Study Outline for Manitoba Hydro Exploratory Study – Interconnection of 400 MW of Generation to the Northern AC System C1064

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Introduction:

The Exploratory Study will look at reliability limitations with up to an additional 400 MW of firm hydro generation connected to the northern AC system. Currently, it is possible to connect two 100 MW Kettle units onto the AC system at Radisson. This can only be done under certain operating conditions and is considered to be non-firm generation. This Exploratory Study will identify the Manitoba Hydro (MH) transmission system upgrades required to connect 400 MW of firm generation to the Radisson 138 kV bus along with associated cost estimates. The upgrades will be identified for incremental amounts of generation up to a total of 400 MW.

For the purposes of this study, the 400 MW generation addition will be integrated into the northern AC system via Kettle untis 1-4. However, the information obtained from the study could also be extended to future northern hydro generating plants other than Kettle as the reliability limitations south of Radisson would apply to any of these generating plants.

Objectives:

The objectives of the Exploratory Study will be:

1. To determine what bottlenecks occur when integrating up to 400 MW of hydro generation to the northern Manitoba AC system at the Radisson 138kV station bus in terms of thermal overloading, steady state voltage violations and transient stability limitations.

2. To determine the amount of generation at which the bottlenecks occur.

3. To identify Network Upgrades and associated cost estimates to mitigate the bottlenecks.

4. To monitor loopflow through SaskPower and to design a transmission solution that does not add additional loopflow.

5. To determine the impact to MH system losses associated with connecting up to 400 MW of generation from Kettle Generating Station units 1-4 to the northern AC system that is normally connected to the HVDC system.

Study Procedure:

The study will be performed using DSA Powertools software.

1) Perform steady state contingency analysis (VSAT)

Contingencies:

- Perform N-1 contingency analysis for all transmission lines and transformers 110 kV and above within Manitoba including tie lines.

- Perform N-2 contingency analysis for all 110 kV and above double-circuit outages in Manitoba and breaker fail outages approximately two buses back from the Generator station.
- Several contingencies in Saskatechwan (yet to be defined) – for example, these contingencies could be chosen based on which SaskPower lines are carrying the highest proportion of Manitoba loop flow or a contingency that would add significant flow to these lines

The 400 MW of generation will result from transferring Kettle units 1-4 from the HVDC collector system to the northern AC system, thereby automatically causing the generation of the HVDC system to become the sink for the new AC system generation. No new generation is being added in this study (except for one sensitivity case as defined below), it is only being injected into a different point within the Manitoba Hydro system. Manitoba Hydro export levels will be kept constant.

Criteria:

Manitoba Hydro facilities identified in post-disturbance analysis will be flagged if loading exceeds 100% and the contingency results in a change > 2% of the branch loading. Branch loadings will be monitored using Rate A for normal conditions and Rate C following a contingency. Bus voltages lower than 0.90 pu and higher then 1.1 pu will be flagged.

SaskPower facilities will also be monitored to see if any impacts occur due to possible loop flow through Saskatchewan, however upgrades will not be determined for SaskPower facilities. The objective is to determine a transmission solution that will not add to existing loop flow through SaskPower.

Power Flow Cases:

Future year summer peak maximum generation MH export (2175 MW) at high NDEX (1950 MW).

INCO load will be set to minimum, i.e. 30 MW.

The power flow cases will include existing firm generation plus the following higher queued generation:

- Pine Falls (+5 MW)
- Great Falls (+4 MW)
- Pointe du Bois (120 MW total)
- Kelsey (+15 MW for a total of 251 MW)
- Wuskwatim (200 MW total) and associated transmission (Birchtree-Wuskwatim, Wuskwatim-Herblet Lake, Herblet Lake-Ralls Is.).
- St. Leon will be set at 100 MW.

As bottlenecks are discovered and mitigated, the power flow models will be modified to include the required upgrade and the contingency analysis will be repeated to ensure no new overloads occur.

Sensitivity Analysis:

Sensitivity analysis will be performed for the following power flow modifications:

- Kelsey (315 MW) and Wuskwatim (223 MW) at maximum potential future generation
- INCO load at intermediate (70 MW)
- INCO load at maximum (140 MW)
- Additional 300 MW wind generation in the southern AC system
- Up to 400 MW of additional generation in the northern HVDC collector system with power exported south (with reduced NDEX to respect D602F thermal loading limit)

2) Perform loss evaluation.

Add 400 MW of generation to the Radisson 138kV bus in increments of 100 MW. Compare the total Manitoba Hydro system losses in the base case to cases with 100 MW, 200 MW, 300 MW and 400 MW moved from the HVDC collector system to the northern AC system.

Power Flow Cases:

The same power flow cases described above in task 1 (steady state contingency analysis) will be used.

3) Perform transient stability analysis (TSAT).

Contingencies:

NERC Category B and C disturbances at stations (lines and other equipment) in the northern Manitoba Hydro AC system will be simulated based on requirements of previous studies [1], [2], including:

- NERC Category B (n-1) – Three-phase faults with normal clearing (system intact) on elements:
  - K24B, B77W, G8P, Ponton SVC, Birchtree SVC, H59C, P18H, P19W, A4D, A3R, G1A, MLR Xfmr Banks 8 and 9, KN36, R26K, KT1, KT2, Kelsey Xfmr Bank 10, H75P, H73/74W, B76W, J30P, F27P, P52E, P58C, loss of INCO load.

  Note: The fault list will be verified by flagging all lines with at least 25% flow from Kettle.
- NERC Category C (n-2) – Single Line-to-Ground stuck breaker faults (system intact) at stations:
  - Cliff Lake, Birchtree, Herblet Lake, Ponton, Mystery Lake, Ralls Island, Wuskwatim, Thompson MLR, Kelsey, Radisson, loss of INCO load.
- NERC Category C (n-2) – Double Circuit Loss with SLGF at:
  - Kelsey (KT1/KT2)
- Several contingencies in Saskatechwan (yet to be defined) – for example, these contingencies could be chosen based on which SaskPower lines are carrying the highest proportion of Manitoba loop flow or a contingency that would add significant flow to these lines

Criteria:

The system must be stable and damped following fault clearing. TSAT measures a damping index for generating units with maximum participation (e.g. Kelsey, Wuskwatim, Kettle, Jenpeg, Grand Rapids) as the worst damping ratio of 3 or 4 of these units. A damping index of 5% is used as security criteria. Certain cases as low as 3% may be accepted.

Transient undervoltages should not drop below 0.7 pu following fault clearing, with the exception of INCO voltage when operating above minimum loading which should not fault below 0.85 pu for 10 cycles.

Post-disturbance voltages must be within 0.9 pu to 1.1 pu. Post-disturbance loading must not exceed 100%.

Power Flow Cases:

The same power flow cases described above in task 1 (steady state contingency analysis) will be used. As stability issues are discovered and mitigated, the power flow models will be modified to include the required upgrade and the transient stability analysis will be repeated for the worst case contingencies which required the mitigation.

Possible Upgrades and Mitigation Measures:

Based on results of previous studies for Kelsey [1] and Wuskwatim [2] generation, the following mitigation measures will be used as starting points for possible upgrades to consider when steady state and stability issues arise:

- Addition of a new 230kV transmission line from Dauphin to Neepawa
- Addition of a second 250 MVA 138kV-230kV transformer bank at the Radisson 138kV station
- Addition of a Grand Rapids – Herblet Lake 230kV transmission line
- Addition of a Radisson – Birchtree – Wuskwatim transmission line
- Addition of series compensation to an appropriate existing transmission line
- Modifications or additions to the existing Northern Crosstrip scheme
- Or any other line upgrades, reactive power support, or new lines in the area that would make sense

Note: Transmission solutions will first be determined that do not modify the existing Northern Crosstrip scheme. Then, the benefits of extending the Nothern Crosstrip scheme will also be discussed up to a maximum generation crosstrip of 200-300 MW.

Deliverables:

1. A draft report describing the results of the study, including the upgrades required to connect 400 MW of firm generation to the northern Manitoba Hydro AC system along with associated cost estimates, for review by Manitoba Hydro.

2. A final report with revisions as requested by Manitoba Hydro.

Estimated Schedule:

The draft report will be provided three (3) months from project kick-off.

The final report will be provided two (2) weeks after receiving comments on the draft report.

References:

[1] “Kelsey Generator Re-Runnering Interconnection Facilities Study”, Manitoba Hydro, System Planning Department, June 1, 2006.

[2] “Wuskwatim Hydro Generating Plant Interconnection Facilities Study Report”, Manitoba Hydro, System Planning Department, November 19, 2004.