MISO

MH-US TSR Sensitivity Analysis

System Impact Study

OASIS Reference #: 76703672, 79258361, 79258364, 79258450, 79258492, 79258646, 79258668, 79429002

MISO Project: A383, A627, A628, A629, A630

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Contents

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1. Introduction

The purpose of this study was to perform sensitivity analysis on the new transmission for the MH-US south- (summer) and US-MH north- (winter) bound TSRs.

2. Summary

A No-Harm test has been performed to study the impact of the proposed Dorsey-Iron Range 500kV transmission line on the existing transmission system.

Yearly Firm transmission service has been requested under the MISO's Open Access Transmission and Energy Markets Tariff.

The combined transmission service requests seeks to reserve up to 883 MW of yearly, firm, network service from MISO to Manitoba Hydro during Winter and from Manitoba Hydro to MISO during Summer.

Table 1 MISO System Impact Study A383, A627, A628, A629, A630

OAIS TSR #	Start Time	Stop Time	Point of Receipt	Point of Delivery	Capacity Requested
MISO 79258668	6/1/2020	6/1/2025	WPS	MHEB-MISO	300
MISO 79258646	6/1/2020	6/1/2036	WPS	MHEB-MISO	200
MISO 79258492	6/1/2020	6/1/2040	MP	MHEB-MISO	133
MISO 79258450	6/1/2015	6/1/2020	MHEB-MISO	WPS	300
MISO 79258364	6/1/2020	6/1/2036	MHEB-MISO	WPS	200
MISO 79258361	6/1/2020	6/1/2040	MHEB-MISO	MP	133
MISO 79429002	6/1/2017	6/1/2037	MP	MHEB-MISO	250
MISO 76703672	6/1/2017	6/1/2037	MHEB-MISO	MP	250

Analysis has been performed for the outer year conditions to assess the impact of the proposed transfer on the transmission system. . The service can be granted in varying amounts pursuant to the mitigation of the transmission constraints as identified in Section 6 of the report.

3. Study Objectives

The objectives of this study are to:

- Identify MISO system constraints newly created or aggravated by the requested service.

- Identify non-MISO system constraints newly created or aggravated by the requested service, especially constraints on impacted systems that are not on the contract path.
- Identify potential system upgrades to mitigate any identified MISO-system constraints.

The study procedure includes:

- Use of Network Analysis to identify steady-state thermal and voltage violations on transmission facilities and flowgate violations.
- The relevant MISO, Reliability Region, and Control Area reliability criteria are used to identify such violations.
- The network analysis includes determining the availability of rollover rights.
- Use of Flow based Analysis to determine negative AFC on constrained Facilities.

The eight transmission service requests were divided into two groups according to the direction of the transfer. This is done to study the impact of the requests on the system.

The south bound transmission service requests (during Summer months) seek to reserve a total of 883 MW of transmission service from Manitoba Hydro to several sinks in the northern Midwest United States(Table 2).

Table 2: MH-US South Bound Requests

TSR #	Start Time	Stop Time	Point of Receipt	Point of Delivery	Capacity Requested
MISO 79258450	6/1/2015	6/1/2020	MHEB-MISO	WPS	300
MISO 79258364	6/1/2020	6/1/2036	MHEB-MISO	WPS	200
MISO 79258361	6/1/2020	6/1/2040	MHEB-MISO	MP	133
MISO 76703672	6/1/2017	6/1/2037	MHEB-MISO	MP	250

The north bound transmission service requests (during Winter months) seeks to reserve a total of 883 MW of transmission service from northern Midwest United States to Manitoba Hydro (Table 3).

Table 3 US-MH North Bound Requests

TSR #	Start Time	Stop Time	Point of Receipt	Point of Delivery	Capacity Requested
MISO 79258668	6/1/2020	6/1/2025	WPS	MHEB-MISO	300
MISO 79258646	6/1/2020	6/1/2036	WPS	MHEB-MISO	200
MISO 79258492	6/1/2020	6/1/2040	MP	MHEB-MISO	133
MISO 79429002	6/1/2017	6/1/2037	MP	MHEB-MISO	250

4. Models, Criteria, Methodology, and Assumptions

4.1 Models

4.1.1. Summer

MTEP 2013 power flow model representing a 2023 Summer Peak case was utilized. 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 1850 MW (south) in the summer peak benchmark case.

The three HVDC bipoles are set at 3874.6 MW in the benchmark case as follows:

- Bipole 1 = 1228.3 MW
- Bipole 2 = 1325.1 MW
- Bipole 3 = 1321.2 MW

The bipole inverters were used to source the south bound requests as shown below. The three HVDC poles were set at 4773.5 MW

- Bipole 1 = 1513.2 MW
- Bipole 2 = 1632.5 MW
- Bipole 3 = 1627.8 MW

4.1.2. Winter

MTEP 2013 power flow model representing a 2018 Winter Peak case was utilized. 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 700 MW (north) in the winter peak benchmark case.

The three HVDC bipoles are set at 1738.8 MW in the benchmark case as follows:

- Bipole 1 = 551.2 MW
- Bipole 2 = 594.7 MW
- Bipole 3 = 592.9 MW

The bipole inverters were used to source the north bound requests as shown below. The three HVDC poles were set at 853.2 MW

- Bipole 1 = 270.5 MW
- Bipole 2 = 291.8 MW
- Bipole 3 = 290.9 MW

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4.2 Criteria

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

- NERC Category A with system intact (no contingencies)
- NERC Category B contingencies
- NERC Category C contingencies (only for the no harm test part.)
- 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 single contingency events in the Dakotas, Manitoba, Minnesota, Wisconsin

The Manitoba HVDC power order reduction scheme was simulated for this sensitivity analysis. This was performed by reducing the flow on HVDC line by the MW pre-contingency flow on the contingent element. Thermal limits were identified using AC solve methods. Voltage and stability considerations were not included in the sensitivities.

4.3 Methodology

Complete sensitivity analysis is comprised of two parts. First part of the analysis studied impact of the transfer only. Both pre and post cases prepared for this part have the transmission plan modeled in them, only difference being the amount of MH-US Transfer. This part of the analysis was performed for all scenarios listed in the Table 2 above.

Second part of the analysis is a no harm test which studied the impact of both transfer and the transmission plan put together. Pre case for this study didn't have transmission plan or the transfer modeled in it, whereas post case included both transfer and the transmission plan in it.

5. Results

PSS®E version 32 and PSS®MUST version 11.1 were used to perform the sensitivity study. Post transfer cases were screened at 100%.

5.1 Summer: 883 MW South-Bound Transfer, 500 kV Transmission

Table 4: MH – US Transfer

Monitored Element	Contingent Element	LBA	Rating	Post Transfer, Post Cont MVA	Pre Transfer, Post Cont MVA	Impact MVA	DF	FCITC
667501 RIEL 2 500 601012 ROSEAUN2 500 1	601062 MIDCOMP-S 500 608635 BLCKBRY2 500 1	MH/XEL	1905.3	2053.1	1391.8	661.3	74.89	685.65
608625 BLCKBRY4 230 608612 RIVERTN4 230 1	601016 CHIS CO2 500 601017 CHIS-N 2 500 1	MP	365	411.8	296	115.8	13.11	526.14
667224 RAD_K1_6 138 667231 RADSNDC6 138 1	667001 HENDAY 4 230 667002 LIMEST54 230 5	MH	125	270	56.8	213.2	24.1	282.46
699211 PT BCH3 345 699630 KEWAUNEE 345 1	694022 FOXRIVER B1 345 699359 N APPLETON 345 1	WEC/WPS	1006	1029.6	992.7	36.9	4.17	318.27
608625 BLCKBRY4 230 608624 FORBES 4 230 1	601012 ROSEAUN2 500 667501 RIEL 2 500 1 667500 DORSEY2 500 667501 RIEL 2 500 1	MP	287	487.2	356.6	130.6	14.79	-470.57

5.2 Winter: 883 MW North-Bound Transfer, 500 kV Transmission

Table 5: US – MH Transfer

Monitored Element	Contingent Element	LBA	Rating	Post Transfer, Post Cont MVA	Pre Transfer, Post Cont MVA	Impact MVA	DF (%)	FCITC
620325 BROWNSV4 230 620327 HANKSON4 230 1	601001 FORBES 2 500 601017 CHIS-N 2 500 1	OTP	351	353.9	317.4	36.5	4.13	812.84
608601 CENTRDC4 230 657756 SQBUTTE4 230 1	601001 FORBES 2 500 601017 CHIS-N 2 500 1	MP/OTP	526	470.5	467.6	2.8	0.32	18385.32
615319 GRE-BENTON 4 230 608617 MUDLAKE4 230 1	601001 FORBES 2 500 601017 CHIS-N 2 500 1	XEL/MP	478	527.5	458.1	69.4	7.86	253.19
615460 GRE-RUSH CY4 230 602037 ROCKCR 4 230 1	601016 CHIS CO2 500 601017 CHIS-N 2 500 1	XEL	398.3	352.1	302.4	49.7	5.62	1703.82
652519 OAHE 4 230 652521 SULLYBT4 230 1	601016 CHIS CO2 500 601017 CHIS-N 2 500 1	WAPA	264	266.8	239.9	26.9	3.04	791.08

5.3 No Harm Test Results Dorsey-Iron Range 500 kV

Table 6: No Harm test results, 500 kV Transmission Line

Monitored Element	Contingent Element	LBA	Rating	Post Transfer, Post Cont MVA	Pre Transfer, Post Cont MVA	Impact MVA	DF (%)	FCITC
NONE	NONE							883

6. Conclusion

In this study, AC contingency analysis is performed for transfer from Manitoba Hydro to US for 883 MW during summer months and US to Manitoba Hydro for winter months. Transfer level is simulated by adjusting MW flows at the DC bipoles in Manitoba Hydro and sinking them to generation in MP and WPS. Section 4.1.1 and 4.1.2 of this report gives information on adjusted MW flows on DC bipoles.

Result tables (South-bound: Table 4; North-bound: Table 5) given in this report are compiled 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 are preliminary estimates. Result summaries of the individual transmission options are described below.

- **883 MW transfer, Dorsey-Blackberry 500kV**
  Analysis has been performed for the near term and outer year conditions to assess the impact of the proposed transfer on the transmission system. The service can be granted if the following transmission constraints are mitigated. Some high level cost estimates are listed in the Table 7 (South-bound TSRs) and Table 8 (North-bound TSRs).

Table 7 Cost estimate to mitigate the constraint (South-bound TSRs)

Monitored Element	LBA	Rating (Normal/Contingency)	Minimum required rating for full transfer (Normal/Contingency)	Estimate upgrade cost
667501 RIEL 2 500 601012 ROSEAUN2 500 1	MH/XEL	1732.1/1905.3	1732.1/2054	Contingency will trigger Manitoba Hydro DC runback mechanism to reduce the flows on the DC line. Transmission Element is not overloaded after the flows on the DC tie and associated interface flows are reduced by the specified amount.
608625 BLCKBRY4 230 608612 RIVERTN4 230 1	MP	365/365	365/412	Contingency will trigger Manitoba Hydro DC runback mechanism to reduce the flows on the DC line. Transmission Element is not overloaded after the flows on the DC tie and associated interface flows are reduced by the specified amount.

667224 RAD_K1_6 138 667231 RADSNDC6 138 1	MH	125/125		The underlying unit is at the swing BUS to the area. Line is being overloaded due to unit generating more than the Pmax. Bringing the unit back to rating resolved the constraint.
699211 PT BCH3 345 699630 KEWAUNEE 345 1	WEC/WPS	960/960	960/1030	$250,000.00
608625 BLCKBRY4 230 608624 FORBES 4 230 1	MP	287/287	287/488	Contingency will trigger Manitoba Hydro DC runback mechanism to reduce the flows on the DC line. Transmission Element is not overloaded after the flows on the DC tie and associated interface flows are reduced by the specified amount.

Table 8 Cost estimate to mitigate the constraints (North-bound TSRs)

Monitored Element	LBA	Rating (Normal/Contingency)	Minimum required rating for full transfer (Normal/Contingency)	Estimate upgrade cost
620325 BROWNSV4 230 620327 HANKSON4 230 1	OTP	319/351	319/354	An investment of $50,000.00 towards the terminal line equipment at OTP's Hankinson substation will increase the rating to 401/442 MVA (normal/contingency)...
608601 CENTRDC4 230 657756 SQBUTTE4 230 1	OTP	478/526		Young#2 unit was over Pmax. Bringing the unit back to rating resolves the constraint.
615319 GRE-BENTON 4 230 608617 MUDLAKE4 230 1	XEL/MP	478/478	478/528	An investment of $130,000.00 towards the terminal line equipment will increase the rating to 513 MVA. This will increase the FCITC to 698 MW. To increase the rating further, a complete rebuild of the line will be required. Initial cost estimates are around $48 million for the 54 mile long 230 kV line.
615460 GRE-RUSH CY4 230 602037 ROCKCR 4 230 1	XEL	398.3/398.3		Transmission Line is not constrained with revised higher rating.
652519 OAHE 4 230 652521 SULLYBT4 230 1	WAPA	240/264	240/269	Note*1

- Note 1: The estimate is not available at the time of report posting. It will be updated during the following facility study stage.

1. South-bound TSRs: 883 MW of summer flow from Manitoba Hydro to US can be granted with the following upgrades:
    a. base case upgrades consisting of following facilities,
        i. Manitoba facilities
            1. Winnipeg (Dorsey) to US border 500 kV line,
            2. Riel 500/230 kV 1200 MVA transformer,
            3. Dorsey/Riel shunt compensation (line reactor and capacitors),
            4. Glenboro 250 MVA phase shifting transformer
        ii. US facilities:
            1. US border to Iron Range (Blackberry) 500 kV line,
            2. 60% series compensation,
            3. Blackberry 500/230 kV 1200 MVA transformer,
            4. Blackberry shunt compensation (line reactor and capacitors)
    b. Point Beach – Kewaunee line upgrade: about $250,000

2. North-bound TSRs:
    698 MW of winter flow from US to Manitoba Hydro can be granted with following network upgrades:
    a. base case upgrades consisting of following facilities,
        i. Manitoba facilities
            1. Winnipeg (Dorsey) to US border 500 kV line,
            2. Riel 500/230 kV 1200 MVA transformer,
            3. Dorsey/Riel shunt compensation (line reactor and capacitors),
            4. Glenboro 250 MVA phase shifting transformer
        ii. US facilities:
            1. US border to Iron Range (Blackberry) 500 kV line,
            2. 60% series compensation,
            3. Blackberry 500/230 kV 1200 MVA transformer,
            4. Blackberry shunt compensation (line reactor and capacitors)
    b. terminal equipment upgrade at Otter Tail Power's Hankinson substation: $50,000.00
    c. terminal equipment upgrade at both Xcel Energy' Benton substation and Minnesota Power's Mudlake substation: $130,000.00

    883 MW of winter flow from US to Manitoba Hydro can be granted by reducing the flows over Glenboro Phase Shifter to mitigate the overloading on Oahe – Sully Bt 230 kV transmission line and with the following network upgrades:
    a. base case upgrades consisting of following facilities,
        i. Manitoba facilities

1. Winnipeg (Dorsey) to US border 500 kV line,
2. Riel 500/230 kV 1200 MVA transformer,
3. Dorsey/Riel shunt compensation (line reactor and capacitors),
4. Glenboro 250 MVA phase shifting transformer

ii. US facilities:
1. US border to Iron Range (Blackberry) 500 kV line,
2. 60% series compensation,
3. Blackberry 500/230 kV 1200 MVA transformer,
4. Blackberry shunt compensation (line reactor and capacitors)

b. terminal equipment upgrade at Otter Tail Power's Hankinson substation: $50,000.00
c. reconductor the transmission line between Xcel Energy' Benton substation and Minnesota Power's Mudlake substation: $48 million

- **No Harm Test, Dorsey-Blackberry 500kV,**
  No constraints were found for the addition of the new 500 kV transmission line.

7. 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 Transfer, Post Cont MVA: This is the amount of MVA flow on the limiting element in the model without the transfer modeled.

Post Transfer, Post Cont MVA: This is the amount of MVA flow on the limiting element in the model having study transfers modeled.

Base Flow: This is the MVA 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 MVA: This value is calculated as difference between the **Pre Transfer, Post Cont MVA** and **Post Transfer, Post Cont MVA**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)

FCITC: First Contingency Incremental transfer Capability is the incremental available capacity on a given transmission element for a given contingency
FCITC = (Contingency Limit – Pre-Shift Continegcny Flow)/DF