MH-US TSR Sensitivity Analyses

Draft Report

January 3, 2013

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Contents

Introduction

The purpose of this study was to perform sensitivity analysis on alternative transmission options for the MH-US south bound TSRs. The sensitivity included iterations of the MH-US transfer.

Executive Summary

Results from this study show that the impact of the proposed Riel-Shannon 230kV or Dorsey-Iron Range 500kV (750 or 1100MW) transmission options do not impact the existing transmission system in an adverse way. The facilities that are impacted have mitigations that are outlined in the report. The estimated costs associated with these mitigations are relatively small. The status of G519 (Excelsior 600MW) was studied as a sensitivity to access its individual impact. Mitigation costs are shown below.

Scenario	Mitigation Costs (millions)
Riel-Shannon 230kV (250MW transfer) G519 offline	0
Riel-Shannon 230kV (250MW transfer) G519 online	0
Dorsey-Iron Range 500kV (750MW transfer) G519 offline	0
Dorsey-Iron Range 500kV (750MW transfer) G519 online	5.52
Dorsey-Iron Range 500kV (1100MW transfer) G519 offline	0
Dorsey-Iron Range 500kV (1100MW transfer) G519 online	9.66

Description of Request

The south bound requests reserve a total of 1100 MW of transmission service from Manitoba Hydro to several sinks in the northern Midwest United States (Table 1).

Table 1: MH-US South Bound Requests

\Oasis Ref No	Service Type	Start time	Stop Time	POR	POD	Requested Capacity	Queue Date	Study Number
76703536	Network	Nov-2014	Nov-2024	MHEB-MISO	GRE	200	12/7/2006	A388
76703671	Network	Jun-2017	Jun-2027	MHEB-MISO	WPS	500	6/12/2007	A380
76703672	Network	Jun-2017	Jun-2037	MHEB-MISO	MP	250	7/6/2007	A383
76703686	Network	Jun-2017	Jun-2027	MHEB-MISO	NSP	50	4/17/2008	A416
76703687	Network	Jun-2017	Jun-2027	MHEB-MISO	WEC	100	4/17/2008	A417

The proposed sensitivity options are described in Table 2.

Table 2 Sensitivity Options

Option	Description
230 kV, w/ G519	• MH-MP TSR only (250 MW) • Riel – Shannon 230 kV (294.15 miles) ○ Line data based on R50M • G519 assumed dispatched to NSP
230 kV, w/o G519	• MH-MP TSR only (250 MW) • Riel – Shannon 230 kV (294.15 miles) ○ Line data based on R50M • G519 removed
Y500 kV, w/ G519	• MH-MP TSR + MH-WPS TSR (750 MW) • Dorsey – Blackberry 500 kV (271.12 miles) ○ Line data based on Dorsey – Bison 500 kV option • Arrowhead PST = 0 • One 500/230 kV transformer at Blackberry (based on Forbes 500/230 kV) • G519 assumed dispatched to NSP
Y500 kV, w/o G519	• MH-MP TSR + MH-WPS TSR (750 MW) • Dorsey – Blackberry 500 kV (271.12 miles) ○ Line data based on Dorsey – Bison 500 kV option • Arrowhead PST = 0 • One 500/230 kV transformer at Blackberry (based on Forbes 500/230 kV) • G519 removed
Y500 kV + A/B, w/ G519	• All TSRs (1100 MW) • One Dorsey – Blackberry 500 kV circuit (271.12 miles) ○ Line data based on Dorsey – Bison 500 kV option • Two 345 kV circuits from Blackberry – Arrowhead (71.15 miles) • Arrowhead PST = 0 • Two 500/345 kV transformers at Blackberry (based on Maple River 500/345 kV) • One 500/230 kV transformer at Blackberry (based on Forbes 500/230 kV) • G519 assumed dispatched to NSP
Y500 kV + A/B, w/o G519	• All TSRs (1100 MW) • One Dorsey – Blackberry 500 kV circuit (271.12 miles) ○ Line data based on Dorsey – Bison 500 kV option • Two 345 kV circuits from Blackberry – Arrowhead (71.15 miles) • Arrowhead PST = 0 • Two 500/345 kV transformers at Blackberry (based on Maple River 500/345 kV) • One 500/230 kV transformer at Blackberry (based on Forbes 500/230 kV) • G519 removed

Criteria, Methodology, and Assumptions

Models

A benchmark power flow model representing a 2017 Summer Peak condition was utilized (MH_SUPK_Benchmark_2009-June.sav). Modeling of TSRs and GIPs was based on "MHEB Group TSR System Impact Study Transmission Options W.1 and W.2" with revision date April 19, 2010. Flow on the MHEX is 1845 MW (south) in the summer peak benchmark case.

The three HVDC bipoles are set at 3400 MW in the benchmark case as follows:

- Bipole 1 = 1077.8 MW
- Bipole 2 = 1162.8 MW
- Bipole 3 = 1159.4 MW

The bipole inverters were used to source the south bound requestsas shown in Table 3.

Table 3 MH-US TSR Sources

250 MW Injection	750 MW Injection	1100 MW Injection
• Bipole 1 = 1157 MW • Bipole 2 = 1248.2 MW • Bipole 3 = 1244.6 MW	• Bipole 1 = 1348 MW • Bipole 2 = 1546 MW • Bipole 3 = 1258 MW	• Bipole 1 = 1539.6 MW • Bipole 2 = 1535.2 MW • Bipole 3 = 1427.2 MW

Study TSRs were sunk to the generators in Table 4.

Table 4 MH-US TSR Sinks

Bus #	Generator Name	MW
WPS (A380)		
699993	Skygen Unit #1	172
699661	West Marinette Unit #3	75.0
699597	Pulliam Unit #31	74.0
698925	AP_PPRGT Unit	42.3
699591	Pulliam Unit #5	51.0
699679	Weston Unit #1	62.0
699595	Pulliam Unit #6	23.7
GRE (A388)		
615031	Pleasant Valley Unit #1	29.0
615041	Lakefield Unit #1	84.9
615045	LakefieldUnit #5	86.1
MP (A383)		
608667	Potlatch	24
608676	Hibbard Unit #3	20
608676	Hibbard Unit #4	15
608776	Boswell Unit #1	54
608777	Boswell Unit #2	54
608665	Thomson	36

Bus #	Generator Name	MW
608702	Laskin Unit #1	25
608702	Laskin Unit #2	22
Xcel Energy (A416)		
600073	River Falls	20
605308	Hatfield	6
600035	Wheaton Unit #4	24
WEC (A417)		
699322	Germantown Unit #5	83
699507	Valley Unit #2	17

Criteria

The following system conditions were considered for the steady-state analysis.

- NERC Category A with system intact (no contingencies)
- NERC Category B contingencies
- Outage of single element 100 kV or higher (B.2 and B.3) associated with single contingency event in the following areas: ATCLLC (WEC, ALTE, WPS, MGE, UPPC), DPC, GRE, ITC Midwest, MH, MP, OTP, SMMPA, WAPA, XEL
- Outage of multiple-elements 100 kV or higher (B.2 and B.3) associated with associated with single contingency events in the Dakotas, Manitoba, Minnesota, Wisconsin

The Manitoba HVDC power order reduction scheme was not simulated for this sensitivity. Overloads that would be properly mitigated by a Manitoba HVDC runback were not included in the results of this study report. Thermal limits were identified using AC solve methods. Voltage and stability considerations were not included in the sensitivities.

Analysis Results

PSS®E version 32 and PSS®MUST version 10.2 were used to perform the sensitivities. Post transfer cases were screened at 100%.

250 MW Transfer, 230 kV Transmission, G519 Dispatched

Table 5: 250 MW Transfer, 230 kV Transmission, G519 Dispatched

Monitored Element	Pre ContMW	Post ContMW	Base Flow	Rating	Cont. Ld%	Contingency Description	Impact	DF
602006 SHEYNNE4 230 652435 FARGO 4 230 1	429.1	441.2	238.9	403.9	109.2	620358 BUFFALO3 345 620369 JAMESTN3 345 1	12.1	4.84
Contingency is incomplete, contingency 220 is correct version, as Sheyenne-Fargo did not flag for 220 this contingency could be ignored.								
657751 CENTER 4 230 661042 HESKETT4 230 1	478.4	487.7	278.7	471	103.5	220	9.3	3.72
Center-Heskett 230kV will be upgraded prior to ISD of 500kV option.								
657751 CENTER 4 230 661042 HESKETT4 230 1	481.5	490.3	278.7	471	104.1	620358 BUFFALO3 345 620369 JAMESTN3 345 1	8.8	3.52
Contingency is incomplete, contingency 220 is correct version, Center-Heskett 230kV will be upgraded prior to ISD of 500kV option.								

750 MW Transfer, 500 kV Transmission, G519 Dispatched

Table 6: 750 MW Transfer, 500 kV Transmission, G519 Dispatched

Monitored Element	Pre ContMW	Post ContMW	Base Flow	Rating	Cont. Ld%	Contingency Description	Impact	DF
608739 BLCKBRY7 115 608781 20L TAP7 115 1	84	176.5	173.2	176	100.3	608737 NASHWAK7 115 618133 GRE-LWRNCTP7 115 1	92.5	12.3
Line can be upgraded to increase thermal rating above post-contingent levels. Estimated cost is $3.36 million.								
608739 BLCKBRY7 115 608781 20L TAP7 115 1	83.6	176	173.2	176	100	608748 BOSWELL7 115 618133 GRE-LWRNCTP7 115 1	92.4	12.3
Line can be upgraded to increase thermal rating above post-contingent levels. Estimated cost is $3.36 million.								
608737 NASHWAK7 115 608739 BLCKBRY7 115 1	163.6	207.5	139.2	158	131.3	20L	43.9	5.9
Line can be upgraded to increase thermal rating above post-contingent levels. Estimated cost is $2.16 million.								

1100 MW Transfer, 500 kV + 345 kV A/B Transmission, G519 Dispatched

Table 7: 1100 MW Transfer, 500 kV + 345 kV A/B Transmission, G519 Dispatched

Monitored Element	Pre ContMW	Post ContMW	Base Flow	Rating	Cont. Ld%	Contingency Description	Impact	DF
602017 ST LAKE5 161 699450 ST LAKE 345 1	433.8	514.9	309.6	420	122.6	699450 ST LAKE 345 699676 GARDR PK 345 1	81.1	7.4
Addition of a second Stone Lake 345/161kV transformer would mitigate this violation. Cost is estimated at 7.5 million.								
608666 FONDULAC 115 608676 HIBBARD7 115 1	9.4	58	13.1	44	131.8	608667 POTLTCH7 115 608668 CLOQUET7 115 1	48.6	4.4
The Fond Du Lac–Hibbard 115kV line has an associated project in MTEP11 (#2549) that will resolve the loading issues identified on this line.								
608683 STIN-MN7 115 608684 STIN-WI7 115 1	208.8	253.3	30.6	250	101.3	699449 ARROWHD 345 699450 ST LAKE 345 1	44.5	4.0
Stinson Phase shifter will be adjusted to reduce loading to acceptable levels.								
608737 NASHWAK7 115 608739 BLCKBRY7 115 1	135.3	172.5	110	158	109.2	20L	37.2	3.4
Line can be upgraded to increase thermal rating above post-contingent levels. Estimated cost is $2.16 million								
608666 FONDULAC 115 608676 HIBBARD7 115 1	15.6	51	13.1	44	115.9	608668 CLOQUET7 115 608673 ARROWHD7 115 1	35.4	3.2
The Fond Du Lac–Hibbard 115kV line has an associated project in MTEP11 (#2549) that will resolve the loading issues identified on this line.								

250 MW Transfer, 230 kV Transmission, G519 Removed

Table 8: 250 MW Transfer, 230 kV Transmission, G519 Removed

Monitored Element	Pre ContMW	Post ContMW	Base Flow	Rating	Cont. Ld%	Contingency Description	Impact	DF
602006 SHEYNNE4 230 652435 FARGO 4 230 1	409.7	421.3	255	403.9	104.3	620369 JAMESTN3 345 657791 CENTER 3 345 1	11.6	4.64
Facility is overloaded in pre-project case, manual simulation of contingency also showed Center-Heskett 230KV overloaded which would trigger a SPS runback and mitigate other associated overloads and impacts								

750 MW Transfer, 500 kV Transmission, G519 Removed

Table 9: 750 MW Transfer, 500 kV Transmission, G519 Removed

Monitored Element	Pre ContMW	Post ContMW	Base Flow	Rating	Cont. Ld%	Contingency Description	Impact	DF
657751 CENTER 4 230 661042 HESKETT4 230 1	460.9	483.5	267.6	471	102.7	620358 BUFFALO3 345 620369 JAMESTN3 345 1	22.6	3.0
Contingency is incomplete, contingency 220 is correct version, Also Center-Heskett 230kV will be upgraded prior to ISD of 500kV option.								

1100 MW Transfer, 500 kV + 345 kV A/B Transmission, G519 Removed

Table 10: 1100 MW Transfer, 500 kV + 345 kV A/B Transmission, G519 Removed

Monitored Element	Pre ContMW	Post ContMW	Base Flow	Rating	Cont. Ld%	Contingency Description	Impact	DF
608666 FONDULAC 115 608676 HIBBARD7 115 1	10.9	52.2	11.3	44	118.6	608667 POTLTCH7 115 608668 CLOQUET7 115 1	41.3	3.75
The Fond Du Lac-Hibbard 115kV line has an associated project in MTEP 11 (#2549) that will resolve the loading issues identified on this line.								
608666 FONDULAC 115 608676 HIBBARD7 115 1	18.7	52.3	11.3	44	118.9	608668 CLOQUET7 115 608673 ARROWHD7 115 1	33.6	3.05
The Fond Du Lac-Hibbard 115kV line has an associated project in MTEP11 (#2549) that will resolve the loading issues identified on this line.								

Summary

In this study AC contingency analysis is performed for following three transfer levels made from Manitoba Hydro to US: 250MW, 750 MW and 1100MW. Each transfer level is further studied with and without G519 project, hence a total of 6 scenarios. Transfer level are simulated by adjusting MW flows at the DC bipoles in Manitoba Hydro and sinking them to generation in MP, WPS, WEC, Xcel Energy and GRE. Table 3 and Table 4 of this report gives information on adjusted MW flows on DC bipoles and the study sinks respectively.

Details on study assumptions are given in the Table 2 of this report. Result tables given in this report are made by comparing the AC analysis results of post and pre transfer scenarios. Since this was not a facility study cost of various upgrades suggested by the study remain as preliminary estimates. Result summaries of the individual transmission options are described below.

- **250MW transfer, Riel-Shannon 230kV**

The 250MW transfer options both with and without G519 showed violations on Center-Heskett 230kV and Fargo-Sheyenne 230kV. It is expected that the Center-Heskett 230kV line will be upgraded prior to the expected in service date of a 230kV transmission option. The Fargo-Sheyenne 230kV line is overloading in both pre-project post-contingent cases so drives other than the 230kV build from Riel-Shannon point to an upgrade being required for this line.

- **750MW transfer, Dorsey-Blackberry 500kV**

The 750MW transfer option with G519 showed violations on two MP facilities. These would both be mitigated by increasing the thermal line ratings. It is estimated to cost 3.36 million to upgrade Blackberry-20L Tap 115kV and 2.16 million for Blackberry-Nashwauk 115kV. The 750MW option without G519 did not show any valid constraints.

- **1100MW transfer, Dorsey-Blackberry 500kV, 345kV Blackberry-Arrowhead 345kV double circuit**

The 1100MW transfer option with G519 showed a need to add an additional 345/161kV transformer at Stone Lake the estimated cost for this is 7.5 million. Blackberry-Nashwauk 115kV would also need to be upgraded at a cost of 2.16 million. Increased loading was also shown on the Stinson phase shifter, while the phase shifter can be tapped to reduce flow a more detailed study would need to be performed to coordinate the Stinson and Arrowhead phase shifters. The Fond Du Lac-Hibbard 115kv line post-contingent overload is a known existing issues with mitigation already identified in the MTEP11 process. MTEP #2549 is the project associated with the mitigation. Without G519 the only issues are related to Fond Du Lac-Hibbard 115kv with the same mitigation as defined in the scenario with G519 online.

Definition of Terms

In order to make it easier for the reader to interpret the results, definitions of various columns used in the result tables are provided below:

Monitored Element: This is the limiting element. Description of the limiting element does not represent the actual name of the network elements. These are the names used in the PSSE models and include PSSE bus numbers.

Pre ContMW: This is the amount of MW flow on the limiting element in the model without the transfer modeled.

Post ContMW: This is the amount of MW flow on the limiting element in the model having study transfers modeled.

Base Flow: This is the MW flow on the limiting element in the base case having study transfers implemented.

Rating: This is the rating of the limiting element.

Cont. Ld%: This is the post-contingency percentage loading on the limiting element in the model having study transfers modeled.

Contingency Description: This is the contingent element. Description of the contingent element does not represent the actual name of the network element. These are the names used in the PSSE models and include PSSE bus numbers.

Impact: This value is calculated as difference between the **Pre ContMW** and **Post ContMW** values defined above.

DF: Distribution factor is the Impact calculated as percentage of the MW transfer level being studied. For this study all post –contingent overloads with greater than 100 Cont LD% and a DF of 3.0% were included.

DF = ((Impact/MW transfer Level)*100)