# State of Minnesota

## DEPARTMENT OF COMMERCE
## DIVISION OF ENERGY RESOURCES

**Utility Information Request**

Docket Number: E015/CN-12-1163 Date of Request:July 7, 2014

Requested From: David R. Moeller, Senior Attorney Response Due:July 17, 2014

Analyst Requesting Information: Stephen Rakow

| Type of Inquiry: | [ ]......Financial | [ ]......Rate of Return | [ ]......Rate Design |
|---|---|---|---|
| | [ ]......Engineering | [ ]......Forecasting | [ ]......Conservation |
| | [ ]......Cost of Service | [ ]......CIP | [ ]......Other: |

*If you feel your responses are trade secret or privileged, please indicate this on your response.*

| Request No. | |
|---|---|
| 6 | Please provide the final reports related to Appendix Q (see page 69 of the Petition) or indicate that MP will provide the final reports in direct testimony. |

**Response:**

The TSR reports referenced on page 69 of the Petition were never produced as final reports. Attached are the last revisions that were issued by MISO on July 3rd, 2013, (MH-MP_AC_Thermal_Sensitivity_Analysis-Western_Plan-Draft_Report-01-07-13.pdf) and (MH-MP_AC_Thermal_Sensitivity_Analysis-Eastern_Plan-Draft_Report-01-07-13.pdf). This previous analysis was tabled in favor of revised model assumptions as well as new TSRs requests. This revised TSR study was completed and issued in a final report by MISO on May 30th, 2014 (SISR_A627_A628_A629_A630_Report_FINAL.pdf).

Response by: Scott Hoberg________________ List Sources of Information:

Title: Engineer Senior______________ _________________________________

Department: System Performance & Transmission Planning _______________________

Telephone: 218-355-2618________________ _________________________________

# MH-US TSR Sensitivity Analysis Draft Report (Western Plan)

**July 3, 2013**

Prepared By:

**MISO Transmission Access Planning**

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## Contents

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## 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 Dorsey to Barnesville 500 kV Line and Barnesville to Monticello 345 kV double circuit line (250, 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) has been confirmed as withdrawn, and hence it is not modeled for this study. Mitigation costs are shown below.

| Scenario | Mitigation Costs (millions) |
|---|---|
| Dorsey – Barnesville 500 kV and Barnesville - Monticello 345 kV (250MW) | 0 |
| Dorsey – Barnesville 500 kV and Barnesville - Monticello 345 kV (750MW) | 4 |
| Dorsey – Barnesville 500 kV and Barnesville - Monticello 345 kV (1100MW) | 4 |

## 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.

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Table 2 Sensitivity Options

| Option | Description |
|---|---|
| Y500 kV + A/B - 250 | • MH-MP TSR only (250 MW)<br>• One Dorsey – Barnesville 500 kV circuit<br>• Two 345 kV circuits from Barnesville – Monticello<br>• Two 500/345 kV transformers at Barnesville |
| Y500 kV + A/B - 750 | • MH-MP TSR + MH-WPS TSR (750 MW)<br>• One Dorsey – Barnesville 500 kV circuit<br>• Two 345 kV circuits from Barnesville – Monticello<br>• Two 500/345 kV transformers at Barnesville |
| Y500 kV + A/B - 1100 | • All TSRs (1100 MW)<br>• One Dorsey – Barnesville 500 kV circuit<br>• Two 345 kV circuits from Barnesville – Monticello<br>• Two 500/345 kV transformers at Barnesville |

# Criteria, Methodology, and Assumptions

## Models

MTEP 2012 power flow model representing a 2022 Summer Peak condition 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 3670 MW in the benchmark case as follows:

- Bipole 1 = 958 MW
- Bipole 2 = 1032 MW
- Bipole 3 = 1680 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 = 1243.8 MW<br>• Bipole 2 = 1341.9 MW<br>• Bipole 3 = 1338.0 MW | • Bipole 1 = 1404.2 MW<br>• Bipole 2 = 1515.0 MW<br>• Bipole 3 = 1510.6 MW | • Bipole 1 = 1516.8 MW<br>• Bipole 2 = 1636.5 MW<br>• Bipole 3 = 1631.7 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 |

| Bus # | Generator Name | MW |
|---|---|---|
| 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 |
| 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
- 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 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.

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## 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. This part of the analysis was performed only for the 'Y500 kV + A/B - 1100' option as listed in the Table 2 above.

## 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, 500 kV + 345 kV A/B Transmission

### Table 5: 250 MW Transfer, 230 kV Transmission

| Monitored Element | Pre ContMW | Post ContMW | Base Flow | Rating | Cont. Ld% | Contingency Description | Impact | DF |
|---|---|---|---|---|---|---|---|---|
| 608696 TAC HBR6 138 608699 DUNKARD6 138 1 | 131.7 | 139.3 | 81.3 | 89 | 156.5 | 608696 TAC HBR6 138 608698 HOYT LK6 138 1 | 7.6 | 3.04 |
| **There is an existing SPS monitoring the flow on the transmission lines out of Tac Harbor, an overload would be mitigated by the SPS.** | | | | | | | | |
| 608696 TAC HBR6 138 608698 HOYT LK6 138 1 | 131.4 | 139 | 80.5 | 89 | 156.2 | 608696 TAC HBR6 138 608699 DUNKARD6 138 1 | 7.6 | 3.04 |
| **There is an existing SPS monitoring the flow on the transmission lines out of Tac Harbor, an overload would be mitigated by the SPS.** | | | | | | | | |
| 608696 TAC HBR6 138 608698 HOYT LK6 138 1 | 125.4 | 133 | 80.5 | 89 | 149.5 | 608698 HOYT LK6 138 608699 DUNKARD6 138 1 | 7.6 | 3.04 |
| **There is an existing SPS monitoring the flow on the transmission lines out of Tac Harbor, an overload would be mitigated by the SPS.** | | | | | | | | |
| 608698 HOYT LK6 138 608699 DUNKARD6 138 1 | 124 | 131.5 | 73.2 | 89 | 147.8 | 608696 TAC HBR6 138 608698 HOYT LK6 138 1 | 7.5 | 3 |
| **There is an existing SPS monitoring the flow on the transmission lines out of Tac Harbor, an overload would be mitigated by the SPS.** | | | | | | | | |

## 750 MW Transfer, 500 kV + 345 kV A/B Transmission

### Table 6: 750 MW Transfer, 500 kV Transmission

| Monitored Element | Pre ContMW | Post ContMW | Base Flow | Rating | Cont. Ld% | Contingency Description | Impact | DF |
|---|---|---|---|---|---|---|---|---|
| 657754 MAPLE R4 230 B$0371 345/230 1.00 1 | 405.8 | 460.6 | 261.6 | 420 | 109.7 | 3Wnd: OPEN B$0375 345/230 2 | 54.8 | 7.306667 |
| **Needs to be upgraded to 448 MVA. Estimated cost of upgrade is $ 4,000,000** | | | | | | | | |
| 620361 MAPLE R3 345 B$0371 345/230 1.00 1 | 416.1 | 469.9 | 264.7 | 420 | 111.9 | 3Wnd: OPEN B$0375 345/230 2 | 53.8 | 7.173333 |
| **Same transformer as above.** | | | | | | | | |
| 657754 MAPLE R4 230 B$0375 345/230 1.00 2 | 406.4 | 461.1 | 263.1 | 420 | 109.8 | 3Wnd: OPEN B$0371 345/230 1 | 54.7 | 7.293333 |
| **Needs to be upgraded to 448 MVA. Estimated cost of upgrade is $ 4,000,000** | | | | | | | | |
| 620361 MAPLE R3 345 B$0375 345/230 1.00 2 | 416.7 | 470.6 | 266.3 | 420 | 112 | 3Wnd: OPEN B$0371 345/230 1 | 53.9 | 7.186667 |
| **Same transformer as above.** | | | | | | | | |

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

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

| Monitored Element | Pre ContMW | Post ContMW | Base Flow | Rating | Cont. Ld% | Contingency Description | Impact | DF |
|---|---|---|---|---|---|---|---|---|
| 657754 MAPLE R4 230 B$0371 345/230 1.00 1 | 405.8 | 460.6 | 261.6 | 420 | 109.7 | 3Wnd: OPEN B$0375 345/230 2 | 54.8 | 7.306667 |
| **Needs to be upgraded to 448 MVA. Estimated cost of upgrade is $ 4,000,000** | | | | | | | | |
| 620361 MAPLE R3 345 B$0371 345/230 1.00 1 | 416.1 | 469.9 | 264.7 | 420 | 111.9 | 3Wnd: OPEN B$0375 345/230 2 | 53.8 | 7.173333 |
| **Same transformer as above.** | | | | | | | | |
| 657754 MAPLE R4 230 B$0375 345/230 1.00 2 | 406.4 | 461.1 | 263.1 | 420 | 109.8 | 3Wnd: OPEN B$0371 345/230 1 | 54.7 | 7.293333 |
| **Needs to be upgraded to 448 MVA. Estimated cost of upgrade is $ 4,000,000** | | | | | | | | |
| 620361 MAPLE R3 345 B$0375 345/230 1.00 2 | 416.7 | 470.6 | 266.3 | 420 | 112 | 3Wnd: OPEN B$0371 345/230 1 | 53.9 | 7.186667 |
| **Same transformer as above.** | | | | | | | | |

## No Harm Test Results, 500 kV + 345 kV A/B Transmission

### Table 8: No Harm test results, 500 kV + 345 kV A/B Transmission

| Monitored Element | Max Post Case Loading | Max Pre Case Loading | Rating | Contingency Description |
|---|---|---|---|---|
| 657754 MAPLE R4 230 B$0371 345/230 1.00 1 | 116 | 46.78571429 | TRUE | 3Wnd: OPEN B$0375 345/230 2 |
| **Needs to be upgraded to 448 MVA. Estimated cost of upgrade is $ 4,000,000** | | | | |
| 620361 MAPLE R3 345 B$0371 345/230 1.00 1 | 118.1 | 47.47619048 | TRUE | 3Wnd: OPEN B$0375 345/230 2 |
| **Same transformer as above.** | | | | |
| 657754 MAPLE R4 230 B$0375 345/230 1.00 2 | 116.2 | 46.83333333 | TRUE | 3Wnd: OPEN B$0371 345/230 1 |
| **Needs to be upgraded to 448 MVA. Estimated cost of upgrade is $ 4,000,000** | | | | |
| 620361 MAPLE R3 345 B$0375 345/230 1.00 2 | 118.3 | 47.52380952 | TRUE | 3Wnd: OPEN B$0371 345/230 1 |
| **Same transformer as above.** | | | | |

## 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. 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**
  The 750MW transfer option showed violations on transmission lines coming out from Tac-Harbor substation. There is an existing SPS monitoring the flow on the transmission lines out of Tac-Harbor, and an overload would be mitigated by the SPS.
- **750MW transfer**
  The 750MW transfer option showed loading violations on the two Maple River 3 Winding transformers. Both of these will be mitigated by increasing the thermal ratings to 448 MVA. It is estimated to cost 8 million to upgrade Maple River transformers (4 million each).
- **1100MW transfer**
  The 1100MW transfer option showed loading violations on the two Maple River 3 Winding transformers. Both of these will be mitigated by increasing the thermal ratings to 448 MVA. It is estimated to cost 8 million to upgrade Maple River transformers (4 million each).
- **No Harm Test, Dorsey-Blackberry 500kV, 345kV Blackberry-Arrowhead 345kV double circuit**
  The no harm test also showed loading violations on the two Maple River 3 Winding transformers. Both of these will be mitigated by increasing the thermal ratings to 448 MVA. It is estimated to cost 8 million to upgrade Maple River transformers (4 million each).

## 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)**

# MH-US TSR Sensitivity Analysis

# Draft Report (Eastern Plan)

**July 3, 2013**

Prepared By:

**MISO Transmission Access Planning**

## 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) has been confirmed as withdrawn, and hence it is not modeled for this study. Mitigation costs are shown below.

| Scenario | Mitigation Costs (millions) |
|---|---|
| Riel-Shannon 230kV (250MW transfer) | 0 |
| Dorsey-Iron Range 500kV (750MW transfer) | 2.16 |
| Dorsey-Iron Range 500kV (1100MW transfer) | 0 |

## 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.

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Table 2 Sensitivity Options

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

# Criteria, Methodology, and Assumptions

## Models

MTEP 2012 power flow model representing a 2022 Summer Peak condition 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 3670 MW in the benchmark case as follows:

- Bipole 1 = 958 MW
- Bipole 2 = 1032 MW
- Bipole 3 = 1680 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 = 1241.4 MW<br>• Bipole 2 = 1339.3 MW<br>• Bipole 3 = 1335.4 MW | • Bipole 1 = 1405.7 MW<br>• Bipole 2 = 1516.5 MW<br>• Bipole 3 = 1512.1 MW | • Bipole 1 = 1519.6 MW<br>• Bipole 2 = 1639.5 MW<br>• Bipole 3 = 1634.7 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 |
| 608702 | Laskin Unit #1 | 25 |
| 608702 | Laskin Unit #2 | 22 |
| Xcel Energy (A416) | | |
| 600073 | River Falls | 20 |
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| 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
- 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 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.

### 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. This part of the analysis was performed only for the 'Y500 kV + A/B' option as listed in the Table 2 above.

## 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%.

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## 250 MW Transfer, 230 kV Transmission

### Table 5: 250 MW Transfer, 230 kV Transmission

| Monitored Element | Pre ContMW | Post ContMW | Base Flow | Rating | Cont. Ld% | Contingency Description | Impact | DF |
|---|---|---|---|---|---|---|---|---|
| N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

## 750 MW Transfer, 500 kV Transmission

### Table 6: 750 MW Transfer, 500 kV Transmission

| Monitored Element | Pre ContMW | Post ContMW | Base Flow | Rating | Cont. Ld% | Contingency Description | Impact | DF |
|---|---|---|---|---|---|---|---|---|
| 608625 BLCKBRY4 230 B$0490 BANK 3 1.00 3 | 572.4 | 816.5 | 816.5 | 800 | 102.1 | ** Base Case ** | 244.1 | 32.54667 |
| **Blackberry 500/230KV transformer loading not a concern as actual size can still be changed to fit need.** | | | | | | | | |
| B$0490 BANK 3 1.00 608635 BLCKBRY2 500 3 | 573.3 | 816.5 | 816.5 | 800 | 102.1 | ** Base Case ** | 243.2 | 32.42667 |
| **Blackberry 500/230KV transformer loading not a concern as actual size can still be changed to fit need.** | | | | | | | | |
| 608737 NASHWAK7 115 608739 BLCKBRY7 115 2 | 126.7 | 164 | 106 | 158 | 103.8 | 20L | 37.3 | 4.973333 |
| **Line can be upgraded to increase thermal rating above post-contingent levels. Estimated cost is $2.16 million.** | | | | | | | | |
| 608737 NASHWAK7 115 608739 BLCKBRY7 115 2 | 126.7 | 163.9 | 106 | 158 | 103.7 | 608739 BLCKBRY7 115 608781 20L TAP7 115 1 | 37.2 | 4.96 |
| **Same line section as above, 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

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

| Monitored Element | Pre ContMW | Post ContMW | Base Flow | Rating | Cont. Ld% | Contingency Description | Impact | DF |
|---|---|---|---|---|---|---|---|---|
| N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |

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## No Harm Test Results, 500 kV + 345 kV A/B Transmission

**Table 8: No Harm test results, 500 kV + 345 kV A/B Transmission**

| Monitored Element | Max Post Case Loading | Max Pre Case Loading | Rating | Contingency Description |
|---|---|---|---|---|
| N/A | N/A | N/A | N/A | N/A |

## 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. 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**
  No valid constraints were found for 250 MW transfer.
- **750MW transfer, Dorsey-Blackberry 500kV**
  The 750MW transfer option showed violations on two MP facilities. These would both be mitigated by increasing the thermal line ratings. Blackberry 500/230 kV Transformer is not a concern as actual size can still be changed to fit the need. It is estimated to cost 2.16 million to upgrade Blackberry-Nashwauk 115kV.
- **1100MW transfer, Dorsey-Blackberry 500kV, 345kV Blackberry-Arrowhead 345kV double circuit**
  No valid constraints were found for 1100 MW transfer.
- **No Harm Test, Dorsey-Blackberry 500kV, 345kV Blackberry-Arrowhead 345kV double circuit**
  No valid constraints were found for 1100 MW transfer.

## 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)**

# 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

Final Report

May 30, 2014

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## Contents

MISO

## 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 |

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# 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

MISO

### 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<br>601012 ROSEAUN2 500 1 | 601062 MIDCOMP-S 500<br>608635 BLCKBRY2 500 1 | MH/XEL | 1905.3 | 2053.1 | 1391.8 | 661.3 | 74.8<br>9 | 685.65 |
| 608625 BLCKBRY4 230<br>608612 RIVERTN4 230 1 | 601016 CHIS CO2 500<br>601017 CHIS-N 2 500 1 | MP | 365 | 411.8 | 296 | 115.8 | 13.1<br>1 | 526.14 |
| 667224 RAD_K1_6 138<br>667231 RADSNDC6 138 1 | 667001 HENDAY 4 230<br>667002 LIMEST54 230 5 | MH | 125 | 270 | 56.8 | 213.2 | 24.1 | 282.46 |
| 699211 PT BCH3 345<br>699630 KEWAUNEE 345 1 | 694022 FOXRIVER B1 345<br>699359 N APPLETON 345 1 | WEC/WPS | 1006 | 1029.6 | 992.7 | 36.9 | 4.17 | 318.27 |
| 608625 BLCKBRY4 230<br>608624 FORBES 4 230 1 | 601012 ROSEAUN2 500<br>667501 RIEL 2 500 1<br>667500 DORSEY2 500<br>667501 RIEL 2 500 1 | MP | 287 | 487.2 | 356.6 | 130.6 | 14.7<br>9 | -<br>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<br>620327 HANKSON4 230 1 | 601001 FORBES 2 500<br>601017 CHIS-N 2 500 1 | OTP | 351 | 353.9 | 317.4 | 36.5 | 4.13 | 812.84 |
| 608601 CENTRDC4 230<br>657756 SQBUTTE4 230 1 | 601001 FORBES 2 500<br>601017 CHIS-N 2 500 1 | MP/OTP | 526 | 470.5 | 467.6 | 2.8 | 0.32 | 18385.32 |
| 615319 GRE-BENTON 4 230<br>608617 MUDLAKE4 230 1 | 601001 FORBES 2 500<br>601017 CHIS-N 2 500 1 | XEL/MP | 478 | 527.5 | 458.1 | 69.4 | 7.86 | 253.19 |
| 615460 GRE-RUSH CY4 230<br>602037 ROCKCR 4 230 1 | 601016 CHIS CO2 500<br>601017 CHIS-N 2 500 1 | XEL | 398.3 | 352.1 | 302.4 | 49.7 | 5.62 | 1703.82 |
| 652519 OAHE 4 230<br>652521 SULLYBT4 230 1 | 601016 CHIS CO2 500<br>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<br>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<br>699630 KEWAUNEE 345 1 | WEC/WPS | 960/960 | 960/1030 | $250,000.00 |
| 608625 BLCKBRY4 230<br>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<br>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<br>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<br>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<br>602037 ROCKCR 4 230 1 | XEL | 398.3/398.3 | | Transmission Line is not constrained with revised higher rating. |
| 652519 OAHE 4 230<br>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**