Report R164-08

MHEB Group TSR System Impact Study
Out-Year Power Flow Analysis
US to MH Requests
Winter Peak / North Flow

Prepared for

Midwest ISO

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Revision History

Date	Description
3/20/2009	Original
6/26/2009	General revision for model updates and removed option 2
7/17/2009	Incorporated study group comments

Contents

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Executive Summary

Several requests for long term firm transmission service have been made under the Midwest ISO's Open Access Transmission and Energy Markets Tariff. This report presents the results of a steady-state power flow analysis performed on a winter peak scenario to evaluate the requests for transmission service shown in Table E-1. These requests seek to reserve 1100 MW of transmission service from various sources in the US to Manitoba Hydro.

Table E-1: MHEB Group TSR US to MH Requests

Oasis Ref No	Service Type	Start Time	Stop Time	POR	POD	Requested Capacity	Queue Date	Study Number
76537582	Network	Jun-2009	Jun-2027	WPS	MHEB	500	06/13/07	A380
76544699	Network	Jun-2009	Jun-2037	MP	MHEB	250	07/06/07	A383
76637089	P-to-P	Nov-2014	Nov-2024	GRE	MHEB	100	04/17/08	A415
76637091	P-to-P	Nov-2014	Nov-2024	GRE	MHEB	100	04/17/08	A415
76637257	P-to-P	Jun-2009	Jun-2027	WEC	MHEB	50	04/17/08	A414
76637259	P-to-P	Jun-2009	Jun-2027	ALTE	MHEB	50	04/17/08	A413
76637260	P-to-P	Jun-2009	Jun-2027	ALTE	MHEB	50	04/17/08	A413
					Total (MW)	1100		

This study was performed by Siemens PTI under the direction of Midwest ISO and an Ad Hoc Study Group consisting of American Transmission Company (ATC LLC), Basin Electric Power Cooperative (BEPC), Dairyland Power Cooperative (DPC), Great River Energy (GRE), Manitoba Hydro (MHEB), Minnesota Power (MP), Minnkota Power Cooperative (MPC), Otter Tail Power (OTP), Western Area Power Administration (WAPA) and Xcel Energy (XEL).

Transmission Upgrade Options

The transmission upgrade options proposed by the ad hoc study group are summarized in Table E-2. The cost estimates are for the new 500 kV transmission lines only and are based on $/mile costs taken from the JCSP 2008 Interim Stakeholder Meeting Introduction Presentation[1] and adjusted down from 2024 dollars to 2018 dollars using a 3% escalation factor. The costs for series compensation, transformers, line terminations and other required substation equipment are not included in this preliminary estimate. These costs will be further developed and refined during the Facilities study.

System diagrams depicting the proposed upgrade options are included in Appendix B.

Table E-2: Transmission Upgrade Options

Option No.	Project	Cost in 2018[1]
1	Dorsey – Maple River 50% series compensated 500 kV line with one 500/345 kV, 1200 MVA transformer at Maple River. Maple River – Helena 50% series compensated 500 kV line terminated with two 500/345 kV, 1200 MVA transformers at Helena.	$1.035 B
3	Dorsey – King 50% series compensated 500 kV line terminated via two 500/345 kV, 1200 MVA transformers at King.	$955 M

Note 1: Cost estimates are for transmission lines only

The transmission upgrade options evaluated in this study do not include shunt reactors to compensate for capacitive generation on the new 500 kV lines. Both Option 1 and Option 3 will require shunt reactors on the 500 kV line to control voltage when the line is open-ended. In Option 3, the steady-state voltage is around 1.2 per unit at the series capacitor on the Dorsey-King 500 kV line and the series capacitors will need to be designed accordingly.

Contingencies that simulate the outage of new 500 kV facilities associated with upgrade Option 1 or Option 3 were not modeled with HVDC reduction. Existing 500 kV and 230 kV triggers to the Manitoba Hydro HVDC power order reduction scheme were simulated in the contingency analysis.

Transmission Service Impacts

A benchmark power flow model representing 2019 winter peak system conditions was created without the requested transmission service. TSR study cases were created by adding the requested transmission service to the benchmark case along with one of two transmission upgrade options. Using the benchmark case as a reference, the total system losses within the study area decrease slightly with Option 1 and increase by 1.8% with Option 3. Option 1 is 35 MW more efficient compared with Option 3.

A nonlinear (ac) contingency analysis was performed and the combined impacts of the transmission upgrade options and the 1100 MW aggregate study TSRs were evaluated by comparing flows and voltages in the benchmark and study cases. Linear (dc) analysis was

[1] http://www.midwestmarket.org/publish/Document/81d7e_11b6e66e758_-795e0a48324a/Interim%20Presentation.pdf?action=download&_property=Attachment

used to calculate distribution factors for each TSR and the distribution factors were used to identify the incremental impact of adding each TSR sequentially in queue date order.

Facilities that are constraints to one or more TSRs are summarized in Table E-3. Constraints to individual TSRs are described below the table.

Table E-3: Thermal Constraints

Monitored Element	Owner	Rating (MVA)	Option 1 Study Case	Option 3 Study Case	Contingency
Flowgate 6174:SONCCTCOCSON	MISO	478	X	X	OTDF Flowgate
Rugby – Rugby CPC 115 kV line	WAPA /BEPC	144.4	X	X	C: Rugby – Balta 230 kV line
Cass Lake – Nary 115 kV line	OTP/ MPC	105.6	X		C: Wilton – Cass Lake 230 kV line

A380 (500 MW WPS to MHEB-MISO)

A380 is a request for 500 MW of network transmission service from WPS to MHEB-MISO. A380 constraints are summarized in Table E-4.

Table E-4: A380 Thermal Constraints

Study	Constraint	Rating (MVA)	Loading	
			Option 1	Option 3
A380	Flowgate 6174:SONCCTCOCSON	478	101.8	104.8%
	Rugby – Rugby CPC 115kV line	144.4	-	100.2%

Note 1: Blank cell indicates facility is not significantly affected

A383 (250 MW MP to MHEB-MISO)

A383 is a request for 250 MW of network transmission service from MP to MHEB-MISO. A383 constraints are summarized in Table E-5.

Table E-5: A383 Thermal Constraints

Study	Constraint	Rating (MVA)	Loading	
			Option 1	Option 3
A383	Flowgate 6174:SONCCTCOCSON	478	-	106.5
	Cass Lake – Nary 115 kV line	105.6	100.7%	-
	Rugby – Rugby CPC 115kV line	144.4	-	106.7%

Note 1: Blank cell indicates facility is not significantly affected

A415 (100+100 MW GRE to MHEB-MISO)

A415 consists of two 100 MW requests for point-to-point transmission service from GRE to MHEB-MISO. A415 constraints are summarized in Table E-6.

Table E-6: A415 Thermal Constraints

Study	Constraint	Rating (MVA)	Loading	
			Option 1	Option 3
A415	Flowgate 6174:SONCCTCOCSON	478	103.7% (a) 104.4% (b)	107.4% (a) 108.4% (b)
	Rugby – Rugby CPC 115kV line	144.4	100.6% (a) 102.9% (b)	109.9% (a) 113.1% (b)

Notes:
(a): For 100 MW transmission service
(b): For 200 MW transmission service

A414 (50 MW WEC to MHEB-MISO)

A414 is a request for 50 MW of point-to-point transmission service from WEC to MHEB-MISO. A414 constraints are summarized in Table E-7.

Table E-7: A414 Thermal Constraints

Study	Constraint	Rating (MVA)	Loading	
			Option 1	Option 3
A414	Flowgate 6174:SONCCTCOCSON	478	104.8%	108.9%
	Rugby – Rugby CPC 115kV line	144.4	104.2%	114.7%

Note 1: Blank cell indicates facility is not significantly affected

A413 (50+50 MW ALTE to MHEB-MISO)

A383 consists of two 50 MW requests for point-to-point transmission service from ALTE to MHEB-MISO. A383 constraints are summarized in Table E-8.

Table E-8: A383 Thermal Constraints

Study	Constraint	Rating (MVA)	Loading	
			Option 1	Option 3
A413	Flowgate 6174:SONCCTCOCSON	478	105.2% (a) 105.6% (b)	109.4% (a) 109.9% (b)
	Rugby – Rugby CPC 115kV line	144.4	105.6% (a) 106.9% (b)	116.3% (a) 117.9% (b)

Notes:
(a): For 100 MW transmission service
(b): For 200 MW transmission service

Constraint Mitigation Costs

Estimated costs for resolving each of the TSR constraints during Winter Peak conditions are summarized in Table E-9. The costs are good faith estimates provided by the affected Transmission Owners and will be further developed and refined in the Facility Study.

Table E-9: Mitigation costs for constraints during Winter Peak conditions

Thermal Constraint	Mitigation required	Option 1	Option 3
Stanton - Coal Creek 230 kV (FG: SONCCTCOCSON)	Replace terminal equipment at Stanton and Coal Creek	$500,000	$500,000
Rugby - Rugby CPC 115 kV	Reconductor 0.1 miles of the line	$69,652	$69,652
Cass Lake - Nary 115 kV	Reconductor 11 miles of the line	$7,661,692	-
	Total	$8,231,344	$569,652

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Section

1

Steady-State Analysis

1.1 Methodology

A benchmark power flow model representing 2019 winter peak system conditions was created without the requested transmission service. TSR study cases were created by taking the benchmark case and modeling the requested transmission service along with one of the transmission upgrade options. A nonlinear (ac) contingency analysis was performed and the combined impacts of the transmission upgrade options and the 1100 MW aggregate study TSRs were evaluated by comparing flows and voltages in the benchmark and study cases.

Linear (dc) analysis was used to calculate distribution factors for each TSR and the distribution factors were used to identify the incremental impact of adding each TSR sequentially in queue date order.

1.2 Computer Programs

Analysis was performed using PSS®E version 30.3 and PSS®MUST version 8.3.2.

1.3 Model Development

1.3.1 Winter Peak Benchmark Case

A winter peak benchmark case without the study TSRs and associated transmission upgrades was developed. The source was a 2019 Winter Peak case from the MRO 2008 model series. The Winter Peak benchmark case was developed by adding transmission projects from MTEP 08 Appendices A and B, which are listed in Appendix A, Table A-1. Projects in MTEP 08 Appendix B have not yet been studied through the MTEP cost-allocation process. If any of the projects in MTEP 08 Appendix B do not get developed, as per the identified need (in MTEP), the study TSRs would be reevaluated to determine if they are potentially responsible for the cost of those projects or appropriate alternatives. In addition to future transmission upgrades, the benchmark case was updated to include all existing US to MH firm transmission service commitments, prior-queued transmission service requests (confirmed and study status) not already included in the MRO case, MISO network resource generation and miscellaneous updates and corrections as described in the following sections.

The benchmark power flow case was solved with transformer tap adjustment enabled, switched shunt adjustment enabled, area interchange enabled (ties only), phase shifter adjustment enabled and dc tap adjustment enabled.

1.3.1.1 Existing US to MH Firm Transmission Service

The winter peak benchmark case includes existing firm transmission service commitments on the MHEX_N (Manitoba Hydro Export North) interface, as listed in Table 1-1 below.

Table 1-1: Existing Firm Transmission Service on MHEX_N Interface

TSR Ref# (MH OASIS)	POR	POD	Capacity (MW)	Start Time	End Time	Service
76703255	NSP	MH	500	5/1/2009	5/1/2019	YEARLY FIRM NETWORK DES
76735261	OTP	MH	50	5/1/2009	5/1/2014	YEARLY FIRM PTP
76703241	NSP	MH	200	11/1/2008	5/1/2019	YEARLY FIRM NETWORK DES
76703240	NSP	MH	200	11/1/2008	11/1/2016	YEARLY FIRM NETWORK DES
76703244	GRE	MH	150	11/1/2008	5/1/2015	GFA CARVE OUT - FIRM
		Total	1100 MW			

These TSRs correspond to grandfathered agreements that correspond to energy guarantees. Not all of the energy guarantees can be scheduled simultaneously. The TSRs are conditioned so that the total firm schedule does not exceed 700 MW. The resulting MHEX_N interface flow in the winter peak benchmark case is 699 MW.

1.3.1.2 Prior-Queued WAPA TSRs

The following proposed generating facilities have TSRs under study on the WAPA OASIS and were added to the winter peak benchmark case.

- Culbertson Project GI-0708 + GI-0614a (120+10 MW)

Table 1-2: Firm TSRs on WAPA OASIS

TSR Ref# (WAPA OASIS)	Capacity (MW)	Start Time	End Time	Service
70992013	10	1/1/2008	1/1/2029	YEARLY FIRM NITS
71372179	120	1/1/2009	1/1/2035	YEARLY FIRM NITS

Groton Unit 1 and Unit 2 are dispatched at 120 MW each.

1.3.1.3 Prior-Queued Midwest ISO TSRs

Table 1-3 shows prior-queued Midwest ISO TSRs and confirmed requests that were added to the winter peak benchmark case using sources and sinks provided by Midwest ISO.

Table 1-3: Midwest ISO TSRs Added to the WIPK Case

OASIS	OASIS #	STUDY	POR	POD	CAPACITY REQUESTED (MW)	START	STOP
MISO	Multiple	A054, A101, A183, A234 and A237	NSP	NSP	52	8/1/2002	8/1/2028
MISO	75836490	A194	NSP	NSP	100	12/1/2008	12/1/2025
MISO	76434677	A316	OTP	OTP	50	2/1/2010	11/1/2028
MISO	76509135	A356	GRE	NSP	100	10/1/2008	1/1/2034
MISO	76517411	GFA	GRE	OTP	94	4/1/2007	1/1/2036
MISO	76517414	GFA	GRE	OTP	30	4/1/2007	11/20/2027
MISO	76517415	GFA	GRE	MP	275	4/1/2007	3/2/2010
MISO	76526766	A374	OTP	OTP	49	11/1/2008	11/1/2028
MISO	76541075	A204	MP	MP	25	2/1/2008	2/1/2009
MISO	76541076	A204	MP	MP	25	2/1/2011	2/1/2012
MISO	76561178	A390	SMP	NSP	45	11/1/2007	11/1/2037
MISO	76668811	A373	MP	MP	100	7/1/2010	8/1/2015
MISO	76668831	A373	NSP	MP	100	7/1/2010	8/1/2015
MISO	76668843	A381	GRE	MP	200	7/1/2011	8/1/2016
MISO	76668850	A393	OTP	MP	100	7/1/2010	8/1/2015

1.3.1.4 Midwest ISO Network Resource Generation

The NR generating facilities listed in Table 1-4 were added to the winter peak benchmark case.

Table 1-4: Midwest ISO NR Generation Added to the WIPK Case

MISO Project Number	MISO Queue Number	MISO Queue Date	Control Area	County	Point of Interconnection	Max Output (MW)	Dispatch (MW)
G519	38491-01	19-May-05	MP	Itasca, MN	Blackberry 230/115kV Substation	600	600
G691	39006-02	16-Oct-06	XEL	Vernon, WI	Westby - Cashton tap 69 kV line	50	10
G930	39426-03	10-Dec-07	XEL	Sherburne, MN	Sherco Substation	120	120

1.3.1.5 Miscellaneous Updates and Corrections

Table 1-5 shows other miscellaneous model updates.

Table 1-5: Miscellaneous Updates and Corrections

Area	Description
ATC	Update Ellington-Hintz 138-kV line rating to 381 MVA (WN), 461 MVA (WE)
ITCM	Redispatched Alliant Energy generation so that area slack bus is within limits
MEC	Redispatched MidAmerican generation so that area slack bus is within limits
MH	Added Dorsey – Riel 500 kV circuit #2
MH	Add 3x73.4 MVar shunt capacitors on 46-kV tertiary of Riel 500/230-kV transformer.
MP	Purge extra Blackberry-Wilton 230 kV line
OTP	Added TSRs 76517414 and 76517411 from GRE to OTP so that OTP area slack bus is within limits
SMMPA/XEL	Shifted 220 MW from SMMPA generation in XEL control area to Austin so that SMMPA area slack bus is within limits
WAPA	Purged superfluous zero-impedance branches: - Max-ND Prairie Wind 115-34.5 kV transformer - Ft Thomson-Leland Olds 345 kV line - Whitlock-Glenham 230 kV line
WAPA	Letcher-Wessington correction
WAPA	Purge Storla-Broadland 230 kV line
WAPA	Set Miles City DC tie at 150 MW east to west Set Boundary Dam at 165 MW south to north
WAPA	Remove Selby generator and associated topology changes to make WIPK model topology consistent with SUPK model. Selby 540 MW output compensated by dispatching BEPC and MDU peakers.
WAPA	Redispatched WAPA generation so that area slack bus is within limits.
XEL	Increased generator MW limits at Prairie Island and Monticello (A201)
XEL	Removed Chanarambie 115/34.5 kV #4 transformer
XEL	Change the control area of Tatanka Wind to XEL (600)
XEL	Lena Tap correction
XEL	Colville generator updates
XEL	Update facility ratings for M602F, F601C and Coon Creek-Kolman Lake
XEL	Change Forbes SVC rating from +400/-450 Mvar (10 second capability) to +110/-149 Mvar (continuous).

1.3.2 Winter Peak Study Cases

TSR study cases were created by taking the benchmark case and modeling the requested transmission service along with one of the transmission upgrade options. Losses for each TSR study case are summarized in Appendix B.

1.3.2.1 Sources and Sink for Study TSRs

The TSR sink is the Dorsey inverter station and the 1100 MW aggregate study TSRs were sunk by decreasing the injection of the existing two HVDC bipoles at Dorsey from 1950 MW in the benchmark case to 850 MW in the study case. The study TSRs were sourced at the generators shown in Table 1-6.

Table 1-6: US to MH TSR Sources

Bus #	Generator Name	MW
	REMOVED	

1.3.2.2 Transmission Upgrade Options

The transmission upgrade options proposed by the ad hoc study group are summarized in Table 1-7.

System diagrams depicting the proposed upgrade options are included in Appendix B.

Table 1-7: Transmission Upgrade Options

Option No.	Project
1	Dorsey – Maple River 50% series compensated 500 kV line with one 500/345 kV, 1200 MVA transformer at Maple River. Maple River – Helena 50% series compensated 500 kV line terminated with two 500/345 kV, 1200 MVA transformers at Helena.
3	Dorsey – King 50% series compensated 500 kV line terminated via two 500/345 kV, 1200 MVA transformers at King.

The transmission upgrade options evaluated in this study do not include shunt reactors to compensate for capacitive generation on the new 500 kV lines. Both Option 1 and Option 3 will require shunt reactors on the 500 kV line to control voltage when the line is open-ended. In Option 3, steady-state voltage is around 1.2 per unit at the series capacitor on the Dorsey-King 500 kV line and the series capacitors will need to be designed accordingly.

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OPTION 3 BUSES WITH VOLTAGE GREATER THAN 1.1000:

   BUS#  X-- NAME --X  BASKV   V(PU)   V(KV)
 601061  MIDCOMP-N    500.00  1.1758  587.91
 601062  MIDCOMP-S    500.00  1.2041  602.04
```

1.4 Contingency Criteria

A variety of system conditions are considered for the steady-state analysis.

- NERC Category A with system intact (no contingencies)
- NERC Category B contingencies
  - Outage of single element 100 kV and above (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 and above (B.2 and B.3) associated with single contingency event in the Dakotas, Manitoba, Minnesota, Wisconsin

For all contingency and post-disturbance analyses, the power flow cases are solved with transformer tap adjustment and switched shunt adjustment enabled, area interchange adjustment disabled, and phase shifter adjustment plus dc tap adjustment disabled.

1.5 Monitored Facilities

Monitored facilities and associated thermal and voltage limits are shown in Table 1-8.

Table 1-8: Monitored Facilities and Limits

Owner/ Area	Monitored Facilities	Thermal Limits [1]		Voltage Limits
		Pre-Disturbance	Post-Disturbance	
ATC LLC	69 kV and above	95% of Rate A	95% of Rate B	1.10/0.90
BEPC	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
DPC	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
GRE	69 kV and above	100% of Rate A	100% of Rate B	1.10/0.92/0.90 [2]
ITCMW	69 kV and above	100% of Rate A	100% of Rate B	1.10/0.90
MDU	69 kV and above	100% of Rate A	100% of Rate B	1.10/0.90
MEC	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
MH	69 kV and above	100% of Rate A	100% of Rate B	1.15/1.10/0.94/0.90 [3]
MP	69 kV and above	100% of Rate A	100% of Rate B	1.05/0.95
MPC	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
MRES	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
NWPS	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
OTP	69 kV and above	100% of Rate A	100% of Rate B	1.10/0.90
RPU	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
SMMPA	69 kV and above	100% of Rate A	100% of Rate B	1.10/0.90
SPC	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
WAPA	69 kV and above	100% of Rate A	100% of Rate A	1.10/0.90
XEL	69 kV and above	100% of Rate A	100% of Rate B	1.10/0.90

Note 1: PSSE Rate A, or Rate B
Note 2: 0.92 limit applies to load serving buses
Note 3: Limits dependent on nominal bus voltage

1.6 Reliability Margins

Flowgate ratings for this out-year analysis are based on facility ratings and do not consider capacity benefit margin (CBM) or transmission reliability margin (TRM). All other system elements were monitored as shown in Table 1-8.

1.7 Performance Criteria

A branch or flowgate is considered a significantly affected facility if both of the following conditions are met for the transmission service under study:

1) the facility is loaded above its applicable normal or emergency rating in the study case, and
2) the power transfer distribution factor (PTDF) is greater than 5% or the outage transfer distribution factor (OTDF) is greater than 3% for the overloaded facility.

Distribution factors for each TSR are calculated using linear (dc) analysis.

A voltage impact is considered significant if both of the following conditions are met for the transmission service under study:

1) the bus voltage is outside of applicable normal or emergency limits in the study case, and
2) the impact of the requested service on bus voltage is greater than 0.01 per unit.

1.8 Network Analysis Results

1.8.1 Impact on System Losses

The combined impact of the transmission upgrades and the aggregate TSRs (1100 MW) on system losses is shown in Appendix C, Table C-1. For each upgrade option, the change in system losses within the study area is tabulated. The net change in system real power losses (compared to the benchmark case) is lower for Option 1 (5 MW decrease) compared to Option 3 (30 MW increase).

1.8.2 Transmission Service Impacts

Table C-2 in Appendix C shows the combined impact of the transmission upgrades and the aggregate TSRs (1100 MW) on facilities impacted by one or more TSR. A thermal impact is considered significant if the facility loading exceeds the limit shown in Table 1-8 and the distribution factor exceeds the threshold given in Section 1.7. There are no significant voltage impacts attributable to any TSR.

1.8.2.1 A380 (500 MW WPS to MHEB-MISO)

A380 is a request for 500 MW of network transmission service from WPS to MHEB-MISO. Request A380 has a significant impact on the facilities shown in Table 1-9.

Two of the significantly affected facilities are common to both transmission upgrade options: the Leland Olds 345/230 kV transformer #2 and the Stanton-Coal Creek Tap flowgate (#6174). Of these, the Stanton-Coal Creek Tap flowgate is a constraint but the Leland Olds transformer is not a constraint because the post-contingency loading does not exceed the transformer's 700 MVA emergency rating.

With upgrade Option 1, the Tioga-Boundary Dam 230 kV line is a significantly affected facility; however, it is not a constraint because the post-contingency loading does not exceed the 250 MVA emergency rating and the B10T phase-shifting transformer can be used to reduce its flow within normal limits.

The Rugby-Rugby CPC 115kV line is a constraint with upgrade Option 3 only.

1.8.2.2 A383 (250 MW MP to MHEB-MISO)

A383 is a request for 250 MW of network transmission service from MP to MHEB-MISO. Request A383 has a significant impact on the facilities shown in Table 1-10.

The Cass Lake-Nary 115 kV line is a constraint with upgrade Option 1 only. The Rugby-Rugby CPC 115 kV line and the Stanton-Coal Creek Tap flowgate (#6174) are constraints with upgrade Option 3 only.

1.8.2.3 A415 (100+100 MW GRE to MHEB-MISO)

A415 consists of two 100 MW requests for total 200 MW of point-to-point transmission service from GRE to MHEB-MISO. Request A415 has a significant thermal impact on the facilities shown in Table 1-11 and Table 1-12.

Three of the significantly affected facilities are common to both transmission upgrade options: the Leland Olds 345/230 kV transformer #2, the Rugby-Rugby CPC 115kV line and the Stanton-Coal Creek Tap flowgate (#6174). The Leland Olds transformer is not a constraint because the post-contingency loading does not exceed the transformer's 700 MVA emergency rating. The other two facilities are constraints with either option.

With upgrade Option 1, the Tioga-Boundary Dam 230 kV line is a significantly affected facility; however, it is not a constraint because the post-contingency loading does not exceed the 250 MVA emergency rating and the B10T transformer can be used to reduce its flow within normal limits.

1.8.2.4 A414 (50 MW WEC to MHEB-MISO)

A414 is a request for 50 MW of point-to-point transmission service from WEC to MHEB-MISO. Request A414 has a significant thermal impact on the facilities shown in Table 1-13.

Three of the significantly affected facilities are common to all three transmission upgrade options: the Leland Olds 345/230 kV transformer #2, the Rugby-Rugby CPC 115kV line and the Stanton-Coal Creek Tap flowgate (#6174). The Leland Olds transformer is not a constraint because the post-contingency loading does not exceed the transformer's 700 MVA emergency rating. The other facilities are constraints with either option.

With upgrade Option 1, the Tioga-Boundary Dam 230 kV line is a significantly affected facility; however, it is not a constraint because the post-contingency loading does not exceed the 250 MVA emergency rating and the B10T transformer can be used to reduce its flow within normal limits.

1.8.2.5 A413 (50+50 MW ALTE to MHEB-MISO)

A413 consists of two 50 MW requests for total 100 MW of point-to-point transmission service from ALTE to MHEB-MISO. Request A417 has a significant thermal impact on the facilities shown in Table 1-14 and Table 1-15.

Three of the significantly affected facilities are common to all three transmission upgrade options: the Leland Olds 345/230 kV transformer #2, the Rugby-Rugby CPC 115kV line and the Stanton-Coal Creek Tap flowgate (#6174). The Leland Olds transformer is not a constraint because the post-contingency loading does not exceed the transformer's 700 MVA emergency rating. The other facilities are constraints with either option.

With upgrade Option 1, the Tioga-Boundary Dam 230 kV line is a significantly affected facility; however, it is not a constraint because the post-contingency loading does not exceed the 250 MVA emergency rating and the B10T transformer can be used to reduce its flow within normal limits.

Table 1-9: A380 Thermal Constraints (500 MW WPS to MHEB-MISO)

Option 1

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	478	98.1	101.8	3.5	C:Contingency of FlowGate 6174
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	116.8	122.0	5.2	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	113.6	117.4	3.8	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	97.6	101.2	3.6	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	97.7	101.2	3.6	C:GRE-COAL42G-GSU
661084 TIOGA4 4 230 672603 BDV 4 230 1 [1]	BEPC	200	109.9	117.7	3.1	C:MAPLERIV-DORSEY-500

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 3

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	478	100.0	104.8	4.5	C:Contingency of FlowGate 6174
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	84.7	100.2	4.5	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	120.2	125.1	4.8	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	116.2	119.8	3.5	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	101.5	104.8	3.3	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	101.5	104.8	3.3	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	97.4	100.7	3.3	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	97.4	100.7	3.3	C:CENTRDC-SQBUTTE-230

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Table 1-10: A383 Thermal Constraints (250 MW MP to MHEB-MISO)

Option 1

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
620247 CASS LK7 115 657710 NARY 7 115 1	OTP/ MPC	105.6	88.3	100.7	5.2	C:WILTON-CASSLK-230

Option 3

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	478	104.8	106.5	3.3	C:Contingency of FlowGate 6174
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	100.2	106.7	3.8	C:GRE-BALTA-RUGBY-230

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Table 1-11: A415 (1st of 2) Thermal Constraints (100 MW GRE to MHEB-MISO)

Option 1

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	478	103.0	103.7	3.5	C:Contingency of FlowGate 6174
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	98.2	100.6	3.4	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	123.2	124.2	4.7	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	118.3	119.0	3.5	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	102.0	102.7	3.2	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	102.0	102.7	3.2	C:GRE-COAL42G-GSU
661084 TIOGA4 4 230 672603 BDV 4 230 1	BEPC	200	120.8	122.4	3.3	C:MAPLERIV-DORSEY-500

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 3

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	478	106.5	107.4	4.6	C:Contingency of FlowGate 6174
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	106.7	109.9	4.6	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	125.9	126.8	4.5	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	120.3	121.0	3.3	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	105.3	105.9	3.1	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	105.3	105.9	3.1	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	101.3	101.9	3.1	C:CENTER2G-GSU

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	101.3	101.9	3.1	C:CENTRDC-SQBUTTE-230
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500	99.5	100.1	3.1	C:LELAN41G-GSU

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Table 1-12: A415 (2nd of 2) Thermal Constraints (100 MW GRE to MHEB-MISO)

Option 1

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	478	103.7	104.4	3.5	C:Contingency of FlowGate 6174
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	100.6	102.9	3.4	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	124.2	125.1	4.7	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	119.0	119.7	3.5	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	102.7	103.3	3.2	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	102.7	103.3	3.2	C:GRE-COAL42G-GSU
661084 TIOGA4 4 230 672603 BDV 4 230 1 [1]	BEPC	200	122.4	124.0	3.3	C:MAPLERIV-DORSEY-500

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 3

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	478	107.4	108.4	4.6	C:Contingency of FlowGate 6174
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	109.9	113.1	4.6	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500	126.8	127.6	4.5	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500	121.0	121.7	3.3	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500	105.9	106.5	3.1	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500	105.9	106.5	3.1	C:GRE-COAL42G-GSU

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500	101.9	102.5	3.1	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500	101.9	102.5	3.1	C:CENTRDC-SQBUTTE-230
659105 LELANDO3 345 659202 LELND2TY 345 1	BEPC	500	100.1	100.7	3.1	C:LELAN41G-GSU

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Table 1-13: A414 Thermal Constraints (50 MW WEC to MHEB-MISO)

Option 1

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	478	104.4	104.8	3.7	C:Contingency of FlowGate 6174
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	102.9	104.2	3.6	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	125.1	125.7	5.7	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	119.7	120.1	4.2	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	103.3	103.7	3.9	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	103.3	103.7	3.9	C:GRE-COAL42G-GSU
661084 TIOGA4 4 230 672603 BDV 4 230 1 [1]	BEPC	200	124.0	124.8	3.2	C:MAPLERIV-DORSEY-500

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 3

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	478	108.4	108.9	4.8	C:Contingency of FlowGate 6174
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	113.1	114.7	4.6	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	127.6	128.2	5.3	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	121.7	122.1	3.9	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	106.5	106.9	3.6	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	106.5	106.9	3.6	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	102.5	102.8	3.6	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	102.5	102.8	3.6	C:CENTRDC-SQBUTTE-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	100.7	101.1	3.6	C:LELAN41G-GSU

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Table 1-14: A413 (1st of 2) Thermal Constraints (50 MW ALTE to MHEB-MISO)

Option 1

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	478	104.8	105.2	3.7	C:Contingency of FlowGate 6174
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	104.2	105.4	3.6	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	125.7	126.3	5.8	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	120.1	120.6	4.2	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	103.7	104.1	3.9	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	103.7	104.1	3.9	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	99.8	100.2	3.9	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	99.8	100.2	3.9	C:CENTRDC-SQBUTTE-230
661084 TIOGA4 4 230 672603 BDV 4 230 1	BEPC	200	124.8	125.6	3.2	C:MAPLERIV-DORSEY-500

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 3

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	478	108.9	109.4	4.8	C:Contingency of FlowGate 6174
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	114.7	116.3	4.7	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	128.2	128.7	5.4	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	122.1	122.4	3.9	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	106.9	107.3	3.7	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	106.9	107.3	3.7	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	102.8	103.2	3.7	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	102.8	103.2	3.7	C:CENTRDC-SQBUTTE-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	101.1	101.5	3.7	C:LELAN41G-GSU

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Table 1-15: A413 (2nd of 2) Thermal Constraints (50 MW ALTE to MHEB-MISO)

Option 1

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	478	105.2	105.6	3.7	C:Contingency of FlowGate 6174
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	105.4	106.6	3.6	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	126.3	126.8	5.8	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	120.6	121.0	4.2	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	104.1	104.5	3.9	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	104.1	104.5	3.9	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	100.2	100.6	3.9	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	100.2	100.6	3.9	C:CENTRDC-SQBUTTE-230
661084 TIOGA4 4 230 672603 BDV 4 230 1 [1]	BEPC	200	125.6	126.4	3.2	C:MAPLERIV-DORSEY-500

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Option 3

Monitored Branches	Owner	Rating	Pre TSR Loading (%)	Post TSR Loading (%)	DF (%)	Contingency
6174:SONCCTCOCSON	MISO	478	109.4	109.9	4.8	C:Contingency of FlowGate 6174
652452 RUGBY 7 115 659264 RUGBCPC7 115 1	WAPA/ BEPC	144.4	116.3	117.9	4.7	C:GRE-BALTA-RUGBY-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	128.7	129.3	5.4	C:LELND1T-XFMR
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	122.4	122.8	3.9	C:ANTELOP-CHAR.CK-345
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	107.3	107.6	3.7	C:GRE-COAL41G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	107.3	107.6	3.7	C:GRE-COAL42G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	103.2	103.6	3.7	C:CENTER2G-GSU
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	103.2	103.6	3.7	C:CENTRDC-SQBUTTE-230
659105 LELANDO3 345 659202 LELND2TY 345 1 [1]	BEPC	500	101.5	101.8	3.7	C:LELAN41G-GSU

Note 1: Post-contingency loading does not exceed the facility's emergency rating

Appendix

A

MTEP08 Projects

Table A-1 shows the MTEP08 projects that were added to the 2017 Winter Peak benchmark case using response files provided by Midwest ISO.

Table A-1: MTEP08 Projects added to the Winter Peak Case

Transmission Owner	MTEP Project ID	Project Name	MTEP Appendix
ITCM	1288	Replace Hazleton 345/161 kV transformer #1 with 335 MVA unit	A
ITCM	1341	Replace two Hazleton 161/69 kV transformers	A
ITCM	1473	Mason City Armor - Emery North 69 kV line	A
ITCM	1522	6th Street – Beverly	A
ITCM	1619	Grnd Mnd 161-69kV 2nd Xfmr & 161kV loop	A
ITCM	1641	OGS 50 MVAR Cap Bank	A
ITCM	1739	Arnold-Vinton-Dysart-Washburn 161kV Reconductor	A
ITCM	1755	Washington-Hills 69kV Rebuild	A
ITCM	1756	Dyersville-Peoasta 69kV Rebuild	A
ITCM	1758	Beaver Channel-2nd Ave 69kV	A
GRE	1361	Badoura - Birch Lake 115 lines	A
MP	277	Badoura Project: Pine River - Pequot Lakes 115 kV line	A
MP/GRE	1021	Embarass to Tower 115 kV Line	A
MP/GRE	1022	Badoura-Long Lake 115 kV line	A
OTP	973	Big Stone II Generation Project	B
SMP	1367	Lake City load serving upgrades	A
XEL/SMP		SMP-GRANDMEADOW-WF	B
XEL	675	Rebuild Westgate to Scott County 69 kV to 115 kV	A
XEL	1285	Build 18 miles 115 kV line from Glencoe - West Waconia	A
XEL	1457	G287, 37642-03. Upgrades for G287	A
XEL	1549	Eau Claire - Hydro Lane 161 kV Conversion	A
XEL	1953	St. Cloud - Sauk River 115 kV line upgrade	A
XEL	1954	Cherry Creek - Split Rock 115 kV line saperation	A
XEL	1956	Blue Lake - Wilmarth 345 kV line capacity upgrade	A
XEL	1957	New 161/69 kV Sub SW of Eau Claire where Alma – Elk Mound 161 kV intersects Shawtown – Naples 69 kV line. Rebuild 69 kV London/Madison to new substation. New 69 kV from new substation - DPC Union Sub. New 69 kV to DPC Brunswick Sub	A
XEL	1958	Stone Lake-Edgewater 161 kV line. A new radial 161 kV line and substation in Sawyer County, Wisconsin	A
XEL	1959	Yankee Doodle interconnection	A
XEL	1960	Traverse - St. Peter upgrade	A

Transmission Owner	MTEP Project ID	Project Name	MTEP Appendix
XEL	1961	Lake Emily Capacitor bank	A
XEL	2109	G609	A
XEL		G037	
ATC LLC	1463	Twin_Creeks-G384	N/A
ITCM	1645	Leon-1645_69kV_7MVAR	N/A
ITCM	1772	N_Cntrville_69kV-1772_7MVA	N/A
WAPA, BEPC	Correction	Su2009+-SplitWess	N/A
GRE	Network	KRMRLK(53801)	N/A
XEL	1380	WWACONIA-SCOTT	N/A

N/A – These projects have been withdrawn and no longer appear in MTEP Appendix A/B.

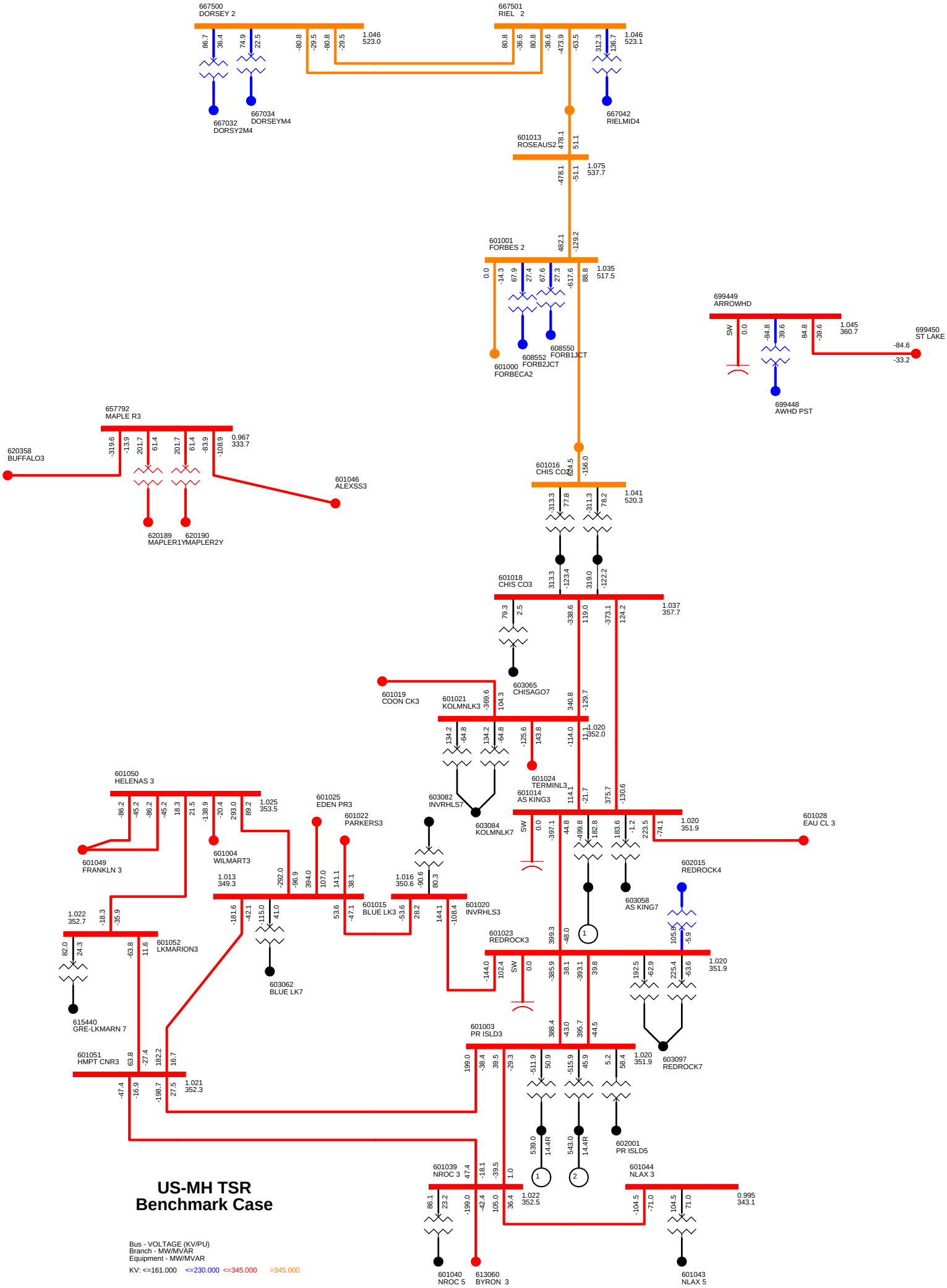
Appendix

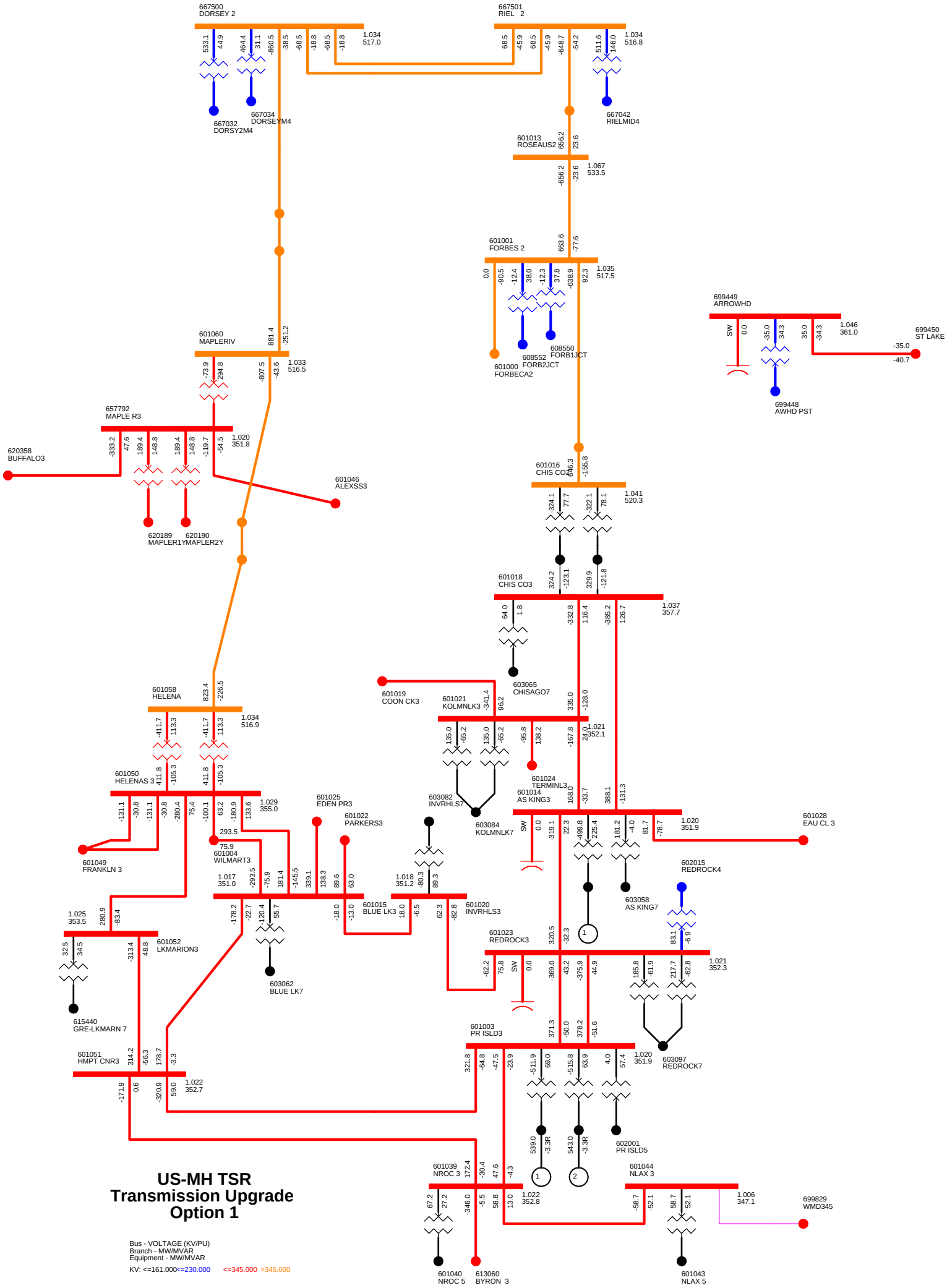
B

Transmission Upgrade Options

Table B-1: Modeling Parameters

Facility	R (pu)	X (pu)	B (pu)	Rate A (MVA)	Rate B (MVA)
Dorsey – Maple River 500 kV line with 50% series compensation	0.00290	0.04830 -0.02415	4.30	1732 1732	1905 2165
Maple River – Helena 500 kV line with 50% series compensation	0.00252	0.04200 -0.02100	3.74	1732 1732	1905 2165
Dorsey – King 500 kV line with 50% series compensation	0.00600	0.10700 -0.05350	10.00	1732 1732	1905 2165
500/345 kV, 1200 MVA Transformer One at Maple River (option1) Two at Helena (Option 1) Two at King (Option 3)	0.000050	0.004700		1200	1200


667500
DORSEY 2
667501
RIEL 2
667032
DORSY2M4
667034
DORSEYM4
667042
RIELMID4
601013
ROSEAUS2
601001
FORBES 2
601000
FORBECA2
608552
FORB2JCT
608550
FORB1JCT
699449
ARROWHD
699450
ST LAKE
699448
AWHD PST
657792
MAPLE R3
620358
BUFFALO3
620189
MAPLER1Y
620190
MAPLER2Y
601046
ALEXSS3
601016
CHIS CO2
601018
CHIS CO3
603065
CHISAGO7
601019
COON CK3
601021
KOLMNLK3
601024
TERMINL3
603082
INVRHLS7
601014
AS KING3
603084
KOLMNLK7
601028
EAU CL 3
602015
REDROCK4
603058
AS KING7
601050
HELENAS 3
601049
FRANKLN 3
601004
WILMART3
601025
EDEN PR3
601022
PARKERS3
601015
BLUE LK3
601020
INVRHLS3
601023
REDROCK3
603097
REDROCK7
601052
LKMARION3
615440
GRE-LKMARN 7
603062
BLUE LK7
601003
PR ISLD3
602001
PR ISLD5
601051
HMPT CNR3
601039
NROC 3
601044
NLAX 3
601040
NROC 5
613060
BYRON 3
601043
NLAX 5
US-MH TSR
Benchmark Case
Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000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BYRON 3
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NLAX 3
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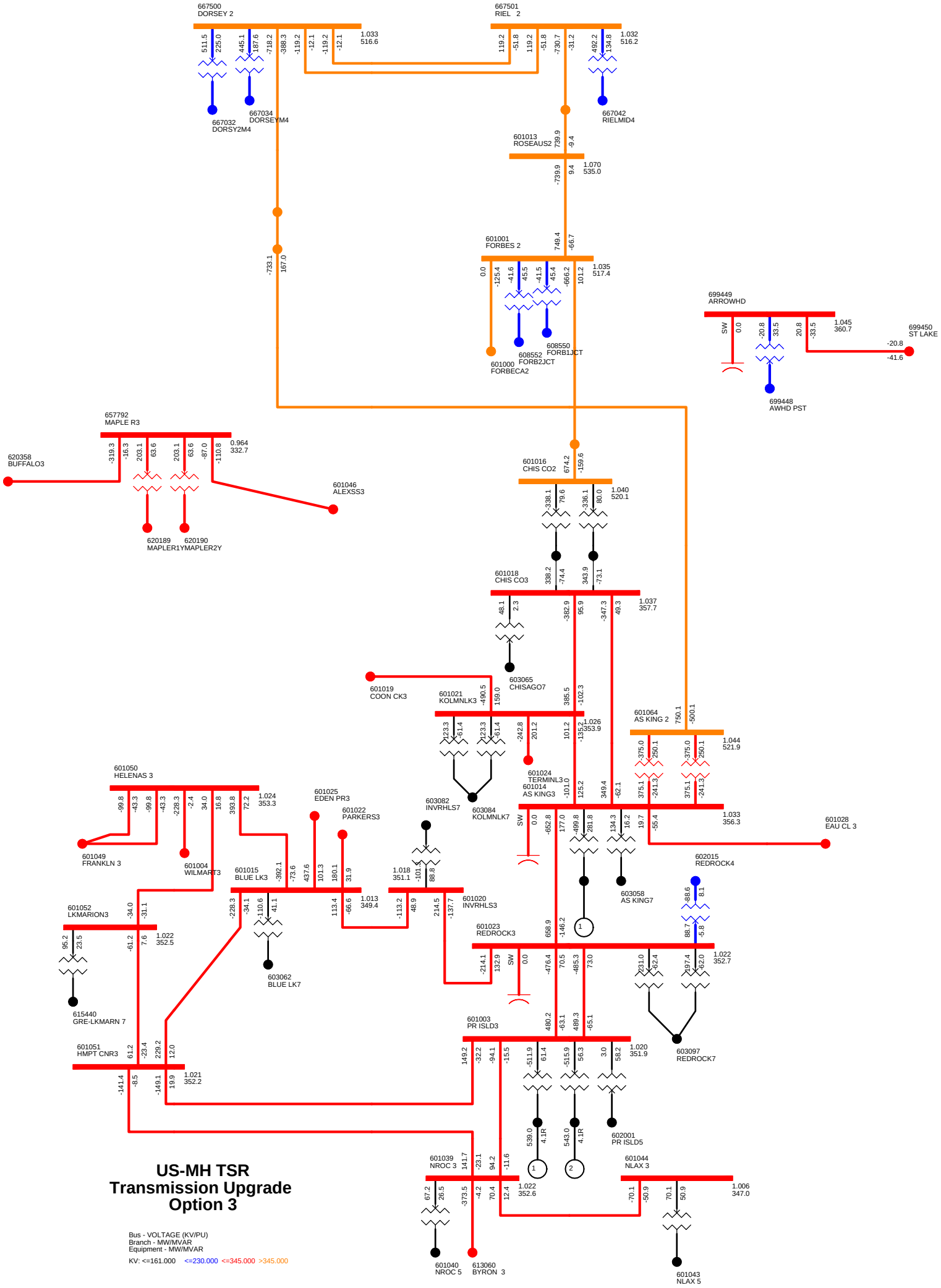
NLAX 5
699829
WMD345
US-MH TSR
Transmission Upgrade
Option 1
Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000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NROC 3
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NLAX 3
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NROC 5
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BYRON 3
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NLAX 5
US-MH TSR
Transmission Upgrade
Option 3
Bus - VOLTAGE (KV/PU)
Branch - MW/MVAR
Equipment - MW/MVAR
KV: <=161.000 <=230.000 <=345.000 >345.000

Appendix

C

Network Analysis Results

Table C-1: Network Loss Analysis Results

Area	Benchmark Case Losses	Option 1 Study Case		Option 3 Study Case	
		Losses	Difference	Losses	Difference
295 WEC	139.5	137.4	-2.1	137.7	-1.8
	2277.4	2237.4	-40.0	2239.2	-38.2
600 XEL	257.3	257	-0.3	276.8	19.5
	2604	2648.9	44.9	2792.4	188.4
608 MP	96.7	104.1	7.4	105.2	8.5
	1332.5	1399.6	67.1	1413.7	81.2
613 SMMPA	1.2	1.1	-0.1	1.1	-0.1
	11.2	9.6	-1.6	10.1	-1.1
615 GRE	103.5	102.2	-1.3	104.5	1.0
	1783	1788.5	5.5	1806	23.0
620 OTP	118.9	125.5	6.6	133.3	14.4
	1003.2	1052	48.8	1099.8	96.6
627 ALTW	81.8	89.7	7.9	87.5	5.7
	908.9	957.2	48.3	945.6	36.7
635 MEC	107.5	112.1	4.6	110.1	2.6
	1267.7	1309.6	41.9	1292.6	24.9
652 WAPA	271.5	274.6	3.1	282.5	11.0
	2650.2	2682.4	32.2	2729.6	79.4
667 MH	210.7	154.8	-55.9	153.9	-56.8
	3634.9	2261.5	-1373.4	2266.4	-1368.5
680 DPC	62.8	60	-2.8	63	0.2
	340	324.5	-15.5	337.6	-2.4
694 ALTE	104.3	99.2	-5.1	100.7	-3.6
	1019.3	980.4	-38.9	991.9	-27.4

Area	Benchmark Case Losses	Option 1 Study Case		Option 3 Study Case	
		Losses	Difference	Losses	Difference
696 WPS	64.9	60.9	-4.0	61.7	-3.2
	610.6	632.3	21.7	637.6	27.0
697 MGE	9.9	9.9	0.0	10.1	0.2
	143.1	141.8	-1.3	144.2	1.1
698 UPPC	9.1	9.1	0.0	9.1	0.0
	29.8	29.6	-0.2	29.7	-0.1
Network Upgrade Facilities	0	36.9	36.9	32.0	32.0
	0	330.2	330.2	376.6	376.6
TOTALS	1639.5	1634.5	-5.0	1669.2	29.7
	19615.9	18785.7	-830.2	19112.9	-503.0

Table C-2: Combined Impact of TSRs and Transmission Upgrade Options on WIPK Case
Thermal Violations, Significantly Impacted Facilities

** From bus **	** To bus **	** CKT	Owner	Rating (MVA)	Benchmark Case Loading (%)	Option 1 Study Case Loading (%)	Option 1 Study Case DF (%)	Option 3 Study Case Loading (%)	Option 3 Study Case DF (%)	Contingency
6174:SONCCTCOCSON			MISO	430	114.6	117.4	1.1	122.2	3.0	C:Contingency of FlowGate 6174
620247 CASS LK7 115	657710 NARY 7 115	1	OTP/MPC	105.6	86.7	101.6	1.4			C:620345 WILTON 4 230 620447 CASS LK4 230 1
652452 RUGBY 7 115	659264 RUGBCPC7 115	1	WAPA/BEPC	144.4	98.1	106.6	1.1	117.9	2.6	C:615903 GRE-BALTA 4 230 620379 RUGBY 4 230 1
659105 LELANDO3 345	659202 LELND2TY 345	1	BEPC	500	118.4	121.0	1.2	122.8	2.0	C:659101 ANTELOP3 345 659183 CHAR.CK3 345 1
659105 LELANDO3 345	659202 LELND2TY 345	1	BEPC	500	99.4	100.6	0.5	103.6	1.9	C:608601 CENTRDC4 230 657748 CENTER2G 20.0 1
659105 LELANDO3 345	659202 LELND2TY 345	1	BEPC	500	99.4	100.6	0.5	103.6	1.9	C:608601 CENTRDC4 230 657756 SQBUTTE4 230 1
659105 LELANDO3 345	659202 LELND2TY 345	1	BEPC	500	103.5	104.5	0.5	107.6	1.9	C:615001 GRE-COAL 41G22.0 615600 GRE-COAL CR4 230 1
659105 LELANDO3 345	659202 LELND2TY 345	1	BEPC	500	103.5	104.5	0.5	107.6	1.9	C:615002 GRE-COAL 42G22.0 615600 GRE-COAL CR4 230 1
659105 LELANDO3 345	659202 LELND2TY 345	1	BEPC	500	97.5	99.8	1.0	101.8	2.0	C:659106 LELANDO4 230 659110 LELAN41G 22.0 1
659105 LELANDO3 345	659202 LELND2TY 345	1	BEPC	500	123.0	126.8	1.7	129.3	2.9	C:659105 LELANDO3 345 659201 LELND1TY 345 1
661084 TIOGA4 4 230	672603 BDV 4 230	1	BEPC	200		126.4				MAPLERIV-DORSEY-500
661084 TIOGA4 4 230	672603 BDV 4 230	1	BEPC	200	136.3	108.7	-5.0	117.0	-3.5	M602F