Rebuttal to Bipole III Coalition underground cable report "Potential Use of Underground Cables for Sections of the Planned 500 kVDC Bipole III Overhead Line in Manitoba"

By Manitoba Hydro, March 4th 2013

The Bipole III Coalition provided the CEC Commission the Underground Cable (U/G) Report authored by Energy Cable Consultants, Inc. which evaluates the high level feasibility of using underground cables in some section of the Bipole III route in southern Manitoba. The cable route proposed starts at a point about 40km east from the Bipole III route near Westbourne and is approximately 65km long, terminating at Laverendrye station. MH does not agree that termination point at Laverendrye for Bipole III project is valid, because of reliability risks due to close proximity to Dorsey station, impact on overall MH transmission system power flows under normal and contingency conditions, and overall reduced HVdc system performance. The unsuitability of such termination points is further explained in MH's review of the other Coalition's reports by Mr. W. A. Derry and Mr. Dennis Woodford. The planning and design of a three-bipole system operating in the weak Manitoba ac system is critical and must be done diligently, supported by a variety of technical simulation studies.

This document summarizes the review on the Coalition U/G Report. The Coalition cable route appears to be simplistic and impractical running through many river oxbows and housing developments. The actual cable length would likely be longer if adjusted for the above issues. However, for the purpose of this review, the 65km cable route length as proposed in the Coalition U/G Report is assumed.

The Coalition U/G Report evaluated quite briefly the underground cable system supply costs, logistics for cable manufacturing and transportation, site accessibility, installation and implementation issues with field splices. MH considers that the costs of the overall underground cable system indicated in the Coalition U/G Report are too low and the risks associated with the cable scheme were not fully examined.

1. Underground vs. overhead costs

The Coalition U/G Report considered two cable options. Cable Option A assumed two cables per pole while Cable Option B assumed one cable per pole. In terms of the unit cost of Cable Option B, the Coalition U/G Report states "This cost estimate ($5M/ km) was provided by a supplier via a private communication and was based on current price "– *page 14*. As recognized in the Coalition U/G Report, such an estimate ignored the cost of a spare cable and associated switching apparatus at both ends to facilitate clearing out the failed cable and switching in the spare cable to restore power delivery. Bipole III is designed for system reliability to provide the supply backup during the loss of Bipole I & II and ultimately to serve growing domestic load in the future. Losing the power of a pole (~1000MW) for months in the event of a failure of one of the in-service cables is not acceptable to MH system reliability. This is also not consistent with MH's 40 year operation practice of the HVdc system which utilizes multiple converter units per pole to reduce the impact of pole outages. Bipole III will have two converters per pole.

Factoring in the need for a spare cable, the unit cost of the complete underground cable system would be approximately $6.5M/km assuming the $5M base and an increase of spare cable material and installation cost (~ 60%). The extra cable would also need to be transported, pulled in, spliced and tested in a wider trench. The percentage of the cable material cost was derived from the cost breakdowns shown on page 15 of the Coalition U/G Report. With all-in cost estimates, the Bipole III O/H line in southern Manitoba is estimated to cost $0.8M/km in 2012 dollars including environmental assessment and licensing, land acquisition, engineering, material and equipment procurement, construction, and environmental protection programs. This is lower than the assumed O/H estimated cost of $1M in the Coalition U/G Report.

Therefore, the underground cable system defined by MH would be about 8 times more expensive than the Bipole III O/H line in terms of per unit cost, not 4 times as stated in the Coalition U/G Report. It's likely that the cable estimate in the Coalition U/G report did not include the costs for licensing, hearing and property, so the difference between the per unit costs may well be even higher than 8 times. For a 65km long cable scheme, the estimated cost would be approximately $422M in 2012 dollars, in comparison to approximately $52M in 2012 dollars for the Bipole III O/H line of the same length. This would result in an incremental cost increase of approximately $370M ($422M-$52M) for the underground cable system portion alone. Additional expenditures of about $30M would also be required to build two transition stations and the required distribution lines for station power and transition station building heating purposes. The total incremental increase of $400M ($370M +$30M) would be approximately equivalent to the cost of 500km of Bipole III O/H lines.

The design life of this type of underground HVdc cable is approximately 40 years based on industry testing recommendations. This is less than one-half the expected life of overhead lines. In terms of this life cycle, the underground cable would need to be replaced after about 40 years resulting in additional capital cost of $422M in 2012 dollars.

2. Schedule risks due to field splices

The Coalition U/G Report estimated 140 field splices for a 65km route assuming Cable Option B and a total of 560 days to complete the field splices alone, with approximately 4 days to make each splice.

MH believes that such an estimate is too optimistic. A splicing time of at least 5 days is more realistic based on MH's evaluation [1] and considering preparations and completion activities for each splice. With the need of a spare cable, the minimum number of field splices would increase to 210, and a splicing time of 1050 working days (35 months) for a 65km long cable route. As noted in the Coalition U/G Report, "Construction scheduling would need to allow for long winter stoppages' - *page 13*. If a 7-month construction period is assumed each year, considering the climate in Manitoba, this would take up to 5 years to complete the field splices alone, assuming 30 working days per month. For comparison purposes, Denmark's Energinet is scheduling two full years for installation of one 90 km 500 kV cable for their partially completed HVdc cable project, with four month interruptions due to cold weather in winter. The splices required for the Energinet project are about 70, one third of the splices required for the 65km cable scheme for Bipole III proposed by the Coalition (private communications with Energinet, 2013). This is a significant risk for the Bipole III in-service date.

The construction time could be reduced by use of more than one splicing crew. However, it's worth noting that splices would be made by specially qualified technicians and tradesmen with high attention to precision, high quality workmanship, in weather resistant and climate-controlled housings. Certified splicers for 500 kV cables are scarce and it may not be possible to find any in North America. Therefore it may be necessary to bring skilled workers from offshore. As recognized in the Coalition U/G Report, "Multiple splicing teams can, of course, be considered, but the long splicing times remain a major concern" – *page 14*. MH concludes that since three of the four MI cable manufacture plants in the world are fully committed up to about 2017, skilled cable splicers are probably also fully committed.

3. Regulatory requirements for cables

An Environmental Impact Assessment and a subsequent licensing process would be required for the proposed Bipole III Coalition's route, consisting of about 40km overhead lines and the 65km cable route discussed in this document. This routing process would cause further delays to the project by 2-3 years. Figure 1 showed a typical EHV cable trench excavation and construction operation. It's worth noting the proposed cable route runs through agricultural farm lands.

Figure 1 Typical trench excavation and construction on farm lands

4. Cable Supplier Factory Capacity and Commitments for MI Cables

The Coalition U/G Report states that "Mass-Impregnated, paper-tape insulated (MI) cables, described in Section 3 of the Report, are the only state-of-the-art underground cables currently suitable for operation at 500 kVDC. These cables are not manufactured in North America and would have to be sourced from either Europe or Japan" – *page 2.* MH agrees with such an assessment. MH has reviewed the global factory capacity for the MI cable, and there is a significant risk to meet a 2017 in-service date for the proposed BP III underground section.

There are currently four factories operated by three suppliers in the world that can manufacture MI cables suitable for the Bipole III project, with a total factory capacity of approximately 800 km per year. One of the four factories has yet to manufacture 500 kV MI cables. Considering the proposed 65 km cable route, capacity requirements for BP III 500 kV underground cables would be a minimum of 3 x 65 km = 195 km. However, most of the factory capacity has been committed to other firm projects. At the present time, only one cable supplier would have sufficient availability and capacity to provide the cables by 2017 but other factors associated with this proposal such as splicing and licensing would not allow a 2017 in-service date to be achieved. This capacity would be lost if one of the upcoming planned projects, such as COBRA (Denmark-Netherlands) or NEMO (Belgium-England), makes a prior commitment for MI cables. Both of these two projects are advanced with approximate 2017 in service dates.

Minimum 500kV MI cable manufacturing time would be over one year after receipt of a purchase order, material ordering, initial engineering and type testing, and would not include transportation time to site. The procurement of the MI cable and transportation to the site would likely take at least two years, even If there was adequate global factory capacity.

5. Logistics for cable transportation and accessibility at site

With the MI cable to be manufactured in Europe or Japan, the Coalition U/G Report states "It is envisaged that the cables will be transported on steel reels from Europe to Montreal and by rail from Montreal to Winnipeg", then "From the Winnipeg depot the cable reels will be transported by road to (or a near as possible) to selected installation sites" – *page 11*. Such an approach would require multiple transfers of cable reels weighing about 100 tonnes before reaching the site. The challenges would be the requirement of about 100 trips with a 100 tonnes cable reel to transport all the cables to the site crossing the agriculture farm lands of the proposed cable route. This is a significant challenge in terms of logistics, risks of cable damages during transportation and handling, and impacts on farm land.

Conclusions:

In summary, the underground cable system defined by MH would be about 8 times more expensive than the Bipole III O/H line in terms of per unit cost. The proposed 65km cable route would result in a capital increase of $400M in 2012 dollars in comparison to the Bipole III O/H line of the same length. In terms of the project life cycle, the U/G cable would need to be replaced after about 40 years resulting in additional capital costs of $422M in 2012 dollars. Significant delay of the project in-service date of 2017 by up to 5 years could be expected due to the increased regulatory requirements, implementation of field splices, and the delivery of cables based on limited global factory capacities for the 500KV MI cables.

Reference:

[1]. "Potential Use of Submarine or Underground Cables for Long Distance Electricity Transmission in Manitoba- A Post Bipole III Concepts Review", MH Concept Review Panel, April 2011 (previously filed with the CEC).