FINAL

Attachment Y2 Study Scope

Minnesota Power

Boswell Units 3 & 4: 959 MW

April 4, 2019

[REDACTED]

MISO

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EXECUTIVE SUMMARY

On August 13, 2018, Minnesota Power submitted an Attachment Y-2 study request to MISO for the potential change of status of Boswell units 3&4 with the study effective date of January 1, 2030.

MISO performed a Transmission System reliability assessment of Boswell Units 3&4 set forth in the MISO Business Practices Manuals and was discussed and reviewed with the impacted Transmission Owners (TOs): Minnesota Power, Otter Tail Power, Great River Energy, Missouri River Energy Services, and Xcel Energy. This Attachment Y2 study focusses on studying various scenarios to identify reliability issues due to potential retirement of Boswell unit 3&4.

After being reviewed for power system reliability impacts as provided for under Section 38.2.7 of MISO's Open Access Transmission, Energy, and Operating Reserve Markets Tariff ("Tariff"), the analysis determined that there are reliability issues identified related to the potential change of status of Boswell Units 3 and 4, jointly or separately, that would likely require robust mitigating solutions to be built before the retirement of the unit(s) could be allowed. One or both units may need to be designated as System Support Resource ("SSR") units in the event the mitigating solution is not built prior to the retirement date indicated in the future Attachment Y study request. The issues are summarized below for each study case.

In Scenario 1 with **Boswell Unit 3 Offline**, there were very few issues identified in the Summer Peak and Shoulder cases. In the Winter Peak case with heavy northward flow toward Northern Minnesota and Manitoba, there appear to be transfer limitations related to the Chisago – Forbes 500 kV Line and parallel 230 kV lines that would result in voltage stability issues following loss of the [REDACTED]. Several related stability, voltage, and thermal violations were also observed in the Winter Peak case. These issues indicated a need for a robust mitigating solution prior to retirement of Boswell Unit 3. Absent such a solution it is likely that Boswell Unit 3 would be designated a System Support Resource if similar results were identified in an Attachment Y Study.

In Scenario 2 with **Boswell Unit 4 Offline**, similar to Scenario 1, there were very few issues identified in the Summer Peak and Shoulder cases. The same Winter Peak voltage stability and related issues were identified in Scenario 2 as in Scenario 1, and were observed to be worse when the larger Boswell unit is offline. If similar results were identified in an Attachment Y Study, it is likely that Boswell Unit 4 would be designated a System Support Resource and a robust mitigating solution would need to be developed.

In Sensitivity 1 with **Boswell Unit 3 & Boswell Unit 4 Offline**, there were also very few issues identified in the Summer Peak and Shoulder cases. The Winter Peak voltage stability and related issues identified with one of the two units offline were found to be worsened with both units offline. If Boswell Unit 3 and Boswell Unit 4 were evaluated under a single Attachment Y Notice and similar results were identified in that study as those found in this Attachment Y2 study, it is likely that both units would be designated a System Support Resource and a robust mitigating solution would need to be developed.

In Sensitivity 2 with **Boswell Unit 3 & Boswell Unit 4 plus [REDACTED] Generators Offline**, additional issues were identified in the Summer Peak, Shoulder, and Winter Peak cases. The Winter Peak voltage stability and related issues identified in the previous cases were found to be present, and some additional stability and voltage issues were also identified due to the [REDACTED] baseload generators also being offline. Since this sensitivity assumes the retirements of several units at several different sites across a relatively large geographic area and none of these units currently have Attachment Y notices in progress, it is difficult to say when or if these issues would show up in future Attachment Y studies. The main conclusion from Sensitivity 2 is that there are certain issues that do not show up in the cases involving only the Boswell units (Scenario 1, Scenario 2, and Sensitivity 1). These issues are therefore more strongly tied to the retirement of the [REDACTED] baseload generators and – at most – would be aggravated by the retirement of the Boswell units if some combination of [REDACTED] generators had already been retired.

The development of robust mitigating solution(s) which would enable the retirement scenarios contemplated in this report are outside the scope of this Attachment Y2 study. Due to the complex nature of the retirements contemplated, any such mitigation solution development would need detailed analysis and discussions. MISO and the Transmission Owner's involved with this study did not conduct an analysis of any potential mitigating solutions because the timeline for conducting the analysis is significantly outside the scope of an Attachment Y2 study.

An Attachment Y-2 study is a non-binding assessment of the Transmission System reliability for the potential suspension or retirement of a Generation Resource(s). The results of the study are not definitive and the analysis is to provide information to the Market Participant to assist them in evaluating their options. However, it does not commit the Market Participant to proceed with plans for suspension or retirement.

Furthermore, while the analysis conducted for the Attachment Y-2 study may be used in preparing a subsequent Attachment Y study, further study may be required to evaluate the impacts due to change in assumptions of system conditions when an Attachment Y Notice is submitted.

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1. INTRODUCTION

On August 13, 2018, Minnesota Power submitted an Attachment Y-2 study request to MISO for the potential change of status of Boswell units 3&4 with the study effective date of January 1, 2030.

The total capacity of Boswell units 3&4 is 959 MW. It is connected to the Minnesota Power transmission system, and is located in Minnesota.

1 Study Units

Power Flow Area	Unit Description	kV Network[1]	Total Net MW	GVTC Value MW	Start Date of Retirement
MP	Boswell Unit 3	20.9	390.9	366.5	1/1/2030
	Boswell Unit 4	22.8	630.0	592.5	
Total MW			1020.9	959	

[REDACTED]

Figure 1: General Location of Boswell Units 3 & 4

[1] In study models

2. STUDY OBJECTIVE

Under Section 38.2.7 of MISO's Tariff, SSR procedures maintain system reliability by providing a mechanism for MISO to enter into agreements with Market Participants (MP) that own or operate Generation Resources or Synchronous Condenser Units (SCUs) that have requested to either Retire or Suspend, but are required to maintain system reliability.

The principal objective of an Attachment Y-2 study is to determine if the unit(s) for which a potential change in status requested is necessary for system reliability based on the criteria set forth in the MISO Business Practices Manuals. The study work included monitoring and identifying the steady state branch/voltage violations on transmission facilities due to the unavailability of the Generation Resource or SCU. The relevant MISO Transmission Owner(s) and/or regional reliability criteria are used for monitoring such violations.

An Attachment Y-2 study is a non-binding informational study intended to determine whether it is likely that the Generation Resource(s) would qualify as an SSR Unit(s). While the analysis conducted for the Attachment Y-2 study may be used in preparing a subsequent Attachment Y study, further study may be required to evaluate the impacts due to change in assumptions of system conditions when an Attachment Y Notice is submitted.

The purpose of this study is to assess the reliability impacts from the potential change of status of Boswell Units 3&4 located in Minnesota, effective January 1, 2030.

3. STUDY ASSUMPTIONS & INPUTS

3.1 Study Models

Studies were performed using the following power flow models:

- 2030 Summer Peak (Source: MISO17_2027_SUM_TA)
- 2030 Shoulder / Summer off peak (Source: MISO17_2027_SUM_TA)
- 2030 Winter Peak (Source: MMWG ERAG 2018 Series 2028-29 Winter Case)[2]

For the model, two scenarios were created which represented the "before" and "after" generator retirement/suspension states. In addition, two sensitivities were created which represented the unique situations of interest to the customer. The following is a brief summary of the four unique study cases:

- The purpose of Scenario 1 is to study the potential change in status of Boswell Unit 3 only
- The purpose of Scenario 2 is to study the potential change in status of Boswell Unit 4 only
- The purpose of Sensitivity 1 is to study the potential change in status of Boswell Unit 3 and Boswell Unit 4
- The purpose of Sensitivity 2 is to study the potential change in status of Boswell Unit 3 and Boswell Unit 4, in addition to several [REDACTED] generators

The scenarios and sensitivities are shown in the tables below.

2 Study Models

Scenario	Model Name	Loads	Topology	Boswell Unit 3 Generation	Boswell Unit 4 Generation	Sensitivity - Base Load Generation (Monticello Nuclear, Allen S King, Prairie Island Nuclear)	Dispatch[3] Type	Contingencies Category
Scenario1	2030SP_B3_OFF	Summer Peak	2030	*Off*	On	On	SCED	P1,P2,P4,P5,P7, Selected P3, P6
	2030SP_B3_ON	Summer Peak	2030	*On*	On	On	SCED + Scale	P1,P2,P4,P5,P7, Selected P3, P6
	2030SH_B3_OFF	Shoulder off Peak	2030	*Off*	On	On	SCED	P1,P2,P4,P5,P7, Selected P3, P6
	2030SH_B3_ON	Shoulder off Peak	2030	*On*	On	On	SCED + Scale	P1,P2,P4,P5,P7, Selected P3, P6

[2] 2030 Winter peak scenario was later added as per customer and impacted transmission owner request. The Manitoba Hydro (MH) interface in this study modeled at ~ 1400 MW import (instead of MH exporting 1000 MW as in the MMWG / ERAG 2028 Winter 2018 series).

[3] Dispatching according to procedure explained in BPM-020. "SCED + Scale" in the online cases means that all generators in the vicinity of the generator under study will remain dispatched at their SCED values identified in the corresponding offline case, and the rest of MISO scaled down to balance the overall generation in MISO after turning on Boswell 3 unit in Scenario1, Boswell 4 unit in Scenario2 and [REDACTED] units in Sensitivity scenario.

Scenario	Model Name	Loads	Topology	Boswell Unit 3 Generation	Boswell Unit 4 Generation	Sensitivity - Base Load Generation (Monticello Nuclear, Allen S King, Prairie Island Nuclear)	Dispatch[3] Type	Contingencies Category
	2030WP_B3_OFF	Winter Peak	2030	*Off*	On	On	SCED	P1,P2,P4,P5,P7, Selected P3, P6
	2030WP_B3_ON	Winter Peak	2030	*On*	On	On	SCED + Scale	P1,P2,P4,P5,P7, Selected P3, P6
Scenario2	2030SP_B4_OFF	Summer Peak	2030	On	*Off*	On	SCED	P1,P2,P4,P5,P7, Selected P3, P6
	2030SP_B4_ON	Summer Peak	2030	On	*On*	On	SCED + Scale	P1,P2,P4,P5,P7, Selected P3, P6
	2030SH_B4_OFF	Shoulder off Peak	2030	On	*Off*	On	SCED	P1,P2,P4,P5,P7, Selected P3, P6
	2030SH_B4_ON	Shoulder off Peak	2030	On	*On*	On	SCED + Scale	P1,P2,P4,P5,P7, Selected P3, P6
	2030WP_B4_OFF	Winter Peak	2030	On	*Off*	On	SCED	P1,P2,P4,P5,P7, Selected P3, P6
	2030WP_B4_ON	Winter Peak	2030	On	*On*	On	SCED + Scale	P1,P2,P4,P5,P7, Selected P3, P6
Sensitivity 1	2030SP_ Sens1_OFF	Summer Peak	2030	*Off*	*Off*	On	SCED	P1,P2,P4,P5,P7, Selected P3, P6
	2030SP _Sens1_ON	Summer Peak	2030	*On*	*On*	On	SCED + Scale	P1,P2,P4,P5,P7, Selected P3, P6
	2030SH_ Sens1_OFF	Shoulder off Peak	2030	*Off*	*Off*	On	SCED	P1,P2,P4,P5,P7, Selected P3, P6
	2030SH _Sens1_ON	Shoulder off Peak	2030	*On*	*On*	On	SCED + Scale	P1,P2,P4,P5,P7, Selected P3, P6
	2030WP_Sens1_OFF	Winter Peak	2030	*Off*	*Off*	On	SCED	P1,P2,P4,P5,P7, Selected P3, P6
	2030WP_Sens1_ON	Winter Peak	2030	*On*	*On*	On	SCED + Scale	P1,P2,P4,P5,P7, Selected P3, P6
Sensitivity 2	2030SP_ Sens2_OFF	Summer Peak	2030	*Off*	*Off*	*Off*	SCED	P1,P2,P4,P5,P7, Selected P3, P6
	2030SP _Sens2_ON	Summer Peak	2030	*On*	*On*	*Off*	SCED + Scale	P1,P2,P4,P5,P7, Selected P3, P6
	2030SH_ Sens2_OFF	Shoulder off Peak	2030	*Off*	*Off*	*Off*	SCED	P1,P2,P4,P5,P7, Selected P3, P6
	2030SH _Sens2_ON	Shoulder off Peak	2030	*On*	*On*	*Off*	SCED + Scale	P1,P2,P4,P5,P7, Selected P3, P6

Scenario	Model Name	Loads	Topology	Boswell Unit 3 Generation	Boswell Unit 4 Generation	Sensitivity - Base Load Generation (Monticello Nuclear, Allen S King, Prairie Island Nuclear)	Dispatch[3] Type	Contingencies Category
	2030WP_Sens2_OFF	Winter Peak	2030	Off	Off	Off	SCED	P1,P2,P4,P5,P7, Selected P3, P6
	2030WP_Sens2_ON	Winter Peak	2030	On	On	Off	SCED + Scale	P1,P2,P4,P5,P7, Selected P3, P6

3.2 Study Assumptions

- **Generation**

Applicable approved Attachment Y (Retirement/Suspension) generation will be modelled offline

3 Generation Assumptions – Nearby Approved Attachment Y & Requested Scenarios

[REDACTED]

- **Transmission Projects**

Future Transmission Projects already included in study models are provided below:

4 MTEP Future Projects in 2030 Models

MOD Project Name	Project Type	Status	MOD Effective Date
GRE-2577-ColumbusTap69-R1	MTEP A	Planned	5/18/2021
GRE-2670-SCHUSTERLAKE_115_41_R1	MTEP A	Planned	8/28/2019
GRE-4380-Priam_115_69_R5	MTEP A	Planned	5/1/2019
GRE-BCC-ElkRiverToMMPA	Base Case Change	Correction	10/1/2018
GRE-7912-Lawndale2-115	MTEP A	Planned	5/1/2021
GRE-7884-Riverview345-115-69	MTEP A	Planned	12/10/2018
GRE-9200-TwoInlets115	MTEP B	Target MTEP A	10/1/2019
GRE-9201-BullMoose115	MTEP B	Target MTEP A	10/1/2019
GRE-9202-Swatara230	MTEP B	Target MTEP A	10/1/2019
GRE-9203-CromwellPump115	MTEP B	Target MTEP A	10/1/2019
GRE-8920-Elisha_115_34_R1	MTEP B	Target MTEP A	5/1/2021
GRE-12106-Scenic69	MTEP A	Planned	5/29/2020

MOD Project Name	Project Type	Status	MOD Effective Date
GRE-12117-MoonLake69	MTEP A	Planned	9/1/2019
GRE-12104-Burnsville-RiverHills69	MTEP A	Planned	9/13/2019
GRE-12122-KnifeFalls115	MTEP A	Planned	9/28/2018
GRE-12165-Vermillion69	MTEP A	Planned	9/30/2019
GRE-10424-Zinran115	MTEP A	Planned	3/30/2018
GRE-12206-BensonCapBank115	MTEP C	Target MTEP A	1/8/2018
GRE-12211-LebanonHills115	MTEP C	Target MTEP A	4/30/2020
GRE-13464-BrooksLake115	MTEP C	Target MTEP A	10/30/2019
GRE-13851-HawickReroute69	MTEP C	Target MTEP A	6/1/2019
GRE-BCC-GardenCityMove	Base Case Change	Field Change	1/19/2018
GRE-BCC-XfmrUpdate20180130-R1	Base Case Change	Error Correction	1/30/2018
GRE-BCC-Update-20180131-01	Base Case Change	As Built	1/31/2018
GRE-9624-RemoveSandstoneTap69	MTEP A	Planned	6/1/2018
GRE-BCC-Update-20180227-01	Base Case Change	As Built	2/27/2018
GRE-BCC-VoltCriteria20180322	Base Case Change	Field Change	3/22/2018
GRE-BCC-Update-20180328-02	Base Case Change	As Built	3/28/2018
GRE-BCC-HutchinsonUnit5	Base Case Change	As Built	4/1/2018
GRE-BCC-BrandonRoad	Base Case Change	Error Correction	4/6/2018
GRE-BCC-BlueberryDistName	Base Case Change	Error Correction	4/23/2018
GRE-BCC-Update-20180424-01	Base Case Change	As Built	4/24/2018
GRE-BCC-AreaZoneCorrections-20180515	Base Case Change	Error Correction	5/15/2018
GRE-BASECASE-REMOVE DODGE WIND	Base Case Change	Correction	5/21/2018
GRE-BCC-ND-FRM-Update-20180618-01	Base Case Change	As Built	11/1/2018
GRE-BCC-Update-20180626-01	Base Case Change	As Built	6/26/2018
GRE-9624-RemoveSandstoneTap69Part2	MTEP A	Planned	7/30/2018
GRE-BCC-Update-20180730-01	Base Case Change	As Built	7/30/2018
GRE-BCC-CoalCreekVS	Base Case Change	Field Change	7/30/2018
MP-2761-MISO-Dunka-Load	MTEP A	Planned	7/1/2020
MP-7910-5LUpgrade	MTEP A	Planned	11/1/2019

MOD Project Name	Project Type	Status	MOD Effective Date
MP-3831-MISO-GNTL500kV-2015.04.16	MTEP A	Planned	6/1/2020
MP-MISO-Bison6	Generator	Planned	1/1/2018
MP-9625-Add_Nemadji	MTEP A	Planned	12/31/2018
MP-10383-LASTacHBRVolConv	MTEP A	Planned	12/31/2020
MP-12563-Bos230-115kVXfmr	MTEP A	Planned	12/31/2018
MP-12323-MISO-93Lupgrade	MTEP A	Planned	6/1/2020
MP-MISO-16LTapNormalOpen2018	Base Case Change	Correction	4/1/2018
MP-MISO-16LTapClosed2018	Base Case Change	Correction	10/1/2018
MP-MISO-16LTapNormalOpen2019	Base Case Change	Correction	4/1/2019
MP-MISO-16LTapClosed2019	Base Case Change	Correction	10/1/2019
MP-MISO-16LTapNormalOpen2020	Base Case Change	Correction	4/1/2020
MP-MISO-16LTapClosed2020	Base Case Change	Correction	10/1/2020
MP-MISO-16LTapNormalOpen2021	Base Case Change	Correction	4/1/2021
MP-MISO-16LTapClosed2021	Base Case Change	Correction	10/1/2021
MP-MISO-16LTapNormalOpen2022	Base Case Change	Correction	4/1/2022
MP-MISO-16LTapClosed2022	Base Case Change	Correction	10/1/2022
MP-MISO-16LTapNormalOpen2023	Base Case Change	Correction	4/1/2023
MP-MISO-16LTapClosed2023	Base Case Change	Correction	10/1/2023
MP-MISO-16LTapNormalOpen2024	Base Case Change	Correction	4/1/2024
MP-MISO-16LTapClosed2024	Base Case Change	Correction	10/1/2024
MP-MISO-16LTapNormalOpen2025	Base Case Change	Correction	4/1/2025
MP-MISO-16LTapClosed2025	Base Case Change	Correction	10/1/2025
MP-MISO-16LTapNormalOpen2026	Base Case Change	Correction	4/1/2026
MP-MISO-16LTapClosed2026	Base Case Change	Correction	10/1/2026
MP-MISO-16LTapNormalOpen2027	Base Case Change	Correction	4/1/2027
MP-MISO-16LTapClosed2027	Base Case Change	Correction	10/1/2027
MP-13364-NorthShoreTransLineUpgradesProject	MTEP C	Target MTEP A	12/30/2019
MP-12583-MISO-76Lupgrade	MTEP A	Planned	5/1/2018
MP-7996-MISO-15LUpgrade	MTEP A	Planned	10/1/2019

MOD Project Name	Project Type	Status	MOD Effective Date
MP-9646-MISO-NSWK_14LTapUpgrade	MTEP C	Target MTEP A	6/1/2020
MP-13504-MISO-LAS-TACHBRLUpgrades	MTEP C	Target MTEP A	12/31/2020
MP-13526-MISO-TiogaSub_MP	MTEP C	Target MTEP A	10/1/2018
MP-12644-MISO-NSS_STATCOM	MTEP A	Planned	9/1/2019
MP-9647-MISO-53LUpgrade	MTEP B	Target MTEP A	6/1/2020
MP-13484-MISO-TwoHarbors115kV	MTEP C	Target MTEP A	12/31/2019
MP-4294-18L Upratedatechng	MTEP A	Planned	3/1/2018
MP-MISO-16LTapClosed2028	Base Case Change	Correction	10/1/2028
MP-MISO-16LTapNormalOpen2028	Base Case Change	Correction	5/1/2028
MP-MISO-Nemadjitopofix	Base Case Change	Correction	12/31/2018
MP-12563-Boswell-Blackwater115kV	MTEP A	Planned	12/31/2018
MP-MISO-TacRidgecorrection	Base Case Change	Error Correction	1/8/2018
MP-13485-MISO-HoytLakes115kV	MTEP C	Target MTEP A	12/31/2020
MP-7997-MISO-15thAveModernization	MTEP A	Planned	12/31/2018
MP-MISO-NSSSLineImpUpdates	Base Case Change	As Built	1/15/2018
MP-MISO-Reactivedeviceupdates	Base Case Change	Error Correction	1/17/2018
MP-MISO-BearCrk6946Kvupdates	Base Case Change	As Built	1/31/2018
MP-MISO-BBYXfmr2impfix	Base Case Change	Error Correction	1/31/2018
MP-MISO-PotlatchGenfix	Base Case Change	Error Correction	1/31/2018
MP-MISO-BoiseP2off	Base Case Change	Error Correction	1/31/2018
MP-MISO-BisonXfmrratiofix	Base Case Change	Field Change	2/6/2018
MP-MISO-RemoveHoytlakesCap	Base Case Change	Error Correction	2/6/2018
MP-MISO-16LTapClosed2028	Base Case Change	Correction	10/1/2028
MP-MISO-16LTapNormalOpen2028	Base Case Change	Correction	4/1/2028
MP-MISO-HibbardMbasefix	Base Case Change	Correction	2/6/2018
MP-MISO-37L_rtgupdate	Base Case Change	As Built	2/7/2018
18Series_ALL_MP	Base Case Change	Correction	6/20/2018

MOD Project Name	Project Type	Status	MOD Effective Date
MP-MISO-95LImpchng	Base Case Change	Correction	6/30/2018
MP-MISO-20LImpchng	Base Case Change	Correction	6/30/2018
MP-MISO-71LImpchng	Base Case Change	Correction	2/20/2018
MP-MISO-18LImpchng	Base Case Change	Correction	3/7/2018
MP-MISO-21LImpchng	Base Case Change	Correction	2/20/2018
MP-MISO-6LImpchng	Base Case Change	Correction	4/9/2018
MP-MISO-10LImpchng	Base Case Change	Correction	4/9/2018
MP-MISO-37LImpchng	Base Case Change	Correction	6/4/2018
OTP_2220_BSS-Ellendale 345	MTEP A	Planned	6/30/2019
OTP_4232_TRF_Winger_230 [13-03-28 16:38]	MTEP B	Target MTEP A	11/15/2024
OTP_13344_RedLakeFallSWTap	MTEP A	Planned	1/27/2018
OTP_14056_Parkers_Prairie_115_tap	MTEP B	Target MTEP A	11/30/2020
OTP_Solway_Gen_RT_XT_Update	Base Case Change	Error Correction	1/5/2018
OTP_update_bus_voltage_limits	Base Case Change	Error Correction	1/9/2018
OTP_re-add_Bottineau_TW	Base Case Change	Correction	1/12/2018
OTP_MTEP18_minor_load_fixes	Base Case Change	Error Correction	1/15/2018
OTP_13344_RedLkFallSWTap_add_branch	MTEP A	Planned	1/31/2018
OTP_Buffalo Xfmr2 Impedance fix	Base Case Change	Correction	2/7/2018
OTP-SHEYENNE-MAPLETON-RATING-CORRECTION	Base Case Change	Error Correction	3/29/2018
OTP_CassLk_115kV_Town-CasinoLd_Move	MTEP A	Planned	8/1/2018
OTP_Mapleton_115kV_Compressor & TownLd_Move	MTEP A	Planned	7/15/2018
OTP_15304_Twin Brooks 345 Sub	MTEP A	Planned	7/6/2020
XEL-4224-IRONWOOD-SW-REPLACEMENT_R3	MTEP A	Planned	12/1/2019
XEL-4696-PRENTICE-MEDFORD-REBUILD	MTEP A	Planned	5/30/2020
XEL-8079-LINE_0714_REBUILD	MTEP A	Planned	6/1/2021
XEL-3797-MAPLE_RIVER-RED_RIVER_2ND_CKT_R1	MTEP A	Planned	10/31/2018
XEL-4231-GALESVILLE_REBUILD_R3	MTEP A	Planned	5/31/2018
XEL-4314-ASHLAND-IRONWOOD-REBUILD_R2	MTEP A	Planned	12/1/2021
XEL-4695-WILSON-BUS-BKR-AND-HALF_R1	MTEP A	Planned	9/1/2019
XEL-4305-SW-MN-REACTOR_R2-P2	MTEP A	Planned	6/3/2019
XEL-10288-OSPREY-69KV-EXPANSION-R1	MTEP A	Planned	9/1/2018
XEL-3769-MANKATO_TC_THROUGHFLOW_R5	MTEP A	Planned	6/1/2019

MOD Project Name	Project Type	Status	MOD Effective Date
XEL-10074-AIRPORT-ROGERS-LAKE-REBUILD	MTEP A	Planned	2/15/2019
XEL-10289-ELMWOOD-EAU-GALLE-REBUILD-P2	MTEP A	Planned	12/15/2019
XEL-10069-TWIN-CREEK-69KV	MTEP A	Planned	11/1/2019
XEL-10045-LAKE-HAZELTINE-115	MTEP A	Planned	1/31/2018
XEL-G261-11644 WILMARTH-SWAN LK UPRATE-R1	MTEP A	Planned	10/1/2018
XEL-10076-WEST_ST_CLOUD_TO_MILLWOOD-69-KV-REBUILD	MTEP A	Planned	5/1/2019
XEL-4697-SPK-LAJ-RECONDUCTOR_P2	MTEP A	Planned	11/30/2018
XEL-J426-EXPAND CHANARAMBIE-R1	MTEP A	Planned	12/15/2018
XEL-11993-BLACK-DOG-WILSON-1-AND-3-UPRATE	MTEP A	Planned	12/2/2019
XEL-8149-BAYFIELD_LOOP_34.5_KV_P1_R2	MTEP A	Planned	12/1/2019
XEL-8113-WARD_COUNTY_230kV-R3	MTEP A	Planned	11/30/2018
XEL-14035-14036-TC-Fault-Current	MTEP C	Target MTEP A	12/28/2018
XEL-BLACK-DOG-6-R2	Generator	Planned	6/1/2018
XEL-FORBES-SVC-RETIREMENT	MTEP C	Target MTEP A	6/1/2020
XEL-12011-BLUFF-SIDING-RECONFIGURATION	MTEP C	Target MTEP A	12/31/2019
XEL-14046-FALLS-CAPACITOR	MTEP C	Target MTEP A	6/1/2021
XEL-14047-LINCOLN-CO-CAPACITOR	MTEP C	Target MTEP A	6/1/2020
XEL-3127-BRIGGS-ROAD-REACTOR	MTEP A	Planned	12/31/2018
XEL-14054-PLYMOUTH-AREA-UPGRADES-P2	MTEP C	Target MTEP A	6/1/2018
XEL-3473-SIOUX_FALLS_FINAL_PHASE	MTEP A	Planned	6/1/2018
XEL-WATERVILLE-AREA-RATINGS-CORRECTION	Base Case Change	Error Correction	1/3/2018
XEL-JANUARY-2018-IMPEDANCE-UPDATES	Base Case Change	Error Correction	1/4/2018
XEL-BROOKINGS-CO-TRANSFORMER-IMPEDANCE-CORRECTION	Base Case Change	Error Correction	1/11/2018
XEL-COLVILLE-RATING-CORRECTION	Base Case Change	Error Correction	1/25/2018
XEL-CARTWRIGHT-RATING-CORRECTION	Base Case Change	Error Correction	1/25/2018
XEL-WAVERLY-LOAD-CORRECTION	Base Case Change	Error Correction	1/25/2018
XEL-BAYFRONT-NORRIE-RATING-CORRECTION	Base Case Change	Error Correction	1/25/2018
XEL-RED-ROCK-TRANSFORMER-UPGRADE	MTEP C	Target MTEP A	6/1/2021
XEL-WILMARTH-SWAN-LAKE-RATINGS-CORRECTION	Base Case Change	Field Change	12/31/2018
XEL-CARVER-COUNTY-ARLINGTON-RATINGS-CORRECTION	Base Case Change	Field Change	12/31/2021
XEL-ST-CROIX-FALLS-IMPEDANCE-CORRECTION	Base Case Change	Error Correction	2/6/2018

MOD Project Name	Project Type	Status	MOD Effective Date
XEL-WEST_ST_CLOUD_TO_WESTWOOD-69KV-EXISTING	Base Case Change	Error Correction	2/28/2018
XEL-MERRIAM-PARK-RATINGS-CORRECTION	Base Case Change	Error Correction	2/20/2018
XEL-14054-PLYMOUTH-AREA-UPGRADES-P3_R1	MTEP C	Target MTEP A	12/31/2018
XEL-CAPACITOR-BUS-CORRECTION	Base Case Change	Error Correction	2/28/2018
XEL-GLEASONLK-CAP-BUS-CORRECTION	Base Case Change	Error Correction	3/1/2018
XEL-BROOKINGS_CO-WHITE-RATING-CORRECTION	Base Case Change	Error Correction	3/27/2018
XEL-PRAIRIE-VOLTAGE-LIMIT-CORRECTION	Base Case Change	Error Correction	3/27/2018
XEL-MONTICELLO-LOAD-CORRECTION	Base Case Change	Error Correction	4/4/2018
XEL-MAIN_ST-TERMINAL-RATING-CORRECTIONS	Base Case Change	Error Correction	4/4/2018
XEL-TREMVAL-JACKSON_CO-IMPEDANCE-UPDATE	Base Case Change	Error Correction	4/9/2018
XEL-WABASHA-LAKE_CITY-RATING-UPDATE	Base Case Change	Error Correction	4/13/2018
XEL-REDWING-FRONTENAC_TAP-RATING-UPDATE	Base Case Change	Error Correction	4/13/2018
XEL-RICE_LAKE-BARRON-RATING-UPDATE	Base Case Change	Error Correction	5/4/2018
XEL-KOHLMAN_LAKE-GOOSE_LAKE-RATING-UPDATE	Base Case Change	Error Correction	5/7/2018
XEL-SVEADHAL_TAP-BUTTERFIELD-RATING-UPDATE	Base Case Change	Error Correction	5/4/2018
XEL-APACHE-RATING-UPDATE	Base Case Change	Error Correction	5/30/2018
XEL-25301-FALLS-SPLIT_ROCK-RATING-UPDATE	Base Case Change	As Built	5/30/2018
XEL-BUTTERFIELD_TAP-SVEADAHL_TAP-RATING-UPDATE	Base Case Change	Error Correction	6/15/2018
XEL-GRAVEL_ISLAND-HALLIE-IMPEDANCE-UPDATE	Base Case Change	Error Correction	6/15/2018
XEL-JACKSON_CO-TREMVAL-IMPEDANCE-UPDATE	Base Case Change	Error Correction	6/13/2018
XEL-SIOUX_FALLS_TAP-LAWRENCE-RATING-UPDATE	Base Case Change	Error Correction	6/13/2018
XEL-THOMPSON-PRAIRIE-RATING-UPDATE	Base Case Change	Error Correction	6/15/2018
XEL-JUNE-2018-RATINGS-UPDATE	Base Case Change	Error Correction	6/21/2018
XEL-NROC-NO_HILLS-IMPEDANCE-UPDATE	Base Case Change	Error Correction	6/21/2018
XEL-THOMPSON-PRAIRIE-RATING-UPDATE	Base Case Change	Error Correction	6/15/2018
XEL-THOMPSON-HATTON-RATING-UPDATES	Base Case Change	Error Correction	7/2/2018

MOD Project Name	Project Type	Status	MOD Effective Date
XEL-JULY-RATING-UPDATES	Base Case Change	Error Correction	7/3/2018
XEL-SEVEN-MILE-TRANSFORMER-UPDATES	Base Case Change	Error Correction	7/17/2018
XEL-AUG-RATING-UPDATES	Base Case Change	Error Correction	8/22/2018
MRES-GRE-OTP-15344-W MN Erie Jct to Frazee Project	MTEP A	Target A	1/1/2021

3.3 Monitoring and contingencies

- **Monitor**

Monitor all 69 kV and above facilities in areas MP (608), OTP (620), GRE (615), and XEL (600)

- **Contingencies**

NERC Category P1, P2, P4, P5, and P7 used in MTEP18 study of facilities within areas MP (608), OTP (620), GRE (615), and XEL (600)

Category P3 contingencies will be created using all single generator contingencies (P1-1), extracted from the P1 contingencies provided above, combined with all P1 contingencies provided above. To limit the number of possible P3 combinations:

- Only Category P1 events of facilities 100 kV or above within 6 Buses from the Study Unit(s) will be used in creating the required P3 combinations.
- Generator contingencies (Category P1-1) with aggregated generation above 50 MW will be used in creating the required P3 contingencies.

Similarly, Category P6 contingencies will be created using all non-generator contingencies (P1-2 to P1-5) of facilities 100 kV or above within 6 Buses from the Study Unit(s).

Specific NERC Category P3 and P6 contingencies requested by the customer were also included in the study. These contingencies include the following:

All P6 combinations of the following [REDACTED] + kV [REDACTED] lines:

- [REDACTED]

All P3 combinations for each of the tie lines listed above with each of the generators listed below:

- [REDACTED]

4. STUDY CRITERIA

4.1 Applicable Reliability Criteria

- **Steady State Thermal Reliability Criteria**

Minnesota Power Transmission Planning Criteria applied for thermal analysis:
- For NERC Category P0 (System Intact), all thermal loadings exceeding 100% of the normal rating.
- For NERC Category P1 – P7 contingencies, all thermal loadings exceeding 100% of the emergency rating.

Otter Tail Power Transmission Planning Criteria applied for thermal analysis:
- For NERC Category P0 (System Intact), all thermal loadings exceeding 100% of the normal rating.
- For NERC Category P1 – P7 contingencies, all thermal loadings exceeding 100% of the emergency rating.

Great River Energy Transmission Planning Criteria applied for thermal analysis:
- For NERC Category P0 (System Intact), all thermal loadings exceeding 100% of the normal rating.
- For NERC Category P1 – P7 contingencies, all thermal loadings exceeding 100% of the emergency rating.

Xcel Energy Transmission Planning Criteria applied for thermal analysis:
- For NERC Category P0 (System Intact), all thermal loadings exceeding 100% of the normal rating.
- For NERC Category P1 – P7 contingencies, all thermal loadings exceeding 100% of the emergency rating.

- **Steady State Voltage Reliability Criteria**

Minnesota Power Transmission Planning Criteria applied for voltage analysis:

- For NERC Category P0 (System Intact) – Pre Contingent
- For NERC Category P1 – P7 contingencies – Post Contingent

Rated Voltage / Facility	Pre Contingent		Post Contingent	
	Min PU	Max PU	Min PU	Max PU
500 kV	1.00	1.05	0.95	1.10
230 kV	1.00	1.05	0.95	1.10
161 kV	1.00	1.05	0.95	1.10
138 kV	1.00	1.05	0.95	1.10
118 kV	1.00	1.05	0.95	1.10
115 kV	1.00	1.05	0.95	1.10
Warroad River SC 500 kV	0.90	1.20	0.90	1.20
Western MP 230 kV	0.97	1.05	0.92	1.10
North Dakota MP 230 kV	0.97	1.05	0.92	1.10
Western MP 115 kV	0.97	1.05	0.92	1.10

Otter Tail Power Transmission Planning Criteria applied for the voltage analysis:

- For NERC Category P0 (System Intact) – Pre Contingent
- For NERC Category P1 – P7 contingencies – Post Contingent

Rated Voltage	Pre Contingent		Post Contingent	
	Min PU	Max PU	Min PU	Max PU
345 kV	0.97	1.05	0.92	1.10
230 kV	0.97	1.05	0.92	1.10
115 kV	0.97	1.07	0.92	1.10

Great River Energy Transmission Planning Criteria applied for the voltage analysis:

- For NERC Category P0 (System Intact) – Pre Contingent
- For NERC Category P1-P7 contingencies – Post Contingent

Voltage Ranges / Facility	Pre Contingent		Post Contingent	
	Min PU	Max PU	Min PU	Max PU
Ramsey 230 kV	0.95	1.05	0.90	1.10
Balta 230 kV	0.95	1.05	0.90	1.10
Coal Creek 230 kV6	0.95	1.05	0.90	1.10
Remaining ND Area	0.95	1.05	0.90	1.10
Dickinson 345 kV	0.95	1.05	0.90	1.10
Hubbard 230 & 115 kV 7	0.97	1.05	0.92	1.10
Wing River 230 & 115 kV 8	0.97	1.05	0.92	1.10
115 kV buses in OTP Operating area	0.95	1.07	0.90	1.10
All Load Serving Buses	0.95	1.05	0.92	1.10
Remaining Buses	0.95	1.05	0.90	1.10

Xcel Energy Transmission Planning Criteria applied for the voltage analysis:

- For NERC Category P0 (System Intact) – Pre Contingent
- For NERC Category P1-P7 contingencies – Post Contingent

Voltage Ranges / Facility	Pre Contingent		Post Contingent	
	Min PU	Max PU	Min PU	Max PU
Default for all buses > 100 kV	0.95	1.05	0.92	1.05
Default for all buses < 100 kV*	0.95	1.05	0.92	1.05
Default for all generator buses**	0.95	1.05	0.95	1.05

Voltage Ranges / Facility	**Pre Contingent**		**Post Contingent**	
	Min PU	**Max PU**	**Min PU**	**Max PU**
Roseau 500 kV bus	0.95	1.10	0.92	1.10
Prairie 115 kV main bus	0.95	1.09	0.90	1.09
Prairie 115 kV capacitor bus	0.95	1.15	0.92	1.15
Sheyenne 115 kV capacitor bus	0.95	1.15	0.92	1.15
Running 230 kV capacitor bus	0.95	1.10	0.92	1.10
Roseau 230 kV capacitor bus	0.95	1.05	0.92	1.10
Chisago 500 kV bus	0.95	1.10	0.92	1.10
Forbes 500 kV bus	0.95	1.10	0.92	1.10
Bison 345 kV bus	0.95	1.05	0.92	1.10
Briggs Road 345 kV bus	0.95	1.05	0.92	1.10

*For 34.5 kV and below non-generation buses, pre and post contingent voltage of 0.9PU would be acceptable.
**For all Category P0, P1, P2, P4, P5, and P7 contingencies. [1] After a Category P3 or P6 contingency, generator bus voltage would be allowed to drop to 0.92 PU.

4.2 MISO Transmission Planning BPM SSR Criteria

- Per BPM-020 – R17, available mitigation may be applied for the valid NERC Category P1-P7 thermal and voltage violations as described by NERC Standards.
-

System Support Resource criteria for determining if an identified facility is impacted by the generator change of status will be:

- Under NERC Category P0 conditions and category P1-P7 contingencies, branch thermal violations are only valid if the flow increase on the element in the "after" retirement scenario is equal to or greater than:
  - a) 5% of the "to-be-retired" unit(s) MW amount (i.e. 5% PTDF) for a "base" (P0) violation compared with the "before" retirement scenario, or
  - b) 3% of the "to-be-retired" unit(s) amount (i.e. 3% OTDF) for a "contingency" (P1-P7) violation compared with the "before" retirement scenario.
- Under NERC category P0 conditions and category P1-P7 contingencies, high and low voltage violations are only valid if the change in voltage is greater than 1% as compared to the "before" retirement voltage calculation.
- Available mitigation may be applied for the valid NERC Category P1-P7 thermal and voltage violations as described by NERC Standards.
  - The need for the SSR is determined by the presence of unresolved violations of reliability criteria that can only be alleviated by the SSR generator and where no other mitigation is available.
  - Evaluation of mitigation solutions will consider the use of operating procedures and practices such as equipment switching, generator redispatch, and post-contingent Load Shedding plans allowed in the operating horizon.

5. STUDY METHODOLOGY

5.1 Steady-State Performance Analysis

- PTI – PSS/E version 33 and PowerGEM – TARA will be used to perform AC contingency analysis and SCED. Cases will be solved with automatic control of LTCs, phase shifters, DC taps, switched shunts enabled (regulating), and area interchange disabled. Contingency analysis will be performed on before and after cases. The results will be compared to find if there are any criteria violations due to the unit(s) change of status.

5.2 Voltage Stability Criteria

Voltage Stability Assessment (Power-Voltage Curve Analysis) will not be performed unless a specific concern is raised by the TO or MISO.

5.3 Dynamic Stability Criteria

Dynamic (Transient) Stability Assessment will not be performed unless a specific concern is raised by the TO or MISO.

6. STUDY RESULTS

Appendices of this report summarizes the results and analysis.

6.1 Scenario 1 (Boswell Unit 3) Analysis

The purpose of Scenario 1 was to evaluate the potential change in status of Boswell Unit 3 only.

No thermal violations were seen in the 2030 Summer Peak and Summer Shoulder Case. Thermal violations from the Winter Peak Case are discussed below.

No voltage violations were seen in the 2030 Summer Peak Case. Voltage violations which met the SSR voltage criteria were seen in 2030 Summer Shoulder Case and are shown in Appendix. All violations can be mitigated by Manitoba Hydro HVDC Run Back or Dorsey Synchronous Condensers operating guide. Voltage violations from the Winter Peak Case are discussed below.

There were numerous thermal and voltage violations in the Winter Peak Case, as well as several non-converged contingencies. A "non-converged" contingency is one that the power flow software program (PSS/E) was not able to solve. There could be a number of explanations for why a solution could not be reached, but in general non-converged contingencies are indicative of severe contingencies and in some cases potential voltage or transient stability problems. While most of the thermal violations identified in the Winter Peak Case could be addressed by redispatch or load shedding, the voltage violations and non-converged contingencies appear to require robust mitigating solution(s) for the Scenario 1 (Boswell Unit 3) Offline Case.

The thermal violations which could be addressed by redispatch are shown in Appendix. General observations about the underlying issues behind one of the thermal violations and some of the more severe voltage violations and non-converged contingencies are also discussed below. This is not meant to be an exhaustive discussion of all issues in the Scenario 1 (Boswell Unit 3) Offline Case, but rather to highlight what appear to be some of the more significant issues in the Winter Peak case.

Significant Overloads of Forbes 500/230 kV Transformers

There are two parallel 500/230 kV transformers at the Forbes Substation. For P6 events involving loss of [REDACTED], the remaining Forbes 500/230 kV transformer is loaded well beyond its emergency rating. In the study results, this flagged primarily for Category P6 events, but there are [REDACTED] failure events at Forbes that would produce similar results. Loss of the [REDACTED] leaves a single [REDACTED] as the sole outlet for all of the power flowing north on the Chisago – Forbes 500 kV Line. Post-contingent power flow on the remaining Forbes 500/230 kV transformer (normal capacity = 672 MVA) reaches 900 MVA in Scenario 1 (Boswell Unit 3 Offline); 1,000 MVA in Scenario 2 (Boswell Unit 4 Offline), and up to 1,200 MVA in Sensitivity 1 (Boswell Unit 3 & Boswell Unit 4 Offline). While these overloads were resolved in all study cases with redispatch and load shedding, they are driving a significant portion of the overall need for redispatch and load shedding due to their severity and would be worth addressing as part of a larger overall solution to the non-convergence issues described below.

Non-Convergence Due to Loss of [REDACTED] Line

The most prevalent and serious non-convergence issue identified in both Scenarios and both Sensitivities in the study is loss of the [REDACTED] Line. Across all contingency types (P1 – P7), most of the contingencies involving loss of the [REDACTED] Line result in non-convergence. The underlying issue appears to be regional voltage stability. There is a significant amount of power flowing north on the Chisago – Forbes 500 kV Line in the Winter Peak Case, and when it is lost there are no comparatively large (in terms of voltage and transfer capability) parallel transmission lines delivering power into Northeastern Minnesota. Without the [REDACTED] line, the majority of northward power flow gets rerouted onto five relatively long 230 kV transmission paths originating in the [REDACTED] and the Red River Valley. Based on the study results, these 230 kV lines do not appear to be capable of carrying the large amount of power flowing toward Northern Minnesota while maintaining adequate system voltage without the [REDACTED] line in service in any of the study scenarios. Given the confluence of circumstances contributing to this issue in the Winter Peak case (Boswell units offline, heavy northward MHEX flows, and heavy Northern Minnesota Winter Peak loading), further analysis would be necessary if a formal Attachment Y Notice was requested. In all likelihood, a robust mitigating solution would be necessary to address the voltage stability issues identified in this study.

Non-Convergence Due to Loss of Boswell Unit 4 + Riel – Forbes 500 kV

In the Scenario 1 Offline Case, non-convergence was observed for the [REDACTED] event involving loss of [REDACTED] Line plus an unplanned outage of Boswell Unit 4. While it is not clear what the root cause of the non-convergence is, this contingency would result in significant additional power flow north on Chisago – Forbes 500 kV Line while simultaneously reducing outlet capability at Forbes without the [REDACTED] Line. This could be related to the Loss of [REDACTED] Line voltage stability issue described above and should be considered when developing a solution for it.

6.2 Scenario 2 (Boswell Unit 4) Analysis

The purpose of Scenario 2 was to evaluate the potential change in status of Boswell Unit 4 only.

No thermal violations were seen in the 2030 Summer Peak and Summer Shoulder Case. Thermal violations for the Winter Peak Case are discussed below.

No voltage violations were seen in the 2030 Summer Peak Case. Voltage violations which met the SSR voltage criteria were seen in the 2030 Summer Shoulder Case and are shown in Appendix. All violations can be mitigated by Manitoba Hydro HVDC Runback or Dorsey Synchronous Condensers operating guide. Voltage violations from the Winter Peak Case are discussed below.

There were numerous thermal and voltage violations in the Winter Peak Case, as well as several non-converged contingencies. A "non-converged" contingency is one that the power flow software program (PSS/E) was not able to solve. There could be a number of explanations for why a solution could not be reached, but in general non-converged contingencies are indicative of severe contingencies and in some cases potential voltage or transient stability problems. While most of the thermal violations identified in the Winter Peak Case could be addressed by redispatch or load shedding, the voltage violations and non-converged contingencies appear to require robust mitigating solution(s) for the Scenario 2 (Boswell Unit 4) Offline Case.

The thermal violations which could be addressed by redispatch are shown in Appendix. General observations about the underlying issues behind one of the thermal violations and some of the more severe voltage violations and non-converged contingencies are also discussed below. This is not meant to be an exhaustive discussion of all issues in the Scenario 2 (Boswell Unit 4) Offline Case, but rather to highlight what appear to be some of the more significant issues in the Winter Peak case.

Significant Overloads of Forbes 500/230 kV Transformers

Overloads were observed on the Forbes 500/230 kV transformers for contingencies resulting in loss of the [REDACTED]. Worst-case post-contingent loading on the 672 MVA-rated transformer in Scenario 2 was approximately 1,000 MVA. Further discussion of this issue is provided in Section 6.1.

Non-Convergence Due to Loss of [REDACTED] Line

Many contingencies resulting in loss of the [REDACTED] were non-converged in the Scenario 2 Offline study case. Further discussion of this issue is provided in Section 6.1.

Non-Convergence Due to Loss of [REDACTED]

In the Scenario 2 Offline Case, non-convergence was observed for the NERC Category P6 event involving loss of the [REDACTED] plus loss of the [REDACTED] Line. While it is not clear what the root cause of the non-convergence is, this contingency would result in significant additional power flow north on Chisago – Forbes 500 kV Line while simultaneously reducing outlet capability at Forbes without the Riel – Forbes 500 kV Line. This could be related to the Loss of [REDACTED] voltage stability issue described above and should be considered when developing a solution for it.

Non-Convergence Due to Loss of [REDACTED] Transmission Outlets

In the Scenario 2 Offline Case, non-convergence was observed for NERC Category P7 events involving the [REDACTED] and the [REDACTED] kV Line. The same issue was also observed in the Sensitivity 1 and Sensitivity 2 Offline Cases. These contingencies likely weaken the source to the [REDACTED] in the Winter Peak case significantly enough to lead to a similar voltage stability issue as that described above for the [REDACTED] and should be considered when developing a solution for it.

6.3 Sensitivity 1 (Boswell Unit 3 & Boswell Unit 4) Analysis

The purpose of Sensitivity 1 was to evaluate the potential change in status of both Boswell Unit 3 and Boswell Unit 4 at the same time.

Several thermal violations that met the threshold of SSR criteria (3% OTDF of study units) were observed in the 2030 Summer Peak and Summer Shoulder Sensitivity 1 Case. These violations are shown in Appendix and can be mitigated by Manitoba Hydro HVDC Runback. Thermal violations for the Winter Peak Case are discussed below.

No voltage violations were seen in the 2030 Summer Peak Case. Voltage violations which met the SSR voltage criteria were seen in the 2030 Summer Shoulder Case and are shown in Appendix. As provided in Appendix all violations in the Sensitivity 1 Offline Case can be mitigated by load shed, Manitoba Hydro HVDC Runback, or Dorsey Synchronous Condensers operating guide. Voltage violations from the Winter Peak Case are discussed below.

There were numerous thermal and voltage violations in the Winter Peak Case, as well as several non-converged contingencies. A "non-converged" contingency is one that the power flow software program (PSS/E) was not able to solve. There could be a number of explanations for why a solution could not be reached, but in general non-converged contingencies are indicative of severe contingencies and in some cases potential voltage or transient stability problems. While most of the thermal violations identified in the Winter Peak Case could be addressed by redispatch or load shedding, the voltage violations and non-converged contingencies appear to require robust mitigating solution(s) for the Sensitivity 1 (Boswell Unit 3 & Boswell Unit 4) Offline Case.

The thermal violations which could be addressed by redispatch are shown in Appendix. General observations about the underlying issues behind one of the thermal violations and some of the more severe voltage violations and non-converged contingencies are also discussed below. This is not meant to be an exhaustive discussion of all issues in the Sensitivity 1 (Boswell Unit 3 & Boswell Unit 4) Offline Case, but rather to highlight what appear to be some of the more significant issues in the Winter Peak case.

<u>Significant Overloads of Forbes 500/230 kV Transformers</u>

Overloads were observed on the Forbes 500/230 kV transformers for contingencies resulting in loss of the [REDACTED]. Worst-case post-contingent loading on the 672 MVA-rated transformer in Sensitivity 1 was approximately 1,200 MVA. Further discussion of this issue is provided in Section 6.1.

<u>Non-Convergence Due to Loss of [REDACTED] Line</u>

Many contingencies resulting in loss of the [REDACTED] Line were non-converged in the Scenario 2 Offline study case. Further discussion of this issue is provided in Section 6.1.

<u>Non-Convergence Due to Loss of [REDACTED]</u>

Non-convergence was observed for the NERC Category P6 event involving loss of the [REDACTED] Line plus loss of the [REDACTED]. Further discussion of this issue is provided in Section 6.2.

<u>Non-Convergence Due to Loss of [REDACTED]</u>

Non-convergence was observed for NERC Category P7 events involving the [REDACTED]. Further discussion of this issue is provided in Section 6.2.

6.4 Sensitivity 2 (Boswell Unit 3 & Boswell Unit 4 plus [REDACTED]) Analysis

The purpose of Sensitivity 2 was to evaluate the potential change in status of both Boswell Unit 3 and Boswell Unit 4 at the same time, in conjunction with the potential change in status of several other [REDACTED] generators in the region, including [REDACTED].

Several thermal violations that met the threshold of SSR criteria (3% OTDF of study units) were observed in the 2030 Summer Peak Sensitivity 2 Case. These violations are shown in Appendix and would be mitigated by Manitoba Hydro HVDC Runback. No thermal violations that met the threshold of SSR criteria were observed in the 2030 Summer Shoulder Sensitivity 2 Case. Thermal violations for the Winter Peak Case are discussed below.

Voltage violations which met the SSR voltage criteria were seen in the 2030 Summer Peak and Summer Shoulder Case and are shown in Appendix. As provided in Appendix many of the violations in the Sensitivity 2 Offline Case can be mitigated by load shed, Manitoba Hydro HVDC Runback, or Dorsey Synchronous Condensers operating guide. However, load shedding is not allowed for the low voltage violations caused by NERC Category P1 contingencies in the Summer Peak Case, and therefore a mitigating solution would be required. It should be noted that this sensitivity assumes retirements of several units which are not yet approved or even in progress. Thus it is quite possible, depending on the order in which the units are retired (if they are retired at all) and the system conditions at the time, that an Attachment Y study for any of these units could produce similar low voltage results and thus cause these low voltage violations to be mitigated as a result of the study for that unit. Voltage violations from the Winter Peak Case are discussed below.

There were numerous thermal and voltage violations in the Winter Peak Case, as well as several non-converged contingencies. A "non-converged" contingency is one that the power flow software program (PSS/E) was not able to solve. There could be a number of explanations for why a solution could not be reached, but in general non-converged contingencies are indicative of severe contingencies and in some cases potential voltage or transient stability problems. While most of the thermal violations identified in the Winter Peak Case could be addressed by redispatch or load shedding, the voltage violations and non-converged contingencies appear to require robust mitigating solution(s) for the Sensitivity 2 (Boswell Unit 3 & Boswell Unit 4 plus [REDACTED]) Offline Case.

The thermal violations which could be addressed by redispatch are shown in Appendix. General observations about the underlying issues behind one of the thermal violations and some of the more severe voltage violations and non-converged contingencies are also discussed below. This is not meant to be an exhaustive discussion of all issues in the Sensitivity 2 (Boswell Unit 3 & Boswell Unit 4 plus [REDACTED]) Offline Case, but rather to highlight what appear to be some of the more significant issues in the Winter Peak case.

Significant Overloads of Forbes 500/230 kV Transformers

Overloads were observed on the Forbes 500/230 kV transformers for contingencies resulting in loss of the [REDACTED]. Further discussion of this issue is provided in Section 6.1.

Non-Convergence Due to Loss of [REDACTED] Line

Many contingencies resulting in loss of the [REDACTED] Line were non-converged in the Scenario 2 Offline study case. Further discussion of this issue is provided in Section 6.1.

Non-Convergence Due to Loss of [REDACTED]

Non-convergence was observed for the NERC Category P6 event involving loss of the [REDACTED]. Further discussion of this issue is provided in Section 6.2.

Non-Convergence Due to Loss of [REDACTED]

Non-convergence was observed for NERC Category P7 events involving the [REDACTED]. Further discussion of this issue is provided in Section 6.2.

Non-Convergence Due to [REDACTED]

In the Sensitivity 2 Offline Case, non-convergence was observed due to loss of the [REDACTED]. The "J732 POI" bus is the point of interconnection for Project #J732, the Nemadji Trail Energy Center combined cycle natural gas plant, which is currently in the MISO interconnection queue and has been included in all study cases. The underlying issue appears to be related to a system intact overload of the Arrowhead phase shifting transformer (PST), which is the sole connection between the 345 kV line and the 230 kV system at Arrowhead. The Arrowhead PST has a normal rating of 800 MVA, and there is over 800 MVA flowing into the Arrowhead 230 kV bus from the 345 kV line in the Sensitivity 2 system intact model. This is likely due to the weakening of the [REDACTED] area source with multiple baseload units offline, which causes Northern Minnesota to lean more heavily in the Winter Peak case on its main tie line to Wisconsin. The related non-convergence following [REDACTED] Line seems to be a stability issue related either to the generator at J732 (angular instability) or to the remaining tie lines into Northern Minnesota (voltage stability). In any case, the Arrowhead PST would need to be adjusted in the system intact condition to limit the flow into Arrowhead and avoid overloading the Arrowhead PST. While it is possible that the PST could be used to reduce flow enough to eliminate the non-convergence issue for loss of [REDACTED], such action will likely only shift the problem and aggravate voltage stability issues associated with the other tie lines into Northern Minnesota (some of which have been described above).

Non-Convergence Due to [REDACTED] Area Contingencies

In the Sensitivity 2 Offline Case, there are many contingencies in the area around the [REDACTED] that do not converge or cause low post-contingent voltage violations. These appear to be voltage stability issues caused by loss of multiple transmission sources to the [REDACTED] during Winter Peak and heavy north flow conditions, similar to those described above for Northern Minnesota tie lines. Since this sensitivity assumes retirements of several units which are not yet approved or even in progress, it is difficult to say when or if these issues would show up in future Attachment Y studies. Given that these issues do not show up in the study cases involving only the Boswell units, the main conclusion from this study is that these low voltage and non-convergence issues are more strongly tied to the retirement of the [REDACTED] generators and – at most – would be aggravated by the retirement of the Boswell units if some combination of [REDACTED] area generators had already been retired.

7. CONCLUSION

After being reviewed for power system reliability impacts as provided for under Section 38.2.7 of MISO's Open Access Transmission, Energy, and Operating Reserve Markets Tariff ("Tariff"), the analysis determined that there are reliability issues identified related to the potential change of status of Boswell Units 3 and 4, jointly or separately, that would likely require robust mitigating solutions to be built before the retirement of the unit(s) could be allowed. One or both units may need to be designated as System Support Resource ("SSR") units in the event the mitigating solution is not built prior to the retirement date indicated in the future Attachment Y study request. The issues are summarized below for each study case.

In Scenario 1 with Boswell Unit 3 Offline, there were very few issues identified in the Summer Peak and Shoulder cases. In the Winter Peak case with heavy northward flow toward Northern Minnesota and Manitoba, there appear to be transfer limitations related to the Chisago – Forbes 500 kV Line and parallel 230 kV lines that would result in voltage stability issues following loss of the [REDACTED]. Several related stability, voltage, and thermal violations were also observed in the Winter Peak case. These issues indicated a need for a robust mitigating solution prior to retirement of Boswell Unit 3. Absent such a solution it is likely that Boswell Unit 3 would be designated a System Support Resource if similar results were identified in an Attachment Y Study.

In Scenario 2 with Boswell Unit 4 Offline, similar to Scenario 1, there were very few issues identified in the Summer Peak and Shoulder cases. The same Winter Peak voltage stability and related issues were identified in Scenario 2 as in Scenario 1, and were observed to be worse when the larger Boswell unit is offline. If similar results were identified in an Attachment Y Study, it is likely that Boswell Unit 4 would be designated a System Support Resource and a robust mitigating solution would need to be developed.

In Sensitivity 1 with Boswell Unit 3 & Boswell Unit 4 Offline, there were also very few issues identified in the Summer Peak and Shoulder cases. The Winter Peak voltage stability and related issues identified with one of the two units offline were found to be worsened with both units offline. If Boswell Unit 3 and Boswell Unit 4 were evaluated under a single Attachment Y Notice and similar results were identified in that study as those found in this Attachment Y2 study, it is likely that both units would be designated a System Support Resource and a robust mitigating solution would need to be developed.

In Sensitivity 2 with Boswell Unit 3 & Boswell Unit 4 plus [REDACTED] Baseload Generators Offline, additional issues were identified in the Summer Peak, Shoulder, and Winter Peak cases. The Winter Peak voltage stability and related issues identified in the previous cases were found to be present, and some additional stability and voltage issues were also identified due to the [REDACTED] generators also being offline. Since this sensitivity assumes the retirements of several units at several different sites across a relatively large geographic area and none of these units currently have Attachment Y notices in progress, it is difficult to say when or if these issues would show up in future Attachment Y studies. The main conclusion from Sensitivity 2 is that there are certain issues that do not show up in the cases involving only the Boswell units (Scenario 1, Scenario 2, and Sensitivity 1). These issues are therefore more strongly tied to the retirement of the [REDACTED] baseload generators and – at most – would be aggravated by the retirement of the Boswell units if some combination of [REDACTED] generators had already been retired.

The development of robust mitigating solution(s) which would enable the retirement scenarios contemplated in this report are outside the scope of this Attachment Y2 study. Due to the complex nature of the retirements contemplated, any such mitigation solution development would need detailed analysis and discussions. MISO and the Transmission

Owner's involved with this study did not conduct an analysis of any potential mitigating solutions because the timeline for conducting the analysis is significantly outside the scope of an Attachment Y2 study.

An Attachment Y-2 study is a non-binding assessment of the Transmission System reliability for the potential suspension or retirement of a Generation Resource(s). The results of the study are not definitive and the analysis is to provide information to the Market Participant to assist them in evaluating their options. However, it does not commit the Market Participant to proceed with plans for suspension or retirement.

Furthermore, while the analysis conducted for the Attachment Y-2 study may be used in preparing a subsequent Attachment Y study, further study may be required to evaluate the impacts due to change in assumptions of system conditions when an Attachment Y Notice is submitted.

8. APPENDIX

Detailed thermal and voltage results are displayed in spreadsheets listed below:

1. Boswell_Y2_Thermal_results-REDACTED
2. Boswell_Y2_Voltage_results-REDACTED