility, Minnesota Power and Light, negotiated a tie to their system near Duluth, which went into service in 1976. An agreement was reached with Northern States Power to interconnect their system with Manitoba Hydro at 500 kV. This was negotiated using seasonal diversity as one of the economic justifications for the line. It also provides the Manitoba system with a good backup in case of trouble on the DC system [5] from Northern Manitoba. The line came into service in 1980.

Figure 4: Kettle Plant (Source: Manitoba Hydro)

Figure 5: A view of the largest mercury arc rectifier ever built - this type of valve was originally used in the AC-DC conversion stations in the Nelson River DC transmission system. Most of these valves have now been replaced by thyristors. (Source: Manitoba Hydro).

The value of this 500 kV interconnection [6] with the US system was very vividly demonstrated in 1997, when a wind shear toppled 19 towers on the DC line. This occurred in the early morning hours, before daybreak. The Manitoba system went from an export mode to an import mode without any customer interruptions. The public and some large industrial customers were asked to conserve energy and capacity for the few days it took to build a temporary line around the downed towers. This 500 kV interconnection has had series compensation installed to increase its export capabilities. It has proven to be a valuable source of revenue as well as a source of energy during the 2002-03 years, when one of the worse droughts on record was experienced on the Prairies.

9.0 Winnipeg Hydro

The agreement between the Province and the City of Winnipeg in 1955, which provided for the City to retain its two generating stations and share in the cost of new generation, transmission, and interconnection revenue, was renegotiated each 10 years. The ratio of peak demand and energy use on the two systems had increased to approximately 90/10 and in 2002 Manitoba Hydro purchased the Utility, resulting in one utility supplying the entire province [7] with rates uniform throughout the system and one of the lowest rates in Canada.

Figure 6: 500 kV HVDC transmission line over the new 230 kV North Central transmission line from Kelsey Generating Station. (Source: Manitoba Hydro).

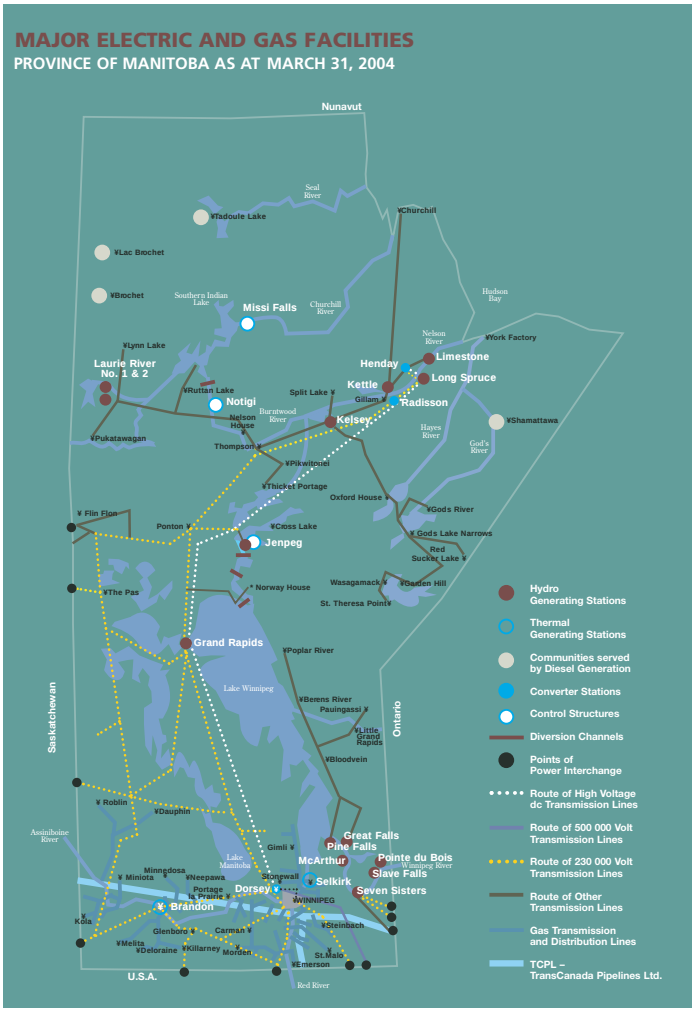
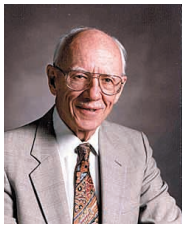


Figure 7: Major electric and gas facilities in the Province of Manitoba, as of March 31, 2004. (Source: Manitoba Hydro-Electric Board 53rd Annual Report).

About the author



Leonard A. Bateman is an electrical engineering graduate from the University of Manitoba with post-graduate qualifications in Engineering and Business Administration. His career spanned thirty-six years in the utilities of Manitoba. His last six years were spent as Chairman and CEO of Manitoba Hydro. He was the last person to hold both of these positions. He has served as President of the Canadian Electrical Association, The Association of Professional and Geophysical Engineers of the Province of Manitoba. He was the first and founding President of the Canadian Society for Senior Engineers. When he left Manitoba Hydro in 1979, he formed his own consulting company - Bateman and Associates Ltd., of which he is still President. As a consultant he has worked and presented papers in many countries of the world. He has received recognition by his peers in many organizations, and in 1994 received the Canadian Engineers' Gold Medal. In 2002 he was awarded the highest recognition that the Province of Manitoba bestows on its citizens - The Order of Manitoba. He is still interested in traveling as well as volunteering in seniors' organizations, having served the two thousand members of Creative Retirement Manitoba as their President in the years 2001 and 2002.