Table E-9: 2025 SPK Category P1-P7 Thermal Constraints

Monitored Element	Rating	Owner	Benchmark Case		Study Case		Contingency label	Contingency	Type	J299 ST	J299 CT	G736	J385	J391	J400	J405	J407	J411	J416	J426	DF>20%	MW>20%*Rating	Outlet Con.	Outlet Mon.	Summary
			Pre Loading (MVA)	Pre Loading (%)	Post Loading	Post Loading (%)				10	63	40	100	50	62.5	40	40	60	40	20	GIP With Impact-1	GIP With Impact-2	GIP With Impact-3	GIP With Impact-4	GIP With Impact
										ER	ER	NR	NR	NR	NR	NR	NR	NR	NR	NR					
No constraints																									

Table E-10: 2025 SPK Category P1-P7 Voltage Constraints

Bus	Area	Vlow	Vhi	Benchmark VCONT	StudyCase VCONT	Delta (> 0.01	Contingency Details	Cont Type
No constraints								

Table E-11: 2025 SPK Non-Converged Category P2-P7 Contingencies

Contingency	Contingency Details	Benchmark	Study
CIPC-56	631069 [ANTA TP5 161.00] TO 631070 [ANITA 5 161.00] 1 631071 [SCRANTN5 161.00] TO 631072 [GU CTR 5 161.00] 1	Blown up	Blown up
CIPC-57	631069 [ANTA TP5 161.00] TO 631070 [ANITA 5 161.00] 1 631071 [SCRANTN5 161.00] TO 631074 [GR JCT 5 161.00] 1	Blown up	Blown up
ITCM-C925-LN	618900 [GRE-BREWSTR5161.00] TO 631040 [HRN LK 5 161.00] 1 602005 [SPLT RK5 161.00] TO 602039 [ROCK CO5 161.00] 1 602039 [ROCK CO5 161.00] TO 605618 [ROCKCOFDR1_134.500] 1	Blown up	Blown up
ITCM-C927-LN	631069 [ANTA TP5 161.00] TO 631070 [ANITA 5 161.00] 1 631071 [SCRANTN5 161.00] TO 631072 [GU CTR 5 161.00] 1 629111 [SCRANTN9 34.500] TO 631071 [SCRANTN5 161.00] 1 631071 [SCRANTN5 161.00] TO 631074 [GR JCT 5 161.00] 1	Blown up	Blown up
ITCM-C932-LN	602039 [ROCK CO5 161.00] TO 631038 [MAGNLIA5 161.00] 1 630056 [MAGNLIA8 69.000] TO 631038 [MAGNLIA5 161.00] 1 631038 [MAGNLIA5 161.00] TO 631039 [ELK 5 161.00] 1 631040 [HRN LK 5 161.00] TO 631041 [LAKEFLD5 161.00] 1 630066 [HERONLK8 69.000] TO 631040 [HRN LK 5 161.00] 2	Blown up	Blown up
ITCM-C938-LN	631104 [EIC 5 161.00] TO 631134 [TRICNTY5 161.00] 1 631115 [OTTUMWA5 161.00] TO 631116 [BRDGPRT5 161.00] 1	Blown up	Blown up

Table E-12: 2025 SPK Non-Converged Category P2-P7 Contingencies DCCC Results

Monitored Element	Rating	Owner	Benchmark Case		Study Case		Contingency label	Contingency	Type	J299 ST	J299 CT	G736	J385	J391	J400	J405	J407	J411	J416	J426	DF>20%	MW>20%*Rating	Outlet Con.	Outlet Mon.	Summary
			Pre Loading (MVA)	Pre Loading (%)	Post Loading	Post Loading (%)				10	63	40	100	50	62.5	40	40	60	40	20	GIP With Impact-1	GIP With Impact-2	GIP With Impact-3	GIP With Impact-4	GIP With Impact
										ER	ER	NR	NR	NR	NR	NR	NR	NR	NR	NR					
No constraints																									

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Appendix

F

Affected System Contingency Analysis Results

F.1 CIPCO/MPC Companies LPC Analysis Results

Table F-1: 2018 SH CIPCO/MPC LPC Analysis Results

Monitored Element	Rating	Owner	Benchmark Case		Study Case		Contingency label	Contingency	Type	J299 ST	J299 CT	G736	J385	J391	J400	J405	J407	J411	J416	J426	DF>3%
			Pre Loading (MVA)	Pre Loading (%)	Post Loading (MVA)	Post Loading (%)				5	31.5	200	0	0	0	0	200	300	200	100	GIP With Impact
										ER	ER	NR	NR	NR	NR	NR	NR	NR	NR	NR	
631079 BNE JCT5 161 636020 FT.DODG5 161 1	199.0	MEC CIPCO	192.9	96.9	220.4	110.8	P61:345-161:MEC-ITCM:G	GRIMES 3 345 - LEHIGH 3 345 1 STRY_CO5 161 - FERNALD5 161 1	P6-1	0.02064	0.02036	0.01576	0.01298	0.01798	0.01800	0.01363	0.01669	0.04775	0.01354	0.02068	J411,
631079 BNE JCT5 161 636020 FT.DODG5 161 1	199.0	MEC CIPCO	176.1	88.5	204.9	103.0	P23:345:MEC:GRIMES 904	FALLOW 3 345 - GRIMES 3 345 1 GRIMES 3 345 - LEHIGH 3 345 1 REMOVE SWSHUNT FROM BUS 636010	P2-3	0.02207	0.02173	0.01738	0.01352	0.01968	0.01969	0.01559	0.01571	0.05166	0.01108	0.02278	J411,

Table F-2: 2018 SPK CIPCO/MPC LPC Analysis Results

Monitored Element	Rating	Owner	Benchmark Case		Study Case		Contingency label	Contingency	Type	J299 ST	J299 CT	G736	J385	J391	J400	J405	J407	J411	J416	J426	DF>3%
			Pre Loading (MVA)	Pre Loading (%)	Post Loading (MVA)	Post Loading (%)				10	63	40	100	50	62.5	40	40	60	40	20	GIP With Impact
										ER	ER	NR	NR	NR	NR	NR	NR	NR	NR	NR	
No constraints																					

Table F-3: 2025 SH CIPCO/MPC LPC Analysis Results

Monitored Element	Rating	Owner	Benchmark Case		Study Case		Contingency label	Contingency	Type	J299 ST	J299 CT	G736	J385	J391	J400	J405	J407	J411	J416	J426	DF>3%
			Pre Loading (MVA)	Pre Loading (%)	Post Loading (MVA)	Post Loading (%)				5	31.5	200	0	0	0	0	200	300	200	100	GIP With Impact
										ER	ER	NR	NR	NR	NR	NR	NR	NR	NR	NR	
631100 LIBERTY5 161 631159 HCKRYCK5 161 1	223.0	CIPCO ITCM	194.5	85.7	223.4	100.2	631139 HAZLTON3	HAZLTON3 345 - HCKRYCK3 345 1	P1	0.02566	0.02599	0.02196	0.02259	0.02302	0.02308	0.01955	0.04080	0.01773	0.05569	0.02294	J407, J416,

Table F-4: 2025 SPK CIPCO/MPC LPC Analysis Results

Monitored Element	Rating	Owner	Benchmark Case		Study Case		Contingency label	Contingency	Type	J299 ST	J299 CT	G736	J385	J391	J400	J405	J407	J411	J416	J426	DF>3%
			Pre Loading (MVA)	Pre Loading (%)	Post Loading (MVA)	Post Loading (%)				10	63	40	100	50	62.5	40	40	60	40	20	GIP With Impact
										ER	ER	NR	NR	NR	NR	NR	NR	NR	NR	NR	
No constraints																					

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F.2 PJM Affected System Study Results

Below is the PJM affected system study report provided by PJM.

Impacts of MISO DPP-2015-February-August

Projects on PJM Facilities

1. MISO generators studied:

2015 February DPP:

MISO Project	POI	Interconnection ServiceType	Summer Max Output (MFO)	Capacity MW	Energy-Only MW	Fuel Type
G736	Big Stone South 230kV Substation	NRIS	200	200	0	Wind
J299	Wilmarth Substation: MEC-CT1 15 kV	ERIS	73	0	73	Gas
J301	Rapson 345 kV	NRIS	101	101	0	Wind
J308	Rapson - Banner 345 kV line	NRIS	301	301	0	Wind
J319	ANO-Pleasant Hill 500 kV line	NRIS	500	500	0	HVDC Line
J321	Rapson - Banner 345 kV line	NRIS	151.2	151.2	0	Wind
J375	Gibson City South Substation 138 kV	ERIS	125.6	0	125.6	Wind
J384	2346 Clearview Road, Cambridge: CHA 138 kV	NRIS	21	21	0	Gas
J385	Chisago 7 115 kV	NRIS	100	100	0	Solar
J390	Townline Road 138 kV	NRIS	702	702	0	Gas
J391	MMU's N 7th Street 115 kV substation	NRIS	50	50	0	Gas
J392	Livingston to Stover 138 kV line: AlbaJ 138 kV	NRIS	434.3	434.3	0	Gas
J394	Tilden 138 kV	NRIS	280	280	0	Gas
J395	Section 34 Township 3N Range 2E: HLM - DAR 138 kV line	ERIS	98	0	98	Wind
J400	Lyon County 115kV Substation	NRIS	62.5	62.5	0	Solar
J401	Stout South Substation 138 kV	NRIS	20	20	0	Battery
J405	Lewis & Clark Jct substation: Lewis 115 kV	NRIS	40	40	0	Gas
J407	Glenworth 161 kV	NRIS	200	200	0	Wind
J408	Banner 345 kV	NRIS	200	200	0	Wind
J411	Lehigh - Raun 345 kV line	NRIS	300	300	0	Wind
J416	Emery - Blackhawk 345 kV line	NRIS	200	200	0	Wind
J417	Grywood 230 kV	NRIS	43	43	0	Waste Heat Recovery
J419	Milan 120 kV	NRIS	100	100	0	Solar
J422	Greenwood Energy Center 26 kV	NRIS Only	30	30	0	Gas
J426	Chanarambie substation 35.4 kV	NRIS	100	100	0	Wind
J431	Goodland 69 kV	NRIS Only	106	106	0	Wind

2015 August DPP:

MISO Project	POI	Interconnection ServiceType	Summer Max Output (MFO)	Capacity MW	Energy-Only MW	Fuel Type
G934	METC Nelson Road 345kV substation	NRIS	150	150	0	Wind
J041	Wellsburg 161 kV Substation	NRIS	90	90	0	Wind
J264	Bingham - Cornell 138 kV	NRIS	120	120	0	Wind
J291	PPI Alsey 138kV Substation	NRIS	42	42	0	Gas
J298	ITC Midwest Toledo 161 kV Switchyard: Toledo 115 kV	NRIS	300.9	300.9	0	Wind
J330	Tracy - Walnut Grove 69 kV	NRIS	24.39	24.39	0	Solar
J396	Entergy Little Gypsy 230 kV Power Station	NRIS	904	904	0	Gas
J399	Black Dog 115 kV substation	NRIS	214	214	0	Gas
J412	LeHigh - Raun 345 kV line	NRIS	200	200	0	Wind
J429	Big Hill 138 kV substation	NRIS	100	100	0	Wind
J436	Big Stone South 345/230 kV sub interconnecting at 345 kV	ERIS	150	0	150	Wind
J437	Big Stone South 345/230 kV sub interconnecting at 345 kV	ERIS	150	0	150	Wind
J438	Poweshiek-Parnell 161 kV line	NRIS	170.2	170.2	0	Wind
J440	Consumers DIGG 230 kV substation	External NRIS	80	80	0	Gas
J442	Big Stone substation via a radial 230 kV line	NRIS	200	200	0	Wind
J443	Greely Tap 69 kV	NRIS Only	41	41	0	Wind
J449	Pioneer Prairie I substation: Mitchell Co 345 kV	NRIS	202	202	0	Wind
J452	Sandusky 120 kV Substation	NRIS	150	150	0	Wind
J453	Duke Edwardsport 6951 69 kV line	ERIS	17.25	0	17.25	Solar
J454	MMU SW 7 115 kV	NRIS Only	18.9	18.9	0	Wind
J455	Webster - Burt 345 kV line	ERIS	300	0	300	Wind
J465	North Bend 138 kV Substation	NRIS	44.1	44.1	0	Waste Heat Recovery
J466	Stein 345 kV Substation	NRIS	30	30	0	Co-Gen
J469	Consumers Grayling Generation 46 kV Substation	External NRIS	1.8	1.8	0	Wood

2. Summer Peak Analysis

- Model used – PJM AA1 Queue SIS 2018 Summer Peak case. All Active PJM queue projects modeled through the AA1 Queue along with all previously studied MISO DPP projects (studied through 2014). The MISO 2015 February and August DPP generators being studied were added to the model.
- Contingencies used – All PJM category B (single) and C contingencies (tower, bus fault, fault with stuck breaker)
- Monitored areas – All PJM areas
- Analysis type – PJM Generation Deliverability Test
- MISO ERIS Projects were modeled as PJM Energy-Only projects.
- MISO NRIS Projects were modeled as PJM Capacity projects.
- Generators were scaled to their respective capacity portions for base case (N-0) and all contingencies.
- Generators were scaled to their respective summer energy-only capabilities for category C contingencies only.
- MISO generation sunk to MISO
- PJM generation sunk to PJM

3. Summer Peak Results :

1. (AEP - AEP) The 05BENTON 345/138 kV transformer (from bus 243212 to bus 243250 ckt 1) loads from 81.70% to 112.26% (AC power flow) of its emergency rating (564 MVA) for the tower line contingency outage of '7029'.

```
CONTINGENCY '7029'
  OPEN BRANCH FROM BUS 243212 TO BUS 243215 CKT 1          / 243212
05BENTON 345 243215 05COOK 345 1
  OPEN BRANCH FROM BUS 243215 TO BUS 247502 CKT 2          / 243215 05COOK
345 247502 T-094 345 2
  END
```

2. (AEP - AEP) The 05BENTON 345/138 kV transformer (from bus 243212 to bus 243250 ckt 1) loads from 81.70% to 112.26% (AC power flow) of its emergency rating (564 MVA) for the line fault with failed breaker contingency outage of '7027_C2_05COOK 345-N'.

```
CONTINGENCY '7027_C2_05COOK 345-N'
  OPEN BRANCH FROM BUS 243212 TO BUS 243215 CKT 1          / 243212
05BENTON 345 243215 05COOK 345 1
  OPEN BRANCH FROM BUS 243215 TO BUS 247502 CKT 2          / 243215 05COOK
345 247502 T-094 345 2
  END
```

3. (AEP - MISO AMIL) The 05EUGENE-7BUNSONVILLE 345 kV line (from bus 243221 to bus 348885 ckt 1) loads from 99.68% to 100.02% (AC power flow) of its emergency rating (908 MVA) for the tower contingency outage of '6488'.

```
CONTINGENCY '6488'
  OPEN BRANCH FROM BUS 243878 TO BUS 243229 CKT 1          / 243878
05MEADOW 345 243229 05OLIVE 345 1
  OPEN BRANCH FROM BUS 243878 TO BUS 243230 CKT 1          / 243878
05MEADOW 345 243230 05REYNOL 345 1
  OPEN BRANCH FROM BUS 243229 TO BUS 243230 CKT 1          / 243229 05OLIVE
345 243230 05REYNOL 345 1
  OPEN BRANCH FROM BUS 243230 TO BUS 255173 CKT 1          / 243230
05REYNOL 345 255173 17REYNOLDS 138 1
END
```

4. (MISO AMIL - AEP) The 7CASEY-05BREED 345 kV line (from bus 346809 to bus 243213 ckt 1) loads from 108.94% to 110.44% (AC power flow) of its emergency rating (1466 MVA) for the line fault with stuck breaker contingency outage of '3128_C2'.

```
CONTINGENCY '3128_C2'
```

OPEN BRANCH FROM BUS 243221 TO BUS 249504 CKT 1 / 243221 05EUGENE 345 249504 08CAYSUB 345 1
OPEN BRANCH FROM BUS 243221 TO BUS 348885 CKT 1 / 243221 05EUGENE 345 348885 7BUNSONVILLE 345 1
OPEN BRANCH FROM BUS 348885 TO BUS 348887 CKT 1 / 348885 7BUNSONVILLE 345 348887 7SIDNEY 345 1
OPEN BRANCH FROM BUS 348885 TO BUS 348886 CKT 1 / 348885 7BUNSONVILLE 345 348886 4BUNSONVILLE 138 1
END

5. (CE - CE) The LORETTO ; B-WILTON ; B 345 kV line (from bus 270704 to bus 270926 ckt 1) loads from 124.94% to 126.67% (AC power flow) of its applicable load dump rating (1577 MVA) for the line fault with failed breaker contingency outage of '012-45-BT11-14'.

CONTINGENCY '012-45-BT11-14'
TRIP BRANCH FROM BUS 270717 TO BUS 270737 CKT 1 / DRESDEN ; R 345 ELWOOD ; R 345
TRIP BRANCH FROM BUS 270853 TO BUS 270717 CKT 1 / PONTIAC ; R 345 DRESDEN ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 270853 CKT 1 / PONTIAC ;2M 138 PONTIAC ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 272261 CKT 1 / PONTIAC ;2M 138 PONTIAC ; R 138
TRIP BRANCH FROM BUS 275210 TO BUS 275310 CKT 1 / PONTIAC ;2M 138 PONTIAC ;2C 34.5
CLOSE BRANCH FROM BUS 272260 TO BUS 272261 CKT 1 / PONTIAC ; B 138 PONTIAC ; R 138
END

6. (CE - MISO AMIL) The KINCAID ; B-7PAWNEE 345 kV line (from bus 270796 to bus 347962 ckt 1) loads from 143.29% to 144.88% (AC power flow) of its emergency rating (717 MVA) for the line fault with failed breaker contingency outage of '080-45-BT5-6__'.

CONTINGENCY '080-45-BT5-6__'
TRIP BRANCH FROM BUS 270852 TO BUS 270668 CKT 1 / PONTIAC ; B 345 BLUEMOUND; B 345
TRIP BRANCH FROM BUS 270853 TO BUS 270717 CKT 1 / PONTIAC ; R 345 DRESDEN ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 270853 CKT 1 / PONTIAC ;2M 138 PONTIAC ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 272261 CKT 1 / PONTIAC ;2M 138 PONTIAC ; R 138
TRIP BRANCH FROM BUS 275210 TO BUS 275310 CKT 1 / PONTIAC ;2M 138 PONTIAC ;2C 34.5

CLOSE BRANCH FROM BUS 272260 TO BUS 272261 CKT 1 / PONTIAC ; B 138 PONTIAC ; R 138
END

7. (CE - MISO AMIL) The KINCAID ; B-7PAWNEE 345 kV line (from bus 270796 to bus 347962 ckt 1) loads from 141.31% to 142.86% (AC power flow) of its emergency rating (717 MVA) for the line fault with failed breaker contingency outage of '080-45-BT4-5__'.

CONTINGENCY '080-45-BT4-5__'
TRIP BRANCH FROM BUS 270852 TO BUS 270668 CKT 1 / PONTI; B 345 BLUEM; B 345
TRIP BRANCH FROM BUS 270852 TO BUS 270704 CKT 1 / PONTI; B 345 LORET; B 345
END

8. (CE - MISO AMIL) The KINCAID ; B-7PAWNEE 345 kV line (from bus 270796 to bus 347962 ckt 1) loads from 138.44% to 140.23% (AC power flow) of its emergency rating (717 MVA) for the line fault with failed breaker contingency outage of '080-45-BT7-8__A'.

CONTINGENCY '080-45-BT7-8__A'
TRIP BRANCH FROM BUS 270853 TO BUS 917500 CKT 1 / PONTIAC ; R 345 Z2-087 TAP 345
TRIP BRANCH FROM BUS 270853 TO BUS 270717 CKT 1 / PONTIAC ; R 345 DRESDEN ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 270853 CKT 1 / PONTIAC ;2M 138 PONTIAC ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 272261 CKT 1 / PONTIAC ;2M 138 PONTIAC ; R 138
TRIP BRANCH FROM BUS 275210 TO BUS 275310 CKT 1 / PONTIAC ;2M 138 PONTIAC ;2C 34.5
CLOSE BRANCH FROM BUS 272260 TO BUS 272261 CKT 1 / PONTIAC ; B 138 PONTIAC ; R 138
END

9. (CE - MISO AMIL) The KINCAID ; B-7PAWNEE 345 kV line (from bus 270796 to bus 347962 ckt 1) loads from 134.15% to 135.73% (AC power flow) of its emergency rating (717 MVA) for the line fault with failed breaker contingency outage of '012-45-BT11-14'.

CONTINGENCY '012-45-BT11-14'
TRIP BRANCH FROM BUS 270717 TO BUS 270737 CKT 1 / DRESDEN ; R 345 ELWOOD ; R 345
TRIP BRANCH FROM BUS 270853 TO BUS 270717 CKT 1 / PONTIAC ; R 345 DRESDEN ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 270853 CKT 1 / PONTIAC ;2M 138 PONTIAC ; R 345

TRIP BRANCH FROM BUS 275210 TO BUS 272261 CKT 1 / PONTIAC ;2M 138 PONTIAC ; R 138
TRIP BRANCH FROM BUS 275210 TO BUS 275310 CKT 1 / PONTIAC ;2M 138 PONTIAC ;2C 34.5
CLOSE BRANCH FROM BUS 272260 TO BUS 272261 CKT 1 / PONTIAC ; B 138 PONTIAC ; R 138
END

10. (CE - CE) The PONTIAC ; B-LORETTO ; B 345 kV line (from bus 270852 to bus 270704 ckt 1) loads from 115.73% to 117.52% (AC power flow) of its applicable load dump rating (1528 MVA) for the line fault with failed breaker contingency outage of '012-45-BT11-14'.

CONTINGENCY '012-45-BT11-14'
TRIP BRANCH FROM BUS 270717 TO BUS 270737 CKT 1 / DRESDEN ; R 345 ELWOOD ; R 345
TRIP BRANCH FROM BUS 270853 TO BUS 270717 CKT 1 / PONTIAC ; R 345 DRESDEN ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 270853 CKT 1 / PONTIAC ;2M 138 PONTIAC ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 272261 CKT 1 / PONTIAC ;2M 138 PONTIAC ; R 138
TRIP BRANCH FROM BUS 275210 TO BUS 275310 CKT 1 / PONTIAC ;2M 138 PONTIAC ;2C 34.5
CLOSE BRANCH FROM BUS 272260 TO BUS 272261 CKT 1 / PONTIAC ; B 138 PONTIAC ; R 138
END

11. (CE - CE) The ROSCOE BE;BT-HARLEM ; B 138 kV line (from bus 272378 to bus 271638 ckt 1) loads from 99.98% to 108.04% (AC power flow) of its emergency rating (175 MVA) for the single line contingency outage of '156-L15624__'.

CONTINGENCY '156-L15624__'
TRIP BRANCH FROM BUS 271192 TO BUS 271202 CKT 1 / CHERR; B 138 B465 ;BT 138
END

12. (CE - CE) The ROSCOE BE;BT-HARLEM ; B 138 kV line (from bus 272378 to bus 271638 ckt 1) loads from 95.69% to 103.74% (AC power flow) of its emergency rating (175 MVA) for the single line contingency outage of '138-L15624_B-R'.

CONTINGENCY '138-L15624_B-R'
TRIP BRANCH FROM BUS 271192 TO BUS 271202 CKT 1 / CHERR; B 138 B465 ;BT 138
TRIP BRANCH FROM BUS 271202 TO BUS 271082 CKT 1 / B465 ;BT 138 BELVI; B 138

```
  TRIP BRANCH FROM BUS 271202 TO BUS 271200 CKT 1              / B465 ;BT 138 B465
; B 138
  MOVE 100 PERCENT LOAD FROM BUS 271082 TO BUS 271083          / BELVI; B 138
BELVI; R 138
  DISCONNECT BUS 271200                                / B465 ; B 138
  END
```

13. (CE - CE) The KELLEY RD; B-BELVIDERE; B 138 kV line (from bus 271852 to bus 271082 ckt 1) loads from 93.79% to 100.73% (AC power flow) of its applicable load dump rating (204 MVA) for the line fault with failed breaker contingency outage of '156-38-L15626_'.

```
CONTINGENCY '156-38-L15626_'
  TRIP BRANCH FROM BUS 271096 TO BUS 271094 CKT 1              / BHAWK;BT 138
BHAWK; B 138
  TRIP BRANCH FROM BUS 271096 TO BUS 272432 CKT 1              / BHAWK;BT 138 SABRO;
B 138
  TRIP BRANCH FROM BUS 271192 TO BUS 271096 CKT 1              / CHERR; B 138
BHAWK;BT 138
  MOVE 100 PERCENT LOAD FROM BUS 271094 TO BUS 271095          / BHAWK; B 138
BHAWK; R 138
  TRIP BRANCH FROM BUS 271192 TO BUS 271202 CKT 1              / CHERR; B 138 B465 ;BT
138
  END
```

14. (CE - CE) The KELLEY RD; B-BELVIDERE; B 138 kV line (from bus 271852 to bus 271082 ckt 1) loads from 93.73% to 100.66% (AC power flow) of its applicable load dump rating (204 MVA) for the bus fault outage of '156_CV-138B__4'.

```
CONTINGENCY '156_CV-138B__4'
  TRIP BRANCH FROM BUS 271192 TO BUS 271096 CKT 1              / CHERR; B 138
BHAWK;BT 138
  TRIP BRANCH FROM BUS 271192 TO BUS 271202 CKT 1              / CHERR; B 138 B465 ;BT
138
  END
```

15. (CE - CE) The CORDOVA ; B-NELSON ; B 345 kV line (from bus 270700 to bus 270828 ckt 1) loads from 87.19% to 108.42% (AC power flow) of its emergency rating (1528 MVA) for the single line contingency outage of '345-L0404___-R'.

```
CONTINGENCY '345-L0404___-R'
  TRIP BRANCH FROM BUS 270864 TO BUS 270890 CKT 1              / QUAD3-11 345
H471 ; 345
  END
```

16. (CE - CE) The CORDOVA ; B-NELSON ; B 345 kV line (from bus 270700 to bus 270828 ckt 1) loads from 87.11% to 108.34% (AC power flow) of its emergency rating (1528 MVA) for the single line contingency outage of '345-L15504__-R'.

```
CONTINGENCY '345-L15504__-R'
  TRIP BRANCH FROM BUS 270828 TO BUS 270890 CKT 1              / NELSO; B 345
H471 ; 345
  END
```

17. (CE - CE) The NELSON ; B-WALTO; B 345 kV line (from bus 270828 to bus 270932 ckt 1) loads from 86.75% to 101.25% (AC power flow) of its emergency rating (1656 MVA) for the single line contingency outage of '345-L0627__B-R'.

```
CONTINGENCY '345-L0627__B-R'
  TRIP BRANCH FROM BUS 274768 TO BUS 270678 CKT 1              / LEECO;BP 345
BYRON; B 345
  END
```

18. (CE - CE) The QUAD 1 3-11-ESS H471 ; 345 kV line (from bus 270864 to bus 270890 ckt 1) loads from 87.17% to 108.39% (AC power flow) of its emergency rating (1528 MVA) for the single line contingency outage of '345-L15503_B-R'.

```
CONTINGENCY '345-L15503_B-R'
  TRIP BRANCH FROM BUS 270828 TO BUS 270700 CKT 1              / NELSO; B 345
CORDO; B 345
  END
```

19. (CE - CE) The ESS H471 ;-NELSON ; B 345 kV line (from bus 270890 to bus 270828 ckt 1) loads from 87.06% to 108.28% (AC power flow) of its emergency rating (1528 MVA) for the single line contingency outage of '345-L15503_B-R'.

```
CONTINGENCY '345-L15503_B-R'
  TRIP BRANCH FROM BUS 270828 TO BUS 270700 CKT 1              / NELSO; B 345
CORDO; B 345
  END
```

20. (CE - CE) The WALTO; B-ELECT JCT; B 345 kV line (from bus 270932 to bus 270730 ckt 1) loads from 87.83% to 101.94% (AC power flow) of its applicable load dump rating (2199 MVA) for the line fault with failed breaker contingency outage of '006-45-BT3-4__'.

```
CONTINGENCY '006-45-BT3-4__'
  TRIP BRANCH FROM BUS 274768 TO BUS 270678 CKT 1              / LEECO;BP 345
BYRON; B 345
  REMOVE UNIT 1 FROM BUS 274656                    / BYRON;1U 25
  END
```

21. (CE - CE) The WALTO; B-ELECT JCT; B 345 kV line (from bus 270932 to bus 270730 ckt 1) loads from 87.48% to 101.92% (AC power flow) of its applicable load dump rating (2199 MVA) for the line fault with failed breaker contingency outage of '006-45-BT3-7__'.

```
CONTINGENCY '006-45-BT3-7__'
  TRIP BRANCH FROM BUS 274768 TO BUS 270678 CKT 1              / LEECO;BP 345
BYRON; B 345
  TRIP BRANCH FROM BUS 270678 TO BUS 270679 CKT 1              / BYRON; B 345
BYRON; R 345
  END
```

22. (CE - CE) The WALTO; B-ELECT JCT; B 345 kV line (from bus 270932 to bus 270730 ckt 1) loads from 87.88% to 102.38% (AC power flow) of its emergency rating (1656 MVA) for the single line contingency outage of '345-L0627__B-R'.

```
CONTINGENCY '345-L0627__B-R'
  TRIP BRANCH FROM BUS 274768 TO BUS 270678 CKT 1              / LEECO;BP 345
BYRON; B 345
  END
```

23. (CE - CE) The LEE CO EC;BP-BYRON ; B 345 kV line (from bus 274768 to bus 270678 ckt 1) loads from 91.14% to 105.00% (AC power flow) of its emergency rating (1726 MVA) for the single line contingency outage of '345-L18402_B-R'.

```
CONTINGENCY '345-L18402_B-R'
  TRIP BRANCH FROM BUS 270932 TO BUS 270730 CKT 1              / WALTO; B 345
ELECT; B 345
  END
```

24. (CE - CE) The LEE CO EC;BP-BYRON ; B 345 kV line (from bus 274768 to bus 270678 ckt 1) loads from 90.85% to 104.71% (AC power flow) of its emergency rating (1726 MVA) for the single line contingency outage of '345-L15502_B-R'

```
CONTINGENCY '345-L15502_B-R'
  TRIP BRANCH FROM BUS 270828 TO BUS 270932 CKT 1              / NELSO; B 345
WALTO; B 345
END
```

25. (CE – AEP) The WILTON-05DUMONT 765 kV line (270644-243206 ckt 1) loads from 95.15% to 110.95% (AC power flow) of its emergency rating (4444 MVA) for the tower contingency outage of '345-L94507_B-S_+_345-L97008_R-S'.

```
CONTINGENCY '345-L94507_B-S_+_345-L97008_R-S'
```

TRIP BRANCH FROM BUS 274750 TO BUS 255112 CKT 1 / CRETE;BP 345 17STJOHN 345
TRIP BRANCH FROM BUS 274804 TO BUS 243229 CKT 1 / UPNOR;RP 345 05OLIVE 345
END

26. (CE – AEP) The WILTON-05DUMONT 765 kV line (270644-243206 ckt 1) loads from 93.8% to 109.59% (AC power flow) of its emergency rating (4444 MVA) for the tower contingency outage of '345-L6607__B-S_+_345-L97008_R-S'.

CONTINGENCY '345-L6607__B-S_+_345-L97008_R-S'
TRIP BRANCH FROM BUS 270728 TO BUS 274750 CKT 1 / E FRA; B 345 CRETE;BP 345
TRIP BRANCH FROM BUS 274804 TO BUS 243229 CKT 1 / UPNOR;RP 345 05OLIVE 345
END

27. (CE – AEP) The WILTON-05DUMONT 765 kV line (270644-243206 ckt 1) loads from 93.07% to 108.52% (AC power flow) of its emergency rating (4444 MVA) for the tower contingency outage of '641'.

CONTINGENCY '641'
OPEN BRANCH FROM BUS 243229 TO BUS 270771 CKT 1 / 243229 05OLIVE 345 270771 G ACR; T 345 1
OPEN BRANCH FROM BUS 243229 TO BUS 274804 CKT 1 / 243229 05OLIVE 345 274804 UPNOR;RP 345 1
END

28. (CE – AEP) The WILTON-05DUMONT 765 kV line (270644-243206 ckt 1) loads from 91.11% to 106.08% (AC power flow) of its emergency rating (4444 MVA) for the tower contingency outage of '345-L6617___-S_+_345-L97008_R-S'

CONTINGENCY '345-L6617___-S_+_345-L97008_R-S'
TRIP BRANCH FROM BUS 270886 TO BUS 255104 CKT 1 / S JOH; T 345 17GRNACR 345
TRIP BRANCH FROM BUS 270886 TO BUS 255112 CKT 1 / S JOH; T 345 17STJOHN 345
TRIP BRANCH FROM BUS 274804 TO BUS 243229 CKT 1 / UPNOR;RP 345 05OLIVE 345
END

29. (MISO – AEP) The 17STILLWELL-05DUMONT 345 kV line (255113-243219 ckt 1) loads from 119.18% to 141.48% (AC power flow) of its emergency rating (1409 MVA) for the stuck breaker contingency outage of '2978_C2_A'.

CONTINGENCY '2978_C2_A'
OPEN BRANCH FROM BUS 243206 TO BUS 907040 CKT 1 / 243206 05DUMONT 765 907040 X1-020 TAP 765 1
OPEN BRANCH FROM BUS 243206 TO BUS 270644 CKT 1 / 243206 05DUMONT 765 270644 WILTON ; 765 1
END

30. (MISO – AEP) The 17STILLWELL-05DUMONT 345 kV line (255113-243219 ckt 1) loads from 110.79% to 133.69% (AC power flow) of its emergency rating (1409 MVA) for the stuck breaker contingency outage of '023-65-BT2-3__'.

CONTINGENCY '023-65-BT2-3__'
TRIP BRANCH FROM BUS 270644 TO BUS 243206 CKT 1 / WILTO; 765 05DUMONT 765
TRIP BRANCH FROM BUS 270607 TO BUS 270630 CKT 1 / COLLI; 765 PLANO; 765
END

31. (MISO – AEP) The 17STILLWELL-05DUMONT 345 kV line (255113-243219 ckt 1) loads from 110.67% to 133.6% (AC power flow) of its emergency rating (1409 MVA) for the stuck breaker contingency outage of '023-65-BT4-5__'.

CONTINGENCY '023-65-BT4-5__'
TRIP BRANCH FROM BUS 275168 TO BUS 270607 CKT 1 / COLLI;2M 345 COLLI; 765
TRIP BRANCH FROM BUS 275168 TO BUS 270697 CKT 1 / COLLI;2M 345 COLLI; R 345
TRIP BRANCH FROM BUS 275168 TO BUS 275268 CKT 1 / COLLI;2M 345 COLLI;2C 33
TRIP BRANCH FROM BUS 270644 TO BUS 243206 CKT 1 / WILTO; 765 05DUMONT 765
END

32. (MISO – AEP) The 17STILLWELL-05DUMONT 345 kV line (255113-243219 ckt 1) loads from 110.36% to 133.29% (AC power flow) of its emergency rating (1409 MVA) for the stuck breaker contingency outage of '112-65-BT3-4__'.

CONTINGENCY '112-65-BT3-4__'
TRIP BRANCH FROM BUS 270644 TO BUS 243206 CKT 1 / WILTO; 765 05DUMONT 765
TRIP BRANCH FROM BUS 275232 TO BUS 270644 CKT 1 / WILTO;3M 345 WILTO; 765
TRIP BRANCH FROM BUS 275232 TO BUS 270926 CKT 1 / WILTO;3M 345 WILTO; B 345
TRIP BRANCH FROM BUS 275232 TO BUS 275332 CKT 1 / WILTO;3M 345 WILTO;3C 33

END

33. (MISO – AEP) The 17STILLWELL-05DUMONT 345 kV line (255113-243219 ckt 1) loads from 110.34% to 133.27% (AC power flow) of its emergency rating (1409 MVA) for the stuck breaker contingency outage of '112-65-BT4-5__'.

CONTINGENCY '112-65-BT4-5__'
TRIP BRANCH FROM BUS 270644 TO BUS 243206 CKT 1 / WILTO; 765 05DUMONT 765
TRIP BRANCH FROM BUS 275233 TO BUS 270644 CKT 1 / WILTO;4M 345 WILTO; 765
TRIP BRANCH FROM BUS 275233 TO BUS 270927 CKT 1 / WILTO;4M 345 WILTO; R 345
TRIP BRANCH FROM BUS 275233 TO BUS 275333 CKT 1 / WILTO;4M 345 WILTO;4C 33
END

4. Light Load analysis

- Model used – PJM AA1 Queue SIS 2018 Light Load case. All Active PJM queue projects modeled through the AA1 Queue along with all previously studied MISO DPP projects (studied through 2014). The MISO 2015 February and August DPP generators being studied were added to the model.
- Contingencies used – All PJM category B (single) and C contingencies (tower, bus fault, fault with stuck breaker)
- Monitored areas – All PJM areas
- Analysis type – PJM Generation Deliverability Test
- Analysis type – Light Load Generation Deliverability
    - All wind generators were scaled to 80% of their respective total capabilities for base case, category B, and category C events
    - The coal generator was scaled to 45% of its respective total capabilities for base case, category B, and category C events
- MISO generation sunk to MISO
- PJM generation sunk to PJM

5. Light Load Results

1. (CE - CE) The LORETTO ; B-WILTON ; B 345 kV line (from bus 270704 to bus 270926 ckt 1) loads from 117.86% to 119.25% (AC power flow) of its emergency rating (1280 MVA) for the single line contingency outage of '345-L8014_T_-S'. MISO project J375 contributes approximately 17.76MW to this overload.

```
CONTINGENCY '345-L8014_T_-S'
 TRIP BRANCH FROM BUS 270853 TO BUS 270717 CKT 1          / PONTIAC ; R 345 DRESDEN ; R 345
 TRIP BRANCH FROM BUS 275210 TO BUS 270853 CKT 1          / PONTIAC ;2M 138 PONTIAC ; R 345
 TRIP BRANCH FROM BUS 275210 TO BUS 272261 CKT 1          / PONTIAC ;2M 138 PONTIAC ; R 138
 TRIP BRANCH FROM BUS 275210 TO BUS 275310 CKT 1          / PONTIAC ;2M 138 PONTIAC ;2C 34.5
 CLOSE BRANCH FROM BUS 272260 TO BUS 272261 CKT 1          / PONTIAC ; B 138 PONTIAC ; R 138
 END
```

2. (CE - CE) The PONTIAC ; B-LORETTO ; B345 kV line (from bus 270852 to bus 270704 ckt 1) loads from 106.27% to 107.7% (AC power flow) of its emergency rating (1240 MVA) for the single line contingency outage of '345-L8014_T_-S'. MISO project J375 contributes approximately 17.76MW to this overload.

```
CONTINGENCY '345-L8014_T_-S'
 TRIP BRANCH FROM BUS 270853 TO BUS 270717 CKT 1          / PONTIAC ; R 345 DRESDEN ; R 345
 TRIP BRANCH FROM BUS 275210 TO BUS 270853 CKT 1          / PONTIAC ;2M 138 PONTIAC ; R 345
 TRIP BRANCH FROM BUS 275210 TO BUS 272261 CKT 1          / PONTIAC ;2M 138 PONTIAC ; R 138
 TRIP BRANCH FROM BUS 275210 TO BUS 275310 CKT 1          / PONTIAC ;2M 138 PONTIAC ;2C 34.5
 CLOSE BRANCH FROM BUS 272260 TO BUS 272261 CKT 1          / PONTIAC ; B 138 PONTIAC ; R 138
 END
```

6. Required System Upgrades & Cost Estimates/Allocations:

1. To relieve the Benton 345/138 kV transformer overloads:
   Add a 2nd Benton 345/138 kV transformer. Estimated cost: $3,500,000. An approximate construction time would be 24 to 36 months after signing an interconnection agreement. PJM Network Upgrade Number N4731.

   The driver for the overload is in the MISO 2015 February DPP Cycle.
   If the driver becomes a project in the MISO 2015 August DPP cycle, projects within the MISO 2015 August DPP cycle may receive cost allocation.

   The cost allocation is as follows:

Queue	MW contribution	% of Cost	Cost ($3.5 M)
J301	9.2	7.14	0.250
J308	27.2	21.11	0.739
J321	13.6	10.56	0.369
J392	53.8	41.78	1.462
J408	17.9	13.89	0.486
J419	7.1	5.51	0.193

2. To relieve the Eugene – Bunsonville 345 kV line overload:

   The AEP end ratings are 1521/1718 MVA (SN/SE) and are sufficient.

   MISO/AMIL needs to ensure the MISO/AMIL end emergency rating is at least 909 MVA.

3. To relieve the Breed – Casey 345 kV line overload:

   Build a second parallel Breed – Casey 345 kV line (PJM Network Upgrade N4729).
   Ameren owns most of the ~28 mile long line. Ameren cost estimate is $60-74M. Time estimate is 5 years for obtaining permits and line construction, per MISO.
   AEP end cost estimate for about 0.9 miles of the line and adding two breakers to accommodate the new line is $4M.
   Total cost estimate is $64-78M.

   The cost allocation is as follows:

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Queue	MW contribution	Percentage of Cost	$ cost ($78 M)
AA1-053	44.14	20.67%	16.123
AA1-055	151.61	71.00%	55.380
J375	17.8	8.34%	6.505

4. To relieve the Loretto – Wilton 345 kV line overload:

   PJM is in process of developing a baseline upgrade for the Loretto – Wilton Center 345kV line.

   If the overload remains after the baseline upgrade is specified, MISO 2015 DPP project J375 will be responsible for an additional upgrade to alleviate the overload; if there is no overload on the line after the baseline upgrade, J375 will have no cost responsibility for this overload.

   In either case, MISO 2015 DPP project J375 can wait until the baseline upgrade is placed into service or J375 can pay an advancement cost to place the baseline upgrade into service earlier, if feasible per ComEd. The feasibility of the advancement of the upgrade and/or the ability of the baseline upgrade to eliminate the need for a customer upgrade will be determined during the PJM Facilities Study.

5. To relieve the Kincaid – Pawnee 345 kV line overloads:

   The ComEd end ALDR for this line segment is 1494 MVA and is sufficient. No ComEd end upgrade required.

   MISO/AMIL end: The MISO/AMIL end ratings are 956/956 MVA (SN/SE) for summer 2018. MISO analysis identified a violation on their end of this line during their April 2015 analysis of PJM projects. AA1-086 is responsible for this upgrade per MISO analysis. Due to MISO cost allocation rules, the 2015 MISO DPP projects do not receive any cost responsibility (MISO to confirm). Note: if queue projects withdrawal from the Queue, the driver for the overloads could become the MISO 2015 DPP projects and they would then receive cost responsibility.
   The planned MISO end upgrade is sufficient for PJM's analysis for the MISO 2015 DPP projects.

6. To relieve the Pontiac - Loretto 345 kV line overload:

   Reconductor the line at an estimated cost of $6 million. The time required to install this reinforcement is 2-3 years. PJM Network Upgrade N4264. New ratings to be 1334/1528 SN/SE. New ALDR to be 2001 MVA.

   The cost allocation is as follows:

Queue	MW contribution	Percentage of Cost	$ cost ($ 6.0 M)
Z1-070	198.6	55.88%	3.3530
Z2-087	76.78	21.61%	1.2963
AA1-086	57.6	16.21%	0.9725
J375	22.4	6.30%	0.3782

7. To relieve the Roscoe – Harlem 138 kV line overloads:

   Existing PJM baseline upgrade B2562 is planned to be put into service by summer 2019. B2562 will rebuild the Roscoe – Harlem 138 kV line. The new line ratings will be 269/349/498 MVA (SN/SE/ALDR).

   The only MISO 2015 DPP project contributing loading to this overload is J390. J390 can wait until B2562 is placed into service or J390 can pay an advancement cost to place B2562 into service earlier, if feasible per ComEd.

8. To relieve the Kelley Road – Belvidere 138 kV line overloads:

   Reconductor ~ 9 miles of overhead line to achieve a SN/SE/SLD rating of 208/264/275 MVA. Preliminary cost of $7M with 18-24 months construction period. PJM Network Upgrade N4732.

   The only MISO 2015 DPP project contributing loading to this overload is J390. J390 is responsible for this cost.

9. To relieve the Cordova - Nelson 345 kV line overloads:

   PJM supplemental project S0704 (reconductor the line) was placed into service in early 2015. The ratings on the line are 1364/1528/1806 MVA (SN/SE/SLD). These ratings are no longer sufficient due to the MISO 2015 DPP projects.

   Existing PJM baseline upgrades B2692.1 & B2692.2 are planned to be put into service by summer 2019. B2692.1 & B2692.2 will upgrade the Cordova - Nelson 345 kV line. The new line ratings will be 1679/2058/2280 MVA (SN/SE/SLD).

   The following MISO 2015 DPP projects contribute loading to this overload: J041, J298, J399, J407, J411, J412, J416, J438, J442, J449. These projects can wait until B2692.1 & B2692.2 are placed into service or the projects can pay an advancement cost to place B2692.1 & B2692.2 into service earlier, if feasible per ComEd.

10. To relieve the Nelson - Walto 345 kV line overload & the Walto – Electric Junction 345 kV line overloads:

    Apply SE =1656 MVA. Replace 2-MOD's at TSS 111 for L15502. Preliminary Estimate = $ 1M, 18-24 months to achieve a SN/SE/SLD = 1334/1726/2084 MVA. PJM Network Upgrade N4734.

    The driver for the overload is in the MISO 2015 August DPP Cycle.

    The cost allocation is as follows:

Queue	MW contribution	Percentage of Cost	1 $ cost ($ 1.0 M)
J298	38.5	39.39%	0.3939
J412	17.4	17.79%	0.1779
J438	21.9	22.43%	0.2243
J449	19.9	20.39%	0.2039

11. To relieve the Quad Cities – ESS H471 345 kV line overload:

    Existing PJM baseline upgrades B2692.1 & B2692.2 are planned to be put into service by summer 2019. B2692.1 & B2692.2 will upgrade the Quad Cities – ESS H471 345 kV line. The new line ratings will be 1679/2011/2280 MVA (SN/SE/SLD).

    The following MISO 2015 DPP projects contribute loading to this overload: J298, J399, J407, J411, J412, J416, J438, J442, J449. These projects can wait until B2692.1 & B2692.2 are placed into service or the projects can pay an advancement cost to place B2692.1 & B2692.2 into service earlier, if feasible per ComEd.

12. To relieve the ESS H471 - Nelson 345 kV line overload:

    Existing PJM baseline upgrades B2692.1 & B2692.2 are planned to be put into service by summer 2019. B2692.1 & B2692.2 will upgrade the ESS H471 - Nelson 345 kV line. The new line ratings will be 1679/2011/2280 MVA (SN/SE/SLD).

    The following MISO 2015 DPP projects contribute loading to this overload: J298, J399, J407, J411, J412, J416, J438, J442, J449. These projects can wait until B2692.1 & B2692.2 are placed into service or the projects can pay an advancement cost to place B2692.1 & B2692.2 into service earlier, if feasible per ComEd.

13. To relieve the Lee County - Byron 345 kV line overload:

    Upgrade - L0627 reconductor @ $29M (20-24 months). Based on reconductor work, SN/SE/SLD = 1679/2011/2280 MVA. PJM Network Upgrade N4737.

    The cost allocation is as follows:

Queue	MW contribution	Percentage of Cost	29 $ cost ($ 29 M)
J399	2.8	4.27%	1.2378
J412	18.3	27.90%	8.0899
J438	25.3	38.57%	11.1845
J449	19.2	29.27%	8.4878

14. To relieve the Wilton – Dumont 765 kV line overloads:
    a. The ComEd-end ALDR is 5466 MVA and is sufficient.
    b. AEP-end ratings are 4249/4801 MVA (SN/SE).
    c. AEP-end upgrade is to replace the Dumont wavetrap and evaluate relay compliance thermal limit to obtain new AEP-end ratings of 6198/7362 MVA (SN/SE) at a cost of $1.5M. PJM Network Upgrade N4789.
    d. The cost allocation is as follows:

       MISO project J437 is the driver for this overload and is responsible for 100% of the cost of this upgrade at this time.

       As changes to the PJM Interconnection Process occur (such as PJM or MISO projects withdrawing from the queue), the driver queue project can change and other MISO and/or PJM queue project(s) could receive cost allocation towards this upgrade going forward.

15. To relieve the Stillwell – Dumont 345 kV line overloads:
    a. The PJM Z1 queue projects drive the loading above 1409 MVA SE. The upgrade is a sag study for less than $5M which is allocated to the PJM Z1 projects only at this time. The new expected AEP-end SE rating is to be 1887 MVA SE after the sag study.
    b. The AEP-end 1887 MVA SE rating and the MISO-end 1779 MVA SE ratings are no longer sufficient due to the MISO 2015 DPP projects and 2nd Benton transformer upgrade.
    c. The AEP-end upgrade is to rebuild 9 miles of the AEP owned line and upgrade necessary Dumont terminal equipment at a cost of $20M. PJM Network Upgrade N4790. New AEP-end ratings to be 1756/2045 MVA (SN/SE).
    d. The MISO-end upgrade is to rebuild NIPSCO portion of line (2.87 miles) at a cost of $6.9M and upgrade Stillwell substation equipment at a cost of $1.2M for a total cost of $8.1M. The new expected MISO-end ratings will be 1869/2240 MVA SN/SE.
    e. The total cost of this upgrade for both the AEP-end and the MISO-end is $28.1M.
    f. The cost allocation is as follows:

       MISO project J298 is the driver for this overload and is responsible for 100% of the cost of this upgrade at this time.

As changes to the PJM Interconnection Process occur (such as PJM or MISO projects withdrawing from the queue), the driver queue project can change and other MISO and/or PJM queue project(s) could receive cost allocation towards this upgrade going forward.

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F.3 SPP Affected System Study Results

Below is the SPP affected system study report provided by SPP.

SPP Facilities Impacts of MISO February 2015 West Area DPP Study Generator Interconnection Requests

May 2016

Generator Interconnection

SPP Southwest Power Pool

Revision History

Date	Author	Change Description
5/20/2016	SPP	Initial Draft Report Issued

Executive Summary

Southwest Power Pool (SPP) has conducted this Affected System Interconnection System Impact Study to evaluate potential impacts to the SPP Transmission System related to the interconnection of generators on the Mid-Continent Independent System Operator (MISO) Transmission System. The generators requesting interconnection to the MISO system will be referred to as the MISO Customers (MISO Customers). The MISO Customers' requests have been clustered together for the following Affected System Impact Study in the MISO Definitive Planning Process February 2015 Study (DPP-FEB2015). The MISO Customer's requests included in this System Impact Cluster Study are listed in **Table 1** by their queue number, amount, requested interconnection service, area, requested interconnection point, proposed interconnection point, and the requested in-service date.

Power flow analysis has indicated that for the power flow cases studied, the SPP Transmission System is impacted from the interconnection of the MISO Customer generation. These impacts are described in Section 8. and Section 9. of this report. Impacts can be mitigated by the Gentleman Generation Station (GGS) – Thedford - Holt 345kV (R-Plan) transmission line, Nebraska City – Mullin Creek – Sibley 345kV transmission line, and certain terminal equipment and line upgrades for Western Area Power Administration (WAPA) facilities. Constraints identified on tie-line circuits between Western Area Power Administration and other MISO membership areas should be reviewed by MISO for potential MISO facilities' Network Upgrades required for mitigation. Within the scope of this affected system impact study, SPP coordinated with WAPA for planning level estimates for mitigation of constraints requiring transmission reinforcements and will require facilities studies analysis if the MISO Interconnection Request(s) impacting the SPP transmission system proceed forward.

Certain constraints identified can be mitigated with either previously approved SPP or MISO upgrades. These include the Gentleman Generation Station (GGS) – Thedford - Holt 345kV (R-Plan) transmission line, and Nebraska City – Mullin Creek – Sibley 345kV line, and MISO MVP projects, which are scheduled to be placed in service by 2019. Interconnection Service for these requests may need to be delayed until that time period.

In no way does this study guarantee operation for all periods of time. This interconnection study identifies impacts for Energy Resource Interconnection Service (ERIS) interconnection injection constraints (defined as a 20% distribution factor impact for observed contingency constraints and 3% distribution factor impact for system intact constraints) and Network Resource Interconnection Service (NRIS) constraints (defined as 3% distribution factor impact) on the MISO Transmission System. This affected system study does not identify impacts for all potential situations. It should be noted that although this study analyzed many of the most probable contingencies, it is not an all-inclusive list and cannot account for every operational situation. Because of this, it is likely that the MISO Customer(s) may be required to reduce their

generation output to 0 MW, also known as curtailment, under certain system conditions to allow system operators to maintain the reliability of the transmission network.

Network constraints listed in **Appendix D** are identified on the SPP Transmission System when this generation is injected into the MISO footprint for Energy Resource Interconnection Service (ERIS) requests. Some MISO Customer generation was also studied for Network Resource Interconnection Service (NRIS). Those constraints are listed in Appendix C. Additional network constraints will have to be verified with a Transmission Service Request (TSR) and associated studies. With a defined source and sink in a TSR, this list of Network Constraints will be refined and expanded to account for all Network Upgrade requirements.

Additional analysis is also required to determine the impacts of the future generator retirements on the SPP Transmission System. This analysis is presently being performed and SPP will update this report as those results become available.

If the Affected System Interconnection Requests proceed, additional analysis will be required through an Affected System Facility Study. The purpose of the Affected System Facility Study is required to perform additional analysis required to refine the scope, cost estimates, and expected time of construction of system facilities identified as Network Upgrades that would be placed in service.

Table of Contents

Introduction

Southwest Power Pool (SPP) has conducted this Affected System Interconnection System Impact Study to evaluate potential impacts to the SPP Transmission System related to the interconnection of generators on the Mid-Continent Independent System Operator (MISO) Transmission System. The generator requesting interconnection to the MISO system will be referred to as the MISO Customers (MISO Customers). The MISO Customers' requests have been clustered together for the following Affected System Impact Study in the MISO Definitive Planning Process February 2015 Study (DPP-FEB2015). The MISO Customer's requests included in this System Impact Cluster Study are listed in **Table 1** by their queue number, amount, requested interconnection service, area, requested interconnection point, proposed interconnection point, and the requested in-service date.

Analysis

1. Interconnection Requests Included in the Study

SPP included all MISO Customer requests as provided by MISO in this study. The MISO Customers represent the DPP-FEB2015 MISO Impact Study. These are listed in **Table 1**.

Table 1: MISO Study Generators

MISO Project	Point of Interconnection	Max MW Output	Service	Fuel Type	Area
G736	Big Stone South 230kV Substation	200	ERIS	Wind	SD-G15
J299	Wilmarth Substation	73	ERIS	Gas	SD-G15
J385	Chisago 115 kV Substation	100	NRIS	Solar	ND-G16
J391	MMU's N 7th Street substation	50	NRIS	Gas	SD-G15
J400	Lyon County 115kV Substation	62.5	NRIS	Solar	SD-G15
J405	MDUs existing Lewis & Clark Jct substation	40	NRIS	Gas	ND-G16
J407	Glenworth 161 kV substation	200	NRIS	Wind	SD-G15
J411	LeHigh - Raun 345 kV Line	300	NRIS	Wind	IA-G09
J416	Emery - Blackhawk 345 kV Line	200	NRIS	Wind	IA-G09
J426	Chanarambie substation 35.4 kV	100	NRIS	Wind	SD-G15

2. Previously Queued Interconnection Requests

2.1. Previously Queued MISO Generators

The previous queued requests included in this study are listed in **Table 2**. These requests were taken from the MISO Interconnection Queue.

Table 2: MISO Prior Queued Generators

MISO Project	Point of Interconnection	Max MW Output	NRIS	Fuel Type	Area
G132	Ellendale Sub 230 kV	180	20%[a]	Wind	SD-G15
G255	Yankee Substation	100	20%	Wind	SD-G15
G263	Lakefield Generating Substation	105	20%	Wind	SD-G15
G287	Nobles County Substation	200	20%	Wind	SD-G15
G349	Brookings County Substation	200	n/a	Wind	SD-G15
G362	Pleasant Valley Substation	200	20%	Wind	SD-G15
G370	Anson 4	205	n/a	Gas	SD-G15
G380	Rugby 115kV Substation	150	n/a	Wind	ND-G16
G386	Lakefield Substation 345kV	100	20%	Wind	SD-G15
G389	Elk River 230 kV substation	200	100%	Gas	SD-G15
G514	Lakefield Station via Trimont G263 Interconnect	150	n/a	Wind	SD-G15
G540	Adams - Lime Creek 161 kV	80	100%	Wind	IA-G09
G548	Barton 161kV Substation	80	100%	Wind	IA-G09
G549	Next to Williams Substation (69kV)	20	100%	Wind	SD-G15
G551	Rice 161 kV	99	20%	Wind	IA-G09
G573	Franklin 161 kV Substation	80	100%	Wind	IA-G09
G574	Franklin 161 kV Substation	80	100%	Wind	IA-G09
G575	Franklin 161 kV Substation	40	100%	Wind	IA-G09
G586	Xcel New Yankee Sub 34.5 kV	30	100%	Wind	SD-G15
G587	69 kV to Winthrop Sub	20	100%	Wind	SD-G15
G595	Lime Creek 161 kV Substation	150	n/a	Wind	IA-G09
G602	Nobles County 115 kV Substation	32	20%	Wind	SD-G15
G604	Owatonna - County Line 69 kV	44	n/a	Wind	SD-G15
G612	ITC Midwest Fernald 115 kV Substation	150	n/a	Wind	IA-G09
G619	GRE Tamarac 41 kV Substation	50	100%	Wind	ND-G16
G620	Kenyon - Dodge 69 kV	19	n/a	Wind	SD-G15
G621	Rock Tap – South Ridge 69kV	20	100%	Wind	SD-G15
G667	Round Lake Tap 69kV	13	n/a	Wind	SD-G15
G685	Lake Lillian-Atwater 69kV	20	n/a	Wind	SD-G15
G735	Lime Creek Substation	200	100%	Wind	IA-G09
G741	Alliant 69kV	8	100%	Waste Heat	SD-G15
G752	Bison-Hettinger 230kV	150	100%	Wind	ND-G16
G788	Ladish 115kV	49	100%	Wind	ND-G16
G798	Fernald 115kV Substation	150	100%	Wind	IA-G09
G826	Lakefield Generation SW – Lakefield Junction 345kV	200	n/a	Wind	SD-G15

G830	McHenry 115kV Substation	99	100%	Wind	SD-G15
G858	Black Oak 69 kV Substation		100%	Wind	SD-G15
G870	Hayward – Winnebago 161kV	201	100%	Wind	SD-G15
G929	Monticello	60	100%	Nuclear	SD-G15
G930	Sherco	60	100%	Coal	SD-G15
G947	Whispering Willows 161kV Substation	99	87%	Wind	IA-G09
G971	Cosmos Township 69kV	20	n/a	Wind	SD-G15
G997	Minden Substation	50	100%	Wind	IA-G09
H007	Edgewood 69kV	41	n/a	Wind	IA-G09
H008	Richfield 69kV Substation	36	100%	Wind	IA-G09
H009	Traer – Marshalltown 161kV	150	n/a	Wind	IA-G09
H021	Wellsburg 115kV Substation	138.6	86%	Wind	IA-G09
H071	Black Oak 69 kV Substation	40	100%	Wind	SD-G15
H078	New Sub in Laurel,IA	121	n/a	Wind	IA-G09
H092	Boswell	60	100%	Coal	ND-G16
H081	Brookings County – Lyon County 345kV	201	n/a	Wind	SD-G15
H096	Grand Junction – Perry 161kV	50	100%	Wind	IA-G09
J020		20	100%	Diesel	SD-G15
J021		40	100%	Diesel	SD-G15
J075	Bauer - Rapson 345 kV	150	100%	Wind	IA-G09
J091	Lime Creek 161kV substation	66	100%	Wind	IA-G09
J110	Glen Ullin	7.5	100%	Biomass	ND-G16
J112	DPC Utica – Lewiston 69kV	4.95	n/a	Wind	SD-G15
J161	Bauer - Rapson 345 kV	155	100%	Wind	IA-G09
J171	Benson 115kV Substation	12	100%	Biomass	SD-G15
J183	Split Rock Substation	200	n/a	Wind	SD-G15
J191	Rolling Hills 345kV Substation	101.2	100%	Wind	IA-G09
J200	RM Heskett Station 115kV & 41.6kV	75	80%	Gas	ND-G16
J201	Manning 138kV Substation	20	100%	Wind	IA-G09
J202	Atlanta - Tuscola 115 kV	101	100%	Wind	IA-G09
J226	Ludington Substation	70	100%	Hydro	IA-G09
J231	Ludington Substation	70	100%	Hydro	IA-G09
J233	Marshalltown 161kV	635	100%	CC	IA-G09
J235	Bauer - Rapson 345 kV	110	100%	Wind	IA-G09
J238	Eagle Valley 138kV Substation	725	100%	Gas	IA-G09
J241	Twin Falls Substation	3.7	100%	Hydro	SD-G15
J249	MDU Tatanka Substation	180	100%[a]	Wind	ND-G16
J256	NIPSCO Plymouth 69kV	8	n/a	Gas	IA-G09
J262	Jamestown 345/115 kV substation	100	100%	Wind	ND-G16
J263	Jamestown 345/115 kV	100	100%	Wind	ND-

	substation				G16
J274	Tap Winterset – Creston 161kV	100	100%	Wind	IA-G09
J278	Pleasant Valley 161kV	200	100%	Wind	SD-G15
J279	Raun 345kV	(Uprate) 30	100%	Coal	IA-G09
J290	Tap Rugby – Glenboro 230kV	150	100%	Wind	ND-G16
R15	Pomeroy 161 kV substation	80	20%	Wind	IA-G09
R23	Monona - Carroll 161 kV	100	20%	Wind	IA-G09
R26	MEC Cooper - Booneville 345 kV	146	n/a	Wind	IA-G09
R34	Council Bluffs - Madison County 345 kV	250	20%	Wind	IA-G09
R38	MEC Council Bluffs - Grimes 345 kV	200	20%	Wind	IA-G09
R39	Raun - Lakefield Junction	500	20%	Wind	IA-G09
R41	MEC Council Bluffs - Grimes 345 kV	100	20%	Wind	IA-G09
R42	Lehigh 345kV Substation	250	100%	Wind	IA-G09
R49	Pomeroy Generating Station	12	n/a	Wind	IA-G09
R65	R34 Expansion	92	100%	Wind	IA-G09
J285	Proposed O'Brien 345 kV Sub	250	100%	Wind	IA-G09
J289	161 kV substation on Winterset Junction to Creston 161 kV line	20	100%	Wind	IA-G09
J316	MDU Tatanka – Ellendale line	150	100%	Wind	ND-G16
J320	High Bridge 115 kV Sub	55	n/a	Gas	SD-G15
J329	Pella West 69 kV Substation	55	100%	Hydro	IA-G09
J343	161 kV substation on Creston – Clarinda 161 kV line	150	100%	Wind	IA-G09
J344	161 kV substation on Poweshiek – Oskaloosa 161 kV line	169	100%	Wind	IA-G09
J382	Christiana Switching Station	48.3	100%	Gas	IA-G09

Notes:
a: NRIS shared between G132 and J249 to total no more than 180 MW at any time.
n/a: NRIS is not available for this request

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G263	Lakefield Generating Substation	105	20%	Wind	SD-G15
G287	Nobles County Substation	200	20%	Wind	SD-G15
G349	Brookings County Substation	200	n/a	Wind	SD-G15
G362	Pleasant Valley Substation	200	20%	Wind	SD-G15
G370	Anson 4	205	n/a	Gas	SD-G15
G380	Rugby 115kV Substation	150	n/a	Wind	ND-G16
G386	Lakefield Substation 345kV	100	20%	Wind	SD-G15
G389	Elk River 230 kV substation	200	100%	Gas	SD-G15
G514	Lakefield Station via Trimont G263 Interconnect	150	n/a	Wind	SD-G15
G540	Adams - Lime Creek 161 kV	80	100%	Wind	IA-G09
G548	Barton 161kV Substation	80	100%	Wind	IA-G09
G549	Next to Williams Substation (69kV)	20	100%	Wind	SD-G15
G551	Rice 161 kV	99	20%	Wind	IA-G09
G573	Franklin 161 kV Substation	80	100%	Wind	IA-G09
G574	Franklin 161 kV Substation	80	100%	Wind	IA-G09
G575	Franklin 161 kV Substation	40	100%	Wind	IA-G09
G586	Xcel New Yankee Sub 34.5 kV	30	100%	Wind	SD-G15
G587	69 kV to Winthrop Sub	20	100%	Wind	SD-G15
G595	Lime Creek 161 kV Substation	150	n/a	Wind	IA-G09
G602	Nobles County 115 kV Substation	32	20%	Wind	SD-G15
G604	Owatonna - County Line 69 kV	44	n/a	Wind	SD-G15
G612	ITC Midwest Fernald 115 kV Substation	150	n/a	Wind	IA-G09
G619	GRE Tamarac 41 kV Substation	50	100%	Wind	ND-G16
G620	Kenyon - Dodge 69 kV	19	n/a	Wind	SD-G15
G621	Rock Tap – South Ridge 69kV	20	100%	Wind	SD-G15
G667	Round Lake Tap 69kV	13	n/a	Wind	SD-G15
G685	Lake Lillian-Atwater 69kV	20	n/a	Wind	SD-G15
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G741	Alliant 69kV	8	100%	Waste Heat	SD-G15
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G830	McHenry 115kV Substation	99	100%	Wind	SD-G15
G858	Black Oak 69 kV Substation		100%	Wind	SD-G15
G870	Hayward – Winnebago 161kV	201	100%	Wind	SD-G15
G929	Monticello	60	100%	Nuclear	SD-G15
G930	Sherco	60	100%	Coal	SD-G15
G947	Whispering Willows 161kV Substation	99	87%	Wind	IA-G09
G971	Cosmos Township 69kV	20	n/a	Wind	SD-G15
G997	Minden Substation	50	100%	Wind	IA-G09
H007	Edgewood 69kV	41	n/a	Wind	IA-G09
H008	Richfield 69kV Substation	36	100%	Wind	IA-G09
H009	Traer – Marshalltown 161kV	150	n/a	Wind	IA-G09
H021	Wellsburg 115kV Substation	138.6	86%	Wind	IA-G09
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H092	Boswell	60	100%	Coal	ND-G16
H081	Brookings County – Lyon County 345kV	201	n/a	Wind	SD-G15
H096	Grand Junction – Perry 161kV	50	100%	Wind	IA-G09
J020		20	100%	Diesel	SD-G15
J021		40	100%	Diesel	SD-G15
J075	Bauer - Rapson 345 kV	150	100%	Wind	IA-G09
J091	Lime Creek 161kV substation	66	100%	Wind	IA-G09
J110	Glen Ullin	7.5	100%	Biomass	ND-G16
J112	DPC Utica – Lewiston 69kV	4.95	n/a	Wind	SD-G15
J161	Bauer - Rapson 345 kV	155	100%	Wind	IA-G09

J171	Benson 115kV Substation	12	100%	Biomass	SD-G15
J183	Split Rock Substation	200	n/a	Wind	SD-G15
J191	Rolling Hills 345kV Substation	101.2	100%	Wind	IA-G09
J200	RM Heskett Station 115kV & 41.6kV	75	80%	Gas	ND-G16
J201	Manning 138kV Substation	20	100%	Wind	IA-G09
J202	Atlanta - Tuscola 115 kV	101	100%	Wind	IA-G09
J226	Ludington Substation	70	100%	Hydro	IA-G09
J231	Ludington Substation	70	100%	Hydro	IA-G09
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J249	MDU Tatanka Substation	180	100%[a]	Wind	ND-G16
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J279	Raun 345kV	(Uprate) 30	100%	Coal	IA-G09
J290	Tap Rugby – Glenboro 230kV	150	100%	Wind	ND-G16
R15	Pomeroy 161 kV substation	80	20%	Wind	IA-G09
R23	Monona - Carroll 161 kV	100	20%	Wind	IA-G09
R26	MEC Cooper - Booneville 345 kV	146	n/a	Wind	IA-G09
R34	Council Bluffs - Madison County 345 kV	250	20%	Wind	IA-G09
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R39	Raun - Lakefield Junction	500	20%	Wind	IA-G09
R41	MEC Council Bluffs - Grimes 345 kV	100	20%	Wind	IA-G09
R42	Lehigh 345kV Substation	250	100%	Wind	IA-G09
R49	Pomeroy Generating Station	12	n/a	Wind	IA-G09
R65	R34 Expansion	92	100%	Wind	IA-G09
J285	Proposed O'Brien 345 kV Sub	250	100%	Wind	IA-G09
J289	161 kV substation on Winterset Junction to Creston 161 kV line	20	100%	Wind	IA-G09
J316	MDU Tatanka – Ellendale line	150	100%	Wind	ND-G16
J320	High Bridge 115 kV Sub	55	n/a	Gas	SD-G15
J329	Pella West 69 kV Substation	55	100%	Hydro	IA-G09
J343	161 kV substation on Creston – Clarinda 161 kV line	150	100%	Wind	IA-G09
J344	161 kV substation on Poweshiek – Oskaloosa 161 kV line	169	100%	Wind	IA-G09
J382	Christiana Switching Station	48.3	100%	Gas	IA-G09

Notes:
a: NRIS shared between G132 and J249 to total no more than 180 MW at any time.
n/a: NRIS is not available for this request

2.2. Other MISO Generators

Also included in this study were Iowa generators in the models that were ramped up to their Pmax. These generators were consistent with generators dispatched at their Pmax value in models provided by MISO.

Table 3: Other MISO generators dispatched to Pmax

Bus Number	Bus Name	Pmax	NRIS	Area
629147	G426/538_WF534.500	100.0000	n/a	IA-G09

629147	G426/538_WF5	34.500	50.0000	20%	IA-G09
629983	G358_WF9	34.500	35.0000	n/a	SD-G15
629984	G298_WF9	34.500	100.0000	n/a	IA-G09
629992	G164_WF9	34.500	200.0000	n/a	SD-G15
630385	SLAKES 8	69.000	40.0000	20%	IA-G09
630385	SLAKES 8	69.000	39.0000	20%	IA-G09
631157	G172_G1	34.500	200.0000	n/a	SD-G15
631158	G172_G2	34.500	100.0000	n/a	SD-G15
633408	MPW GEN8	69.000	22.0000	100%	IA-G09
633408	MPW GEN8	69.000	18.8000	100%	IA-G09
635044	WALNUT0	0.5750	75.0000	20%	IA-G09
635045	WALNUT1	0.5750	75.0000	20%	IA-G09
635312	VICTRYG1	0.5750	99.0000	20%	IA-G09
635316	CARROLG2	0.5750	75.0000	20%	IA-G09
635317	CARROLG1	0.5750	75.0000	20%	IA-G09
635352	CLIPR G1	0.5700	70.5000	20%	IA-G09
635352	CLIPR G1	0.5700	15.0000	20%	IA-G09
635354	CLIPR G2	0.5700	90.0000	20%	IA-G09
635637	ADAIRWG1	0.6900	87.5000	20%	IA-G09
635638	ADAIRWG2	0.6900	87.5000	20%	IA-G09
636027	POCHNTG1	0.5750	94.5000	20%	IA-G09
636033	POCHNTG2	0.5750	103.5000	20%	IA-G09
636035	POCHNTG3	0.5750	51.0000	20%	IA-G09
636035	POCHNTG3	0.5750	29.9000	n/a	IA-G09
636238	ENXCO G1	0.5700	70.5000	20%	IA-G09
636238	ENXCO G1	0.5700	35.0000	n/a	IA-G09
636239	ENXCO G2	0.5700	94.5000	n/a	IA-G09
636309	CCITYSG1	0.5750	75.0000	n/a	IA-G09

Notes:
n/a: NRIS is not available for this request

2.3. Previously Queued SPP Generators

Also included in this study were SPP Generator Interconnection Requests as listed in Appendix A. These Interconnection Requests include Group 9, 13, 15, and 16 Requests through DISIS-2015-001.

3. Models

The 2015 model series Integrated Transmission Planning – Near Term models (used in the 2016ITPNT) including the 2016 Winter Peak (16WP), 2017 spring (17G) and summer peak (17SP), the 2020 light load (20L), summer (20SP), and winter peak (20WP) and the 2025 summer peak (25SP) seasonal scenario 0 cases were used for this study. After the cases were developed, each of the control areas' resources were then re-dispatched to account for the new generation requests using current dispatch orders. The Nebraska City – Mullins Creek – Sibley 345kV line was included in cases prior to their in-service dates.

For Energy Resource Interconnection Service (ERIS), the MISO wind generating plants were modeled at 100% nameplate of maximum generation in the High Variable Energy Resource (HVER) dispatch cases. Coal and gas units were dispatched at 100% in the Low Variable Energy Resource (LVER) dispatch cases. These projects were dispatched as Energy Resources Interconnection Service and sunk to load across the MISO footprint. All generators that requested Network Resource Interconnection Service (NRIS) were dispatched in an additional analysis in accordance with the values listed in Tables 2 and 3. The models used for this study include **Table 4**:

Table 4: Study Dispatches per Seasonal Cases

Seasonal Case	ERIS HVER	ERIS LVER	NRIS
2016 Winter Peak (16WP)	X	X	X
2017 Spring (17G)	X		X
2017 Summer Peak (17SP)	X	X	X
2020 Light Load (20L)	X		X
2020 Summer Peak (20SP)	X	X	X
2020 Winter Peak (20WP)	X	X	X
2025 Summer Peak (25SP)	X	X	X

4. Contingencies

- All branches and ties within the following areas:
  - SPP Internal Areas for 65kV – 999kV facilities:
    - 515 – 546, 640, 645, 650, 652, 998, 999
  - SPP External Areas for 65kV – 999kV facilities:
    - 325 – 329, 331, 332, 334 - 339, 351, 356, 502 -504, 600, 608, 613, 615, 620, 627, 635, 672, 680, 694
- NERC, SPP, and Tier 1 Permanent Contingent Flowgates
- SPP T.O. Specific and Tier 1 Specific Contingencies
- SPP T.O. Specific Op Guide Implementation

5. Monitored Elements

- NERC, SPP, and Tier 1 Permanent Monitor Flowgates
- All branches and ties within the following areas:
  - SPP Internal Areas for 65kV – 999kV facilities:
    - 515 – 546, 640, 645, 650, 652, 998, 999
  - SPP External Areas for 100kV – 999kV facilities:
    - 325 – 329, 331, 332, 334 - 339, 351, 356, 502 -504, 600, 608, 613, 615, 620, 627, 635, 672, 680, 694

6. Sink for Studied Generation

The MISO footprint was used as a sink for the studied generation. The list of buses can be found in Appendix C.

7. Methodology

This Affected System Study for the MISO February 2015 West Area DPP Restudy used both DC screening and ACCC analysis. To perform DC analysis, the FCITC function within PSS/MUST is used to determine the limiting constraints and determine the associated distribution factors (DFs). AC Analysis uses the ACCC function of PSS/E to determine the constraints and PSS/MUST to determine the associated DFs.

Per the following SPP Constraint identification criteria, a facility requires review if loadings are higher than 95%. If loadings are higher than 100% mitigation may be required depending on the type of service requested and the distribution factors associated with the affecting requests and the type of contingency. Other factors may also be considered when determining the effects of requests on overloaded facilities.

7.1. ERIS Constraint Criteria

If a facility is overloaded under no contingency (P0) with distribution factor equal to or greater than 3% or under contingency (P1, P2, and Extreme Events) by a request with a distribution factor of greater than or equal to 19.5%, that request will be labeled as affecting and mitigation may be required. If the overloaded facilities make up a flowgate (PTDF or OTDF) and a request has a distribution factor of greater than or equal to 3% system intact or 19.5% during contingency, that request will be labeled as affecting and mitigation may be required. Non-converged contingencies shall also be considered for mitigation.

7.2. NRIS Constraint Criteria

If a facility is overloaded under no contingency (P0) or under contingency (P1, P2, and Extreme Events) by a request with a distribution factor of greater than or equal to 3%, that request will be labeled as affecting and mitigation may be required. If the overloaded facilities make up a flowgate (PTDF or OTDF) and a request has a distribution factor of greater than or equal to 3%, that request will be labeled as affecting and mitigation may be required. Non-converged contingencies shall also be considered for mitigation.

7.3. Additional Constraint Consideration

Notwithstanding, should any facility be identified by MISO using MISO Constraint Identification Criteria as being affected by a study request, such as “Outlet” constraints or other specific criteria, review and mitigation of those constraints may also be required.

As a note the SPP Permanent List of Flowgates are included within SPP Planning studies and can be reviewed on the SPP OASIS website. The direct link to the current Permanent Flowgate list is as follows: https://www.oasis.oati.com/SWPP/SWPPdocs/Permanent_flowgates.xls

8. Results

The following facilities were found to be impacted by the MISO generators. More detail can be found in **Appendix D**.

Table 5: Potential Constraints

ERIS/NRIS Constraint	Area	Contingency	Affecting Requests	Season
BISMARK - HILKEN 4 230.00 230KV CKT 1	WAPA	Various N-1 Contingencies	J405	2017SP (NRIS) 2020SP(NRIS) 2025SP(NRIS)
CRESTON - J343_SUB 161.00 161KV CKT 1	MEC/WAPA	System Intact	G736	2020L(ERIS) 2020SP(ERIS) 2025SP(ERIS)
FARGO - SHEYNNE 230KV CKT 1	WAPA/XEL	BUFFALO - JAMESTOWN 345KV CKT 1	J391, J400, J426	2017SP (NRIS) 2020SP(NRIS) 2025SP(NRIS)
FARGO - SHEYNNE 230KV CKT 1	WAPA/XEL	CENTER - JAMESTOWN 345KV CKT 1	J391, J400, J426	2017SP (NRIS) 2020SP(NRIS) 2025SP(NRIS)
GR ISLD-LNX3345.00 - HOLT.CO3 345.00 345KV CKT 1	WAPA	RAUN - SUB 3451 FT CAL 345KV CKT 1	J411	16WP(NRIS)
GRACEVT7 - MORRIS 115KV CKT 1	OTP/WAPA	BIG STONE - BLAIR 230KV CKT 1	G736	2017G(ERIS) 2017SP(ERIS)
Non-Converged Contingency	NPPD/WAPA	GR ISLD-LNX3345.00 - HOLT.CO3 345.00 345KV CKT 1	G736, J385, J400, J426	2016WP(ERIS) 2017G(ERIS) 2017SP(ERIS)
PAHOJA - SIOUX FALLS 230KV CKT 1	WAPA	SIOUXCY-LNX3345.00 - SPLIT ROCK 345KV CKT 1	J426	2017SP(NRIS)
RAUN - TEKAMAH 161KV CKT 1	OPPD/MEC	RAUN - SUB 3451 FT CAL 345KV CKT 1	J411	2017SP(NRIS)

8.1. ERIS Impacts

Some overloads in **Table 6** are observed in the near term models but are no longer observed in the longer term models as a possible result of mitigation by system network upgrades.

The following constraint was found to need further evaluation.

Table 6: ERIS Near-Term Model Constraints

ERIS Constraint	Area	Contingency	Loading	Affecting Requests	Season	DF
Non-Converged Contingency	NPPD/WAPA	GR ISLD-LNX3345.00 - HOLT.CO3 345.00 345KV CKT 1	N/A	G736, J385, J400, J426	2016WP(ERIS) 2017G(ERIS) 2017SP(ERIS)	4-7%

8.2. NRIS Impacts

Some overloads in **Table 7** are observed in the near term models but are no longer observed in the longer term models as a possible result of mitigation by system network upgrades.

The following constraint was found to need further evaluation.

Table 7: NRIS Near-Term Model Constraints

ERIS Constraint	Area	Contingency	Loading	Affecting Requests	Season	DF
GR ISLD-LNX3345.00 - HOLT.CO3 345.00 345KV CKT 1	WAPA	RAUN - SUB 3451 FT CAL 345KV CKT 1	119.73%	J411	16WP(NRIS)	3.33%
RAUN - TEKAMAH 161KV CKT 1	OPPD/MEC	RAUN - SUB 3451 FT CAL 345KV CKT 1	100.7	J411	17SP(NRIS)`	6.5%

8.3. Sensitivity Impacts

8.3.1. Nebraska City – Sibley 345kV line

Sensitivity was run to determine impacts on the SPP Transmission System for ERIS constraints prior to the in-service date of the Nebraska City – Mullin Creek – Sibley 345kV line. It was found that Cooper-St Joseph will not overload for system intact conditions prior to the in-service date of the Nebraska City – Mullin Creek – Sibley 345kv line. If for any reason construction or in-service for the south portion of the Nebraska City – Mullins Creek – Sibley 345kV is delayed beyond 12/31/2016, the constraints listed in Error! Reference source not found. could occur and result in curtailment of generator Interconnection Request(s).

Table 8: Constraints for Nebraska City – Mullin Creek – Sibley Delay Scenario

Constraint	Area	Contingency	MVA Rating	Loading	Season
Cooper – St Joseph 345kV	OPPD KCPL/GMO	None	1073	101.6%	2017SP (ERIS)
Cooper_S Flowgate	OPPD KCPL/GMO	None	1465	127.9	2016WP (ERIS) 2017SP (ERIS)

No new NRIS overloads were observed on SPP facilities with the addition of the Nebraska City – Sibley project included. However, NRIS cannot be provided until the in-service date of this line.

8.3.2. Generator Retirements

SPP is currently performing analysis for generator retirements and will update this report once those impacts can be determined.

9. **Determination**

The SPP Transmission System is impacted by the interconnection of the MISO Customer generation. The following ERIS and NRIS constraints could require additional transmission reinforcement. Constraints identified on tie-line circuits between Western Area Power Administration and other MISO membership areas should be reviewed by MISO for potential MISO facilities' Network Upgrades required for mitigation.

Potential mitigations are listed in Error! Reference source not found..

Table 9: SPP Suggested Mitigations within DPP February 2015 West Area Study

Mitigation	Area	Purpose	ERIS and/or NRIS Affecting Requests	Estimated Cost
Delay Interconnection Service until in service date of the Nebraska City – Sibley 345kV line,	OPPD KCPL-GMO	Required to mitigate ERIS constraints on Cooper South flowgate and Saint Joe – Cooper 345kV system intact thermal violations	G736, J385, J400, J407,J411, J416, J426	Approved project scheduled for 12/31/2016
Delay Interconnection Service until in service date of the Gentleman Generating Station – Thedford – Holt 345kV Project ("R-Plan"),	NPPD	Required to mitigate potential ERIS voltage collapse(s) for the outage of Holt – Grand Island 345kV	G736, J385, J400, J411, J426	Approved Project scheduled for 2019
Grand Island – Holt County 345kV update CTs	WAPA	Required to to mitigate NRIS thermal constraints for single contingency outage of Raun – Fort Calhoun 345kV	J411 (NRIS)	$60,000
Delay Interconnection Service until in service date of the certain MISO MVP projects	Various	Required to mitigate overload on Raun-Tekama 161kV	J411	Scheduled for 2019
BISMARK - HILKEN 4 230.00 230KV CKT 1 Reconductor 22 miles of line.	WAPA	Required to mitigate NRIS thermal constraints observed during contingency of Garrison – Jamestown 230kV circuit #1.	J405	$3,400,000 (will need WAPA Facility study)
CRESTON - J343_SUB 161.00 161KV CKT 1 – Potential rebuild on MEC.	MEC/WAPA	Required to mitigate ERIS thermal constraints observed for system intact conditions. SPP has coordinated with WAPA for WAPA facilities at Creston. WAPA facilities are sufficient for loading identified (175 MVA). MISO and MEC may need to further review the facilities under MEC ownership.	G736	No SPP/WAPA costs
FARGO - SHEYNNE 230KV CKT 1 Terminal Equipment – potential rebuild on XCEL.	WAPA/XEL	Required NRIS mitigation for thermal constraints observed during contingency conditions. Mitigation would require upgrades to be at least 437MVA (Summer Peak Emergency). WAPA owns and maintains terminal equipment along with the buses at Fargo. The WAPA Fargo terminal equipment, main bus, and transfer bus would require upgrades. MISO and XCEL may need to further review facilities under XCEL ownership.	J391, J400, J426	$2,000,000 (will need WAPA Facility Study)

Mitigation	Area	Purpose	ERIS and/or NRIS Affecting Requests	Estimated Cost
GRACEVT7 - MORRIS 115KV CKT 1 MISO & OTP review	OTP/WAPA	Required ERIS mitigation review for thermal constraints observed during contingency conditions. SPP has coordinated with WAPA for WAPA facilities at Morris. WAPA facilities are adequate for loading seen (116MVA). MISO and OTP should review facilities for upgrades required to achieve at least 116MVA for this circuit.	G736	No SPP/WAPA costs
PAHOJA - SIOUX FALLS 230KV CKT 1	WAPA	Required NRIS mitigation for thermal constraints observed during contingency conditions. SPP has coordinated with WAPA for WAPA facilities. For mitigation thermal equipment including CTs, Bus work, and Jumpers would be required at Sioux Falls. Mitigation would require upgrades to be at least 343MVA (Summer Peak Emergency).	J426	$2,000,000 (will need WAPA Facility Study)

9.1. Curtailment

In no way does this study guarantee operation for all periods of time. This interconnection study identifies impacts for Energy Resource Interconnection Service (ERIS) interconnection injection constraints (defined as a 20% distribution factor impact for observed contingency constraints and 3% distribution factor impact for system intact constraints) and Network Resource Interconnection Service (NRIS) constraints (defined as 3% distribution factor impact) on the MISO Transmission System. This affected system study does not identify impacts for all potential situations. It should be noted that although this study analyzed many of the most probable contingencies, it is not an all-inclusive list and cannot account for every operational situation. Because of this, it is likely that the MISO Customer(s) may be required to reduce their generation output to 0 MW, also known as curtailment, under certain system conditions to allow system operators to maintain the reliability of the transmission network.

Conclusion

Southwest Power Pool (SPP) has conducted this Affected System Interconnection System Impact Study to evaluate potential impacts to the SPP Transmission System related to the interconnection of generators on the Mid-Continent Independent System Operator (MISO) Transmission System.

Power flow analysis has indicated that for the power flow cases studied, the SPP Transmission System is impacted from the interconnection of the MISO Customer generation. These impacts are described in Section 8. and Section 9. of this report. Impacts can be mitigated by the Gentleman Generation Station (GGS) – Thedford - Holt 345kV (R-Plan) transmission line, Nebraska City – Mullin Creek – Sibley 345kV transmission line, and certain terminal equipment and line upgrades for Western Area Power Administration (WAPA) facilities. Constraints identified on tie-line circuits between Western Area Power Administration and other MISO membership areas should be reviewed by MISO for potential MISO facilities' Network Upgrades required for mitigation. Within the scope of this affected system impact study, SPP coordinated with WAPA for planning level estimates for mitigation of constraints requiring transmission reinforcements and will require facilities studies analysis if the MISO Interconnection Request(s) impacting the SPP transmission system proceed forward.

Certain constraints identified can be mitigated with either previously approved SPP or MISO upgrades. These include the Gentleman Generation Station (GGS) – Thedford - Holt 345kV (R-Plan) transmission line, and Nebraska City – Mullin Creek – Sibley 345kV line, and MISO MVP projects, which are scheduled to be placed in service by 2019. Interconnection Service for these requests may need to be delayed until that time period.

Additional analysis is also required to determine the impacts of the future generator retirements on the SPP Transmission System. This analysis is presently being performed and SPP will update this report as those results become available.

If the Affected System Interconnection Requests proceed, additional analysis will be required through an Affected System Facility Study. The purpose of the Affected System Facility Study is to perform additional analysis required to refine the scope, cost estimates, and expected time of construction of system facilities identified as Network Upgrades that would be placed in service under the SPP Open Access Transmission Tariff.

Appendix
G

Transient Stability Results

Plots of stability simulations for 2018 and 2025 summer shoulder study cases are in separate files which are listed below:

G.1 2018 Summer Shoulder Study Case

AppendixG1_2018SH_Study_Plots.zip

G.2 2025 Summer Shoulder Study Case

AppendixG2_2025SH_Study_Plots.zip

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Appendix
H

MWEX Voltage Study Details

Below is the MWEX voltage stability study report provided by ATC.

MWEX Voltage Stability Study
Prepared For
February 2015 MISO West DPP Study

March 28, 2016
American Transmission Company, LLC

Prepared By:
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Summary

This document describes the results of the steady state voltage stability analysis required for the February 2015 cycle (G736, J299, J385, J391, J400, J405, J407, J411, J416, J426) of the MISO Generation Interconnection Definitive Planning Phase (DPP) in the Western region.

Voltage stability analysis is required to determine if the initial conditions of the DPP system models under study are in a stable state as defined by Power-Voltage (PV) curves of the Minnesota Wisconsin Export Interface (MWEX) for the most severe contingency. MWEX is the summation of the pre-contingent flows on the AS King – Eau Claire 345 kV line measured at AS King and the Arrowhead 230 kV phase shifting transformer (also referred to as phase angle regulator or PAR) measured at the Minnesota Power 230 kV side of the Arrowhead substation. The voltage is measured at the Arrowhead 230 kV bus. Also, normal and emergency voltage limits will be respected in addition to steady state voltage stability limits.

This analysis concentrates on the 2025 shoulder load (2025SH) cases. As shown in Table 1, both the Pre-DPP and Post-DPP scenarios in the 2025SH cases are voltage stable. **The Post-DPP scenario results in a violation of ATC Planning Criteria but the voltage degradation is less than 0.01 per unit so no Network Upgrades are assigned to the Interconnection Customers.**

Table 1 – MWEX Margins to Collapse in 2025SH Cases

	Real Power Flows (MW)							
	AHD-SLK[1]	MWEX				Margin to Nose[2]		
Case	N-0 I.C.	N-0[3] I.C.	N-1[3] I.C.	N-1 I.C. After Phase Shift	N-1 Nose	(MW)	(%)	Notes
Pre-DPP	666	1492	782	719	876	158	18.0	Voltage Stable
Post-DPP	686	1556	805	722	863	141	16.3	Voltage Stable **Nose at V > 0.95**

1. As described in the active MWEX Operating Guide, the AHD-SLK interface is a single element PTDF interface measured at the Minnesota Power 230 kV side of the Arrowhead 230 kV phase shifter.
2. Margin to Nose is defined as the MWEX N-1 Nose minus the N-1 Initial Condition After Phase Shift.
3. Initial Condition flows were measured in the base cases with the most severe contingency plus operation of various control systems (See Appendix) as needed with all transformer taps, switched shunts, and PARs locked.

Model Selection

Each of the four base cases was reviewed before the voltage stability analysis was performed. ATC determined that voltage stability analysis was only necessary using the 2025SH cases because the 2025SH MWEX flow is much greater than the 2025 summer peak load case (2025SP) MWEX flow.

The 2018SH cases are known to be voltage unstable due to non-converging contingencies in previous MISO West DPP near-term models such that MISO includes the Briggs Road – North Madison 345 kV line, prior to its expected in-service date of 12/31/2018. The MISO MVP portfolio, including the Briggs Road – North Madison 345 kV line, is considered the long term voltage stability upgrade. No project has been defined that can be constructed prior to 2018 that will eliminate the voltage instability without the Briggs Road – North Madison 345 kV project. Therefore, voltage stability analysis is not performed on any of the 2018 cases.

Table 2 – Initial Conditions in Each Post-DPP Base Case

	AHD-SLK[1]	MWEX		Arrowhead 230 kV		
Case	**N-0 Flow (MW)**	**N-0 Flow (MW)**	**N-1 Flow (MW)[2]**	**N-0 Voltage (p.u.)**	**N-1 Voltage (p.u.)[2]**	**Post-Contingency Events**
2025SH	690	1561	807	1.022	0.985	MCCC SPS operates SLK reactor switches out (Both AHD 345 kV capacitors in for N-0) TBW system operates HLT system operates
2025SP	261	603	305	1.036	1.031	None
2018SH	617	1489	751	1.031	0.999	2nd AHD 345 kV capacitor switches in (1st capacitor switched in for N-0) MCCC SPS operates TBW system operates HLT system operates
2018SP	220	585	270	1.037	1.032	None
2018SH (w/o BGG-NMA)[3]	642	1547	814	1.024	0.992	2nd AHD 345 kV capacitor switches in (1st capacitor switched in for N-0) SLK reactor switches out MCCC SPS operates TBW system operates HLT system operates SLK capacitor switches in
2018SP (w/o BGG-NMA)[3]	218	580	268	1.037	1.032	None

1. As described in the active MWEX Operating Guide, the AHD-SLK interface is a single element PTDF interface measured at the Minnesota Power 230 kV side of the Arrowhead 230 kV phase shifter.
2. N-1 Flow and N-1 Voltage were measured in the unmodified base cases with the most severe contingency plus operation of various control systems (See Appendix) as needed with all transformer taps, switched shunts, and PARs locked.
3. The 2018 base cases contain the Briggs Road – North Madison 345 kV line as a base assumption. This project has an expected in-service date of 12/31/2018 and was removed for these measurements.

Model Notes

The generation interconnection requests were dispatched as described in Table 3 for the 2025SH cases.

Table 3 – February 2015 MISO West DPP Dispatch Assumptions for MWEX Voltage Stability

				Dispatch (MW)	
Project Number	**Fuel Type**	**Service Type**	**Size (MW)**	**Pre-DPP**	**Post-DPP**
J299	Gas	ER	73.0	343.5	380.0[1]
J391	Gas	NR	50.0	0.0	0.0[2]
J405	Gas	NR	40.0	0.0	0.0[2]
J385	Solar	NR	100.0	0.0	0.0[3]
J400	Solar	NR	62.5	0.0	0.0[3]
G736	Wind	ER	200.0	0.0	200.0[4]
J407	Wind	NR	200.0	0.0	200.0[4]
J411	Wind	NR	300.0	0.0	300.0[4]
J416	Wind	NR	200.0	0.0	200.0[4]
J426	Wind	NR	100.0	0.0	100.0[4]

1. J299 is an expansion of an existing plant. Combined cycle plants are dispatched to 50% of PMAX in SH models.
2. Gas CTs are not dispatched in SH models
3. Solar plants are not dispatched in SH models
4. Wind plants are dispatched to 100% of PMAX in SH models.

Results

Table 4 shows the Control Points for situations when the Arrowhead PAR is in automatic mode and when it is in manual mode. When the Arrowhead PAR is in manual mode the taps can only be adjusted by system operators and will not respond to any other control settings.

Table 4 – MWEX Measurements to Determine Control Point – 2025SH

	N-0 MWEX Measurements (MW)					Incremental Transfer[6] (MW)	
Case	Nose[1]	Collapse[2]	IROL[3]	SOL[4]	Control Point[5]	To Nose	To Collapse
Pre-DPP Automatic PAR	1761	1981	1882	1761	1726	1190	1750
Pre-DPP Manual PAR	N/A	N/A	1761	1585	1553	N/A	N/A
Post-DPP Automatic PAR	1716	1976	1877	1716	1682	710	1300
Post-DPP Manual PAR	N/A	N/A	1716	1544	1514	N/A	N/A

1. Nose: the N-0 flow that corresponds to the point of bifurcation, which is identified as the last transfer that results in a post-contingent, net positive change in real power flow on MWEX.
2. Collapse: the last solving post-contingent transfer step.
3. IROL (Interconnection Reliability Operating Limit) = 0.95 x Collapse.
   a. Manual PAR IROL = Minimum of Automatic PAR IROL and Automatic PAR SOL.
4. SOL (System Operating Limit) = Minimum of Nose and IROL.
   a. Manual PAR SOL = 0.90 x Automatic PAR SOL.
5. Control Point = Minimum of 0.98 x SOL, 0.95 x IROL, and IROL – 100.
6. Incremental Transfer = Total transfer from Source to Sink modeled in addition to the base case initial conditions.

Table 5 shows the Control Points for the flows on Arrowhead to Stone Lake 345 kV line with the PAR in both automatic and manual mode. The measurements made on Arrowhead – Stone Lake 345 kV are made in the same manner as described in the active standing operating guide, 2016-S-010-N-MWEX_ArrowheadStonelake_R11.pdf, from the Minnesota Power Arrowhead 230 kV bus. In manual mode the taps can only be adjusted by system operators and will not respond to any other settings.

Table 5 – AHD-SLK Measurements to Determine Control Point – 2025SH

	N-0 AHD-SLK Measurements (MW)				
Case	Nose[1]	Collapse[2]	IROL[3]	SOL[4]	Control Point[5]
Pre-DPP Automatic PAR	772	814	N/A	772	756
Pre-DPP Manual PAR	N/A	N/A	N/A	694	680
Post-DPP Automatic PAR	751	815	N/A	751	735
Post-DPP Manual PAR	N/A	N/A	N/A	675	662

1. Nose: the N-0 flow that corresponds to the point of bifurcation, which is identified as the last transfer that results in a post-contingent, net positive change in real power flow on MWEX.

2. Collapse: the last solving post-contingent transfer step.
3. IROL (Interconnection Reliability Operating Limit) is not defined for the AHD-SLK interface.
4. SOL (System Operating Limit): Nose.
   a. Manual PAR SOL = 0.90 x Automatic PAR SOL.
5. Control Point = Minimum of 0.98 x SOL.

Figure 1 shows the pre-contingent MWEX flows and the pre-contingent Arrowhead PAR flows. The Arrowhead PAR and additional actions are then modeled in Figure 2 to establish the margin required in the ATC criteria. All Arrowhead PAR settings are subject to change based on annual assessments.

The starting point for each curve represents the base case initial conditions with an intact system.

- Pre-DPP
  - MWEX flow = 1492 MW
  - Arrowhead PAR flow = 666 MW
  - Arrowhead 230 kV voltage = 1.020 p.u.
- Post-DPP
  - MWEX flow = 1556 MW
  - Arrowhead PAR flow = 686 MW
  - Arrowhead 230 kV voltage = 1.013 p.u.

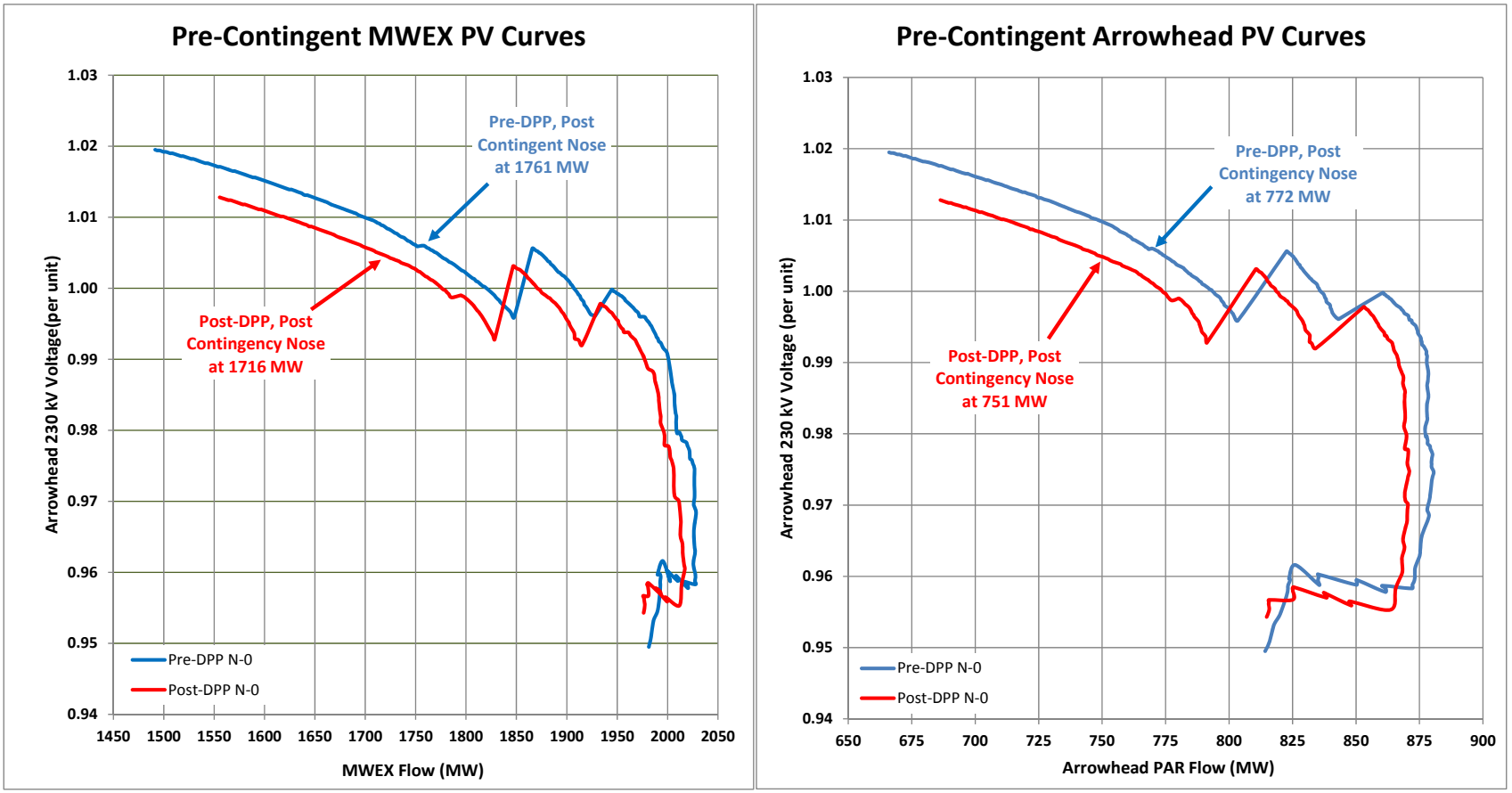

Figure 1 – MWEX and Arrowhead PAR Pre-Contingent PV Curves

The red and blue curves in Figure 2 show the MWEX flows immediately after the most severe contingency, the Arrowhead and Stone Lake 345 kV capacitors switch in, the Monroe County Council Creek (MCCC) Special Protection System (MCCC SPS) operates, and the Timberwolf and Hilltop overload tripping systems operate. The Lublin protection scheme does not operate.

The violet and green curves in Figure 2 show the MWEX flows after the most severe contingency and control systems listed above operate, and the Arrowhead PAR and Stinson PAR adjustments.

The starting point for each curve represents the base case initial conditions with the most severe contingency and ensuing actions as described above.

- Pre-DPP before PAR operates (blue curve)
    - MWEX flow = 782 MW (equal to Arrowhead PAR flow)
    - Arrowhead 230 kV voltage = 1.000 p.u.
- Pre-DPP after PAR operates (purple curve)
    - MWEX flow = 719 MW (equal to Arrowhead PAR flow)
    - Arrowhead 230 kV voltage = 1.014 p.u.
- Post-DPP before PAR operates (red curve)
    - MWEX flow = 805 MW (equal to Arrowhead PAR flow)
    - Arrowhead 230 kV voltage = 0.981 p.u.
- Post-DPP after PAR operates (green curve)
    - MWEX flow = 722 MW (equal to Arrowhead PAR flow)
    - Arrowhead 230 kV voltage = 1.007 p.u.

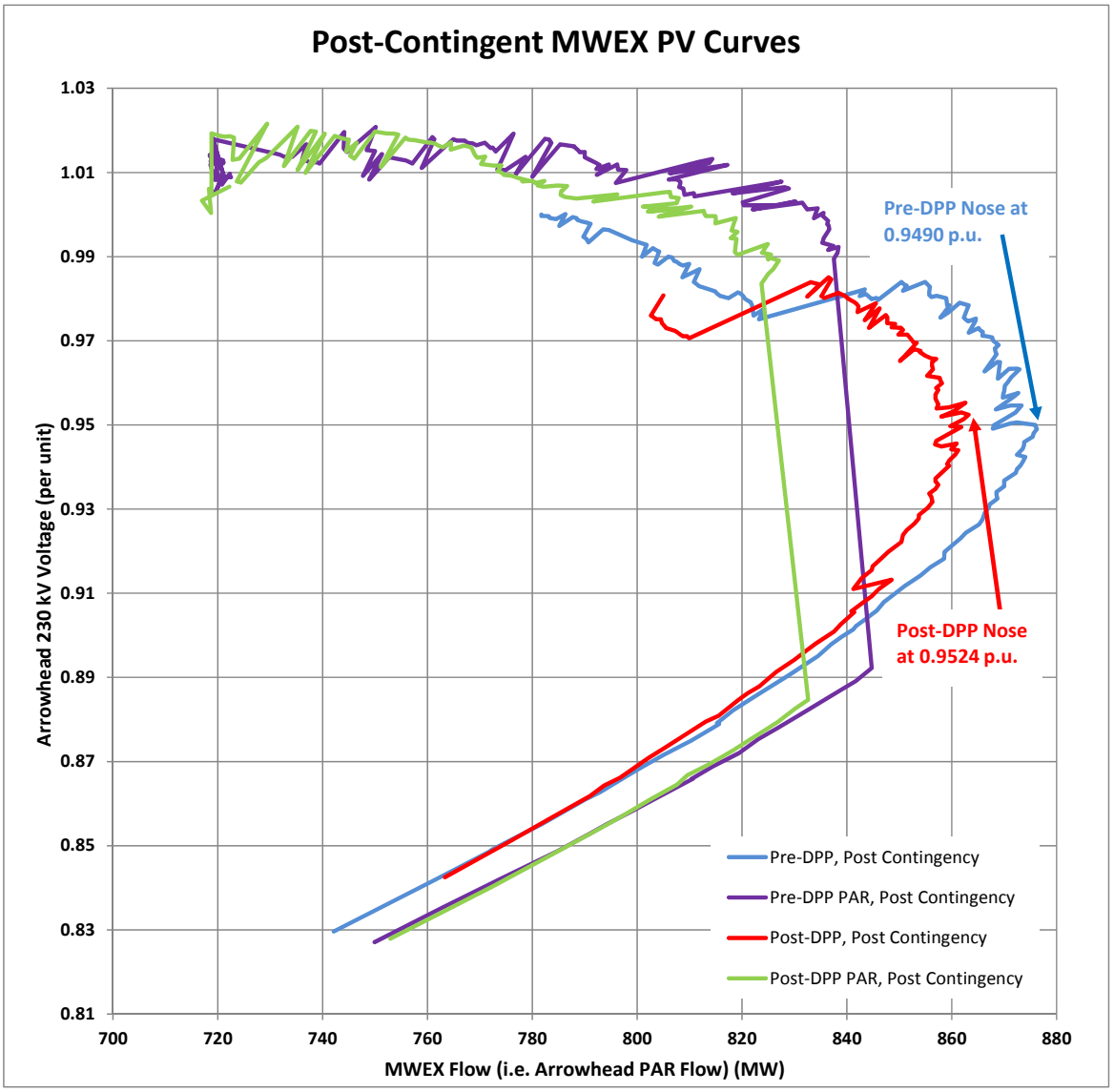

Figure 2 – MWEX Post-Contingent PV Curves

Additional Considerations

Normal and emergency voltage limits will be respected in addition to steady state voltage stability limits. For example, in Figure 2 the Pre-DPP, Post Contingency (blue curve) would have SOL calculated based on the flow at the most restricting limit which is the Minnesota Power emergency minimum voltage of 0.95 per unit which occurs at a MWEX flow of approximately 868 MW.

Conclusion

The results of this analysis show that both the Pre-DPP and Post-DPP scenarios in the 2025 shoulder load cases are voltage stable as defined by having an acceptable real power margin from the initial condition to the nose of the PV curve.

There is a violation of ATC planning criteria due to the post contingent PV nose occurring at a voltage greater than the minimum emergency voltage of 0.95 per unit in the Post-DPP case. However, MISO ERIS Constraint Criteria requires a steady state voltage criteria violation *and* that the voltage degradation is greater than 0.01 per unit. The difference in PV nose voltages is 0.0034 per unit, therefore no Network Upgrades will be assigned to the Interconnection Customers.

Appendix

Background

This MWEX (Minnesota-Wisconsin Export Interface) assessment analyzes generation interconnection requests in the MISO Definitive Planning Phase, or DPP. MWEX consists of the summation of flows on the 345 kV AS King – Eau Claire – Arpin line and the flow through the 230 kV Arrowhead phase shifting transformer or phase angle regulator (PAR) measured at Minnesota Power Arrowhead 230 kV bus. By performing voltage stability analysis with the most severe contingency, the interface the IROL, SOL, and Control Point operating limits are determined for the Arrowhead PAR.

Assumptions & Methodology

All analysis was performed consistent with the annual MWEX assessment to the extent possible except that only the intact system with the most severe contingency was reviewed and no transient stability simulations were performed. The operating limits (SOL, IROL, and Control Point) were determined for the Arrowhead PAR in both automatic and manual control modes as described below. The control point is used to define the flows that MISO will bind to in the day ahead and real time markets.

To be consistent with ATC Planning Criteria version 17, issued on 08/03/2015, which was the latest approved Planning Criteria when this analysis began, this study defined voltage stability violations as follows. These requirements are based on ATC Planning Criteria v17 Section 1.1.5 items 1 and 2.

1. The initial condition results in a post-contingent solution on the unstable side of the PV curve.
2. The initial condition results in a post-contingent solution on the stable side of the PV curve but the Arrowhead PAR is unable to restore the 10% margin with 14 taps.
3. The initial condition results in a post-contingent nose (i.e. point of bifurcation) occurring at a voltage greater than the minimum emergency voltage. This measurement is made before the PAR operates at the Arrowhead 230 kV bus which has a minimum emergency voltage of 0.95 p.u.

ATC Planning Criteria **v17**[1] Section 1.1.5 items 1 and 2:

> 1.1.5. Planning Horizon Steady State Voltage Stability
> 1) The nose of the steady state bus P-V curve should be at or below the applicable bus voltage limit as coordinated with the applicable Planning Coordinator and/or by any applicable Transmission Owner(s) (e.g., the MWEX limitation of 95 percent of nominal voltage at the Arrowhead 230-kV bus) to assure adequate system voltage stability and reactive power resources for NERC Category P0 through P7 contingencies. Different values may be appropriate for areas of the system that contain fast acting reactive power devices (e.g., FACTS devices). If additional voltage stability limitations are discovered on the ATC system, then further analysis will be conducted to determine the appropriate course of action based on the probability and impact of the situation.
>
> 2) The steady state operating point at all ATC buses should be at least 10 percent away from the nose of the bus P-V curve and above the applicable low voltage limit to assure adequate system voltage stability and reactive power resources for NERC Category P0 through P7 contingencies. The pre-contingency voltage stability margin should be adequate to avoid voltage instability for the most severe applicable contingency. This 10 percent voltage stability margin is chosen to reflect uncertainties in load forecasting and modeling, as well as to provide a reasonable reliability margin. Exceptions to the 10 percent margin requirement may

1 https://www.misoenergy.org/Library/Repository/Study/TO Planning Criteria/ATC TO Planning Criteria.pdf

be granted if there are feasible system adjustments which can reliably restore the 10 percent margin post contingent within 30 minutes.

Consistent with the MISO annual operations assessment, all analysis was performed with the Voltage Security Assessment Tool (VSAT), an industry accepted software package for voltage stability analysis. Existing and planned SPS, overload tripping systems, and fast switching reactive devices were modeled to operate as designed.

The power transfer is sourced from load in Minnesota Power, Great River Energy, and Xcel Energy-Minnesota. The power transfer is partially sunk to Wisconsin and partially to areas to the south and east. The Wisconsin sink is 40% of the total sink and is defined as load in We Energies (excluding load in the Upper Peninsula of Michigan), Wisconsin Public Service, Alliant Energy East, and Madison Gas and Electric. The remaining 60% of the sink is defined as load in ComEd and AEP. Both real and reactive power are scaled in the source and sink subsystems. The incremental change of the source decreases the load in 10 MW intervals, and the change in the sink increases the load in 10 MW intervals.

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Appendix

I

Short Circuit Analysis

Short Circuit Study Report

200 MW Wind Generation Interconnection
MISO G736
Prepared for the Midcontinent ISO

Aug 10, 2015

Short Circuit Study

A short circuit analysis was performed to determine the impact of the proposed generation on the adjacent substation fault current levels. The proposed generation, as outlined in this document, was added to the existing Transmission Owner's ASPEN OneLiner system model (BANG13-0503.OLR) and faults were simulated on all busses within one substation from the substation that contained the point of interconnection. As per a recommendation from MISO, the fault current from the G736 wind generation was assumed to be 1 per unit of the full nameplate rating.

Study Results

Based on the results of the study, the fault current ratings of the Otter Tail Power equipment in the area are not exceeded. With the proposed G736 project additions, the fault currents are estimated to be roughly 11.5 kA at the Big Stone South 230 kV bus. There are no short circuit related upgrades needed for G736.

A general protective relay coordination review will need to be performed by Otter Tail Power when the project approaches completion and before energizing the generation source.

Section 4
SHORT CIRCUIT ANALYSIS

4.1 Project Modeling

Leidos performed the short circuit analysis for the Project using the XCEL Energy CAPE database provided by MISO. The Project was modeled using the application data and the Project single line diagram provided by the IC. Leidos added the proposed Generating Facility with a 0.385 kV/34.5 kV transformer, the Interconnection Facility (gen tie), and the main step up transformer (34.5 kV/115 kV). The Project uses SMA Sunny Central 2,200 kVA inverters. CAPE does not have solar PV model in its library. The manufacturer's specification doesn't mention the SMA inverter fault current contribution but the nominal AC current is specified as 3,300 Amps. Leidos used an assumption of 1.2 times the nominal AC current for the inverter fault current contribution which is typical for solar PV inverters. This assumption was used to back calculate the equivalent sub-transient reactance and that value was fed into the CAPE generator model to represent the Project.
Figure 4-1 represents the Short Circuit model topology in CAPE.

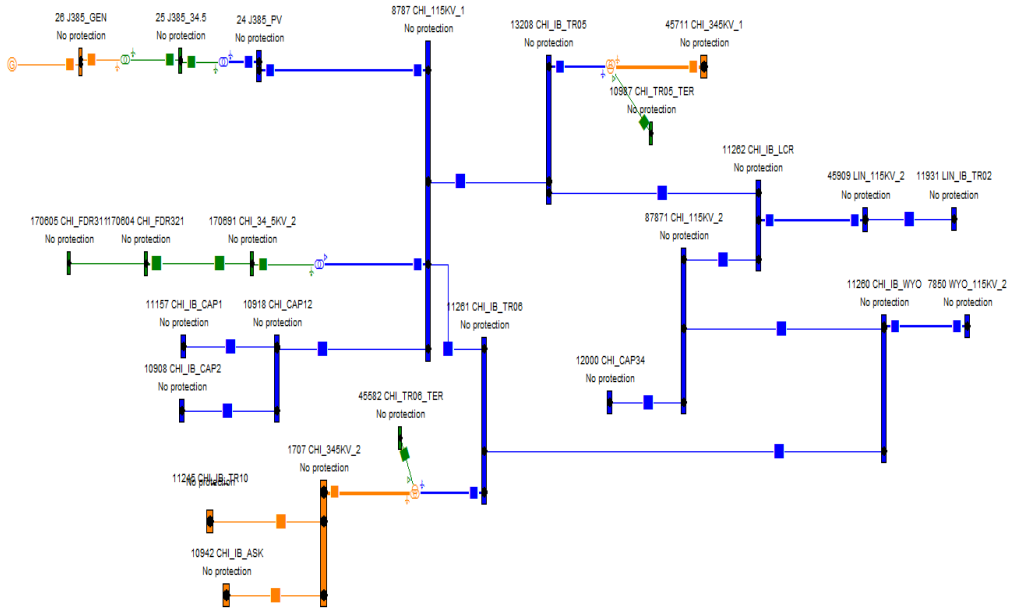


Figure 4-1. System Representation near J385 POI in the CAPE Database

4.2 Short Circuit Results

Leidos performed the short circuit analysis which includes a review of the available fault current at the J385 POI (Chisago 115kV substation) and nearby substations and various components as included in the CAPE database, both with and without the Project. Single-line-to-ground and three phase faults were simulated at these substations and fault currents were documented as shown in Table 4-1.

Table 4-1
Short Circuit Results Summary

CAPE Bus#	Bus Name	Base kV	Pre Project SLG (Amps)	Post Project SLG (Amps)	Delta SLG (Amps)	Pre Project 3-phase (Amps)	Post Project 3-phase (Amps)	Delta 3-phase (Amps)
13208	CHI_IB_TR05	115	27077.1	27642	564.9	24991.8	25550.4	558.6
8787	CHI_115KV_1	115	27077.1	27642	564.9	24991.8	25550.4	558.6
10918	CHI_CAP12	115	27077.1	27642	564.9	24991.8	25550.4	558.6
11157	CHI_IB_CAP1	115	27077.1	27642	564.9	24991.8	25550.4	558.6
10908	CHI_IB_CAP2	115	27077.1	27642	564.9	24991.8	25550.4	558.6
11261	CHI_IB_TR06	115	27077.1	27642	564.9	24991.8	25550.4	558.6
11260	CHI_IB_WYO	115	27077.1	27642	564.9	24991.8	25550.4	558.6
11262	CHI_IB_LCR	115	27077.1	27642	564.9	24991.8	25550.4	558.6
87871	CHI_115KV_2	115	27077.1	27642	564.9	24991.8	25550.4	558.6
12000	CHI_CAP34	115	27077.1	27642	564.9	24991.8	25550.4	558.6
87872	CHI_115KV_C1	115	22018.6	22390.3	371.7	20617.9	20996.3	378.4
87873	CHI_115KV_C2	115	22018.6	22390.3	371.7	20617.9	20996.3	378.4
45711	CHI_345KV_1	345	14162	14296	134	16204.7	16359.3	154.6
1707	CHI_345KV_2	345	14162	14296	134	16204.7	16359.3	154.6
11245	CHI_IB_TR10	345	14162	14296	134	16204.7	16359.3	154.6
10942	CHI_IB_ASK	345	14162	14296	134	16204.7	16359.3	154.6
11244	CHI_IB_TR09	345	14162	14296	134	16204.7	16359.3	154.6
45909	LIN_115KV_2	115	8895.4	8933.1	37.7	11012.4	11089.4	77
7850	WYO_115KV_2	115	6523.2	6535.9	12.7	8776	8807.1	31.1
46027	WYO_115KV_1	115	6523.2	6535.9	12.7	8776	8807.1	31.1

As the results show, contribution of the Project on fault currents in local area is fairly small. The Project increases three phase fault current at the POI by approximately 559 Amps and single-line-to-ground fault current by approximately 565 Amps. XCEL Energy reviewed the results and confirmed that the post-Project fault currents are below the breakers' interrupting capabilities and no breaker upgrades are required for the proposed interconnection.

J391 Short Circuit Study

Introduction

A short circuit analysis was performed by Siemens PTI to assess impact of the J391 generating facility (Combustion Turbine) on the adequacy of existing circuit breakers and related equipment in the Study Project area.

Short Circuit Model

A CAPE short circuit database including positive, negative and zero sequence parameters of the Xcel system and its neighboring systems was provided by the MISO. This starting short circuit model is listed below:

- Short Circuit Model: "NSP_1_5_2016.GDB"

The J391 short circuit study model was developed as follows:

- Applied MRES provided response file to update model in the Marshall area.
- Added J400, J426 generating facilities with online status.
- Added the J391 generating facility with its sequence parameters at MMU's North 7th Street 115 kV substation via a 115 line interconnection radial line (0.5 mile). The associated 115-13.8 kV GSU transformer (Z1=9%, Z0=6.7% at 39 MVA, X/R is 40, D-YG) was also added.
- J391 was represented using the conventional generator model, and impedances of the machine were set as follows:
    - Zero sequence impedance (Z_0): j0.16 pu
    - Negative sequence impedance (Z_2): j0.16 pu
    - Positive sequence impedances (Z_1):
        - Subtransient: j0.16 pu
        - Transient: j0.27 pu
        - Synchronous: j1.67 pu

Short Circuit Analysis

Short circuit analysis was performed on the study case (with the J391 project) and benchmark case (without the J391 project). Classical short circuit solution option was used in the calculation. The following fault simulation options were used in the short circuit analysis:

- Prefault voltage was set to "1.00 per unit with multiplier of 1"
- Current limited generator set to "Enforce machine current limits"
- All loads, shunts and transformer magnetizing branches were ignored.

Buses within 8-bus distance from the POI of J391 project were considered as the Study Project area. Three-phase (3PH) and Single Line to Ground (SLG) faults were simulated in the Study Project area. The results of short circuit currents with J391 (study case) and without J391 (benchmark case) are listed in the below Table.

With addition of the J391 generating facility, the maximum increase in the 3PH short circuit current is 8.88% (966.5 amps), and the maximum increase in the SLG short circuit current is 4.38% (372.9 amps), which are both observed at the North 7th Street 115 kV substation bus.

Summary of Short Circuit Analysis

As shown in the below Table, the change in fault current at buses in the Study Project area is relatively small. Based on the Transmission Owner's short circuit criteria, interconnection of the J391 generation project does not cause any Transmission Owner short circuit constraints.

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J391

Substation	Faulted Bus			Benchmark Case without J391 Project		Study Case with J391 Project		Amps Change with J391 vs Benchmark		% Change with J391 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
NORTH SEVENTH STREET	183200	NSV_115KV_1	115	8521.8	10882.6	8894.7	11849.1	372.9	966.5	4.38%	8.88%
ERIE ROAD (MARSHALL)	135600	ERD_115KV	115	8233.5	10624.1	8555.7	11475.3	322.2	851.2	3.91%	8.01%
MARSHALL SW STATION	170603	MSH_IB_SEA	115	9409.6	11653.4	9778.7	12545.6	369.1	892.2	3.92%	7.66%
MARSHALL SW STATION	170602	MSH_IB_NSV	115	9409.6	11653.4	9778.7	12545.6	369.1	892.2	3.92%	7.66%
MARSHALL SW STATION	170601	MSH_IB_LYC	115	9409.6	11653.4	9778.7	12545.6	369.1	892.2	3.92%	7.66%
MARSHALL SW STATION	170600	MSH_115KV	115	9409.6	11653.4	9778.7	12545.6	369.1	892.2	3.92%	7.66%
SARATOGA (MARSHALL)	199400	SAR_115KV	115	7411.5	9855.9	7645.8	10513.1	234.3	657.2	3.16%	6.67%
SOUTHEAST (MARSHALL)	205200	SEA_115KV	115	7944.6	10333.1	8197.8	11010.1	253.2	677.0	3.19%	6.55%
SOUTHWEST MARSHALL	205507	SWM_IB_TR01	115	7476.5	10054.9	7690.5	10666.6	214.0	611.7	2.86%	6.08%
SOUTHWEST MARSHALL	205506	SWM_IB_SEA	115	7476.5	10054.9	7690.5	10666.6	214.0	611.7	2.86%	6.08%
SOUTHWEST MARSHALL	205505	SWM_IB_SAR	115	7476.5	10054.9	7690.5	10666.6	214.0	611.7	2.86%	6.08%
SOUTHWEST MARSHALL	205504	SWM_IB_LAY	115	7476.5	10054.9	7690.5	10666.6	214.0	611.7	2.86%	6.08%
SOUTHWEST MARSHALL	205501	SWM_115KV_2	115	7476.5	10054.9	7690.5	10666.6	214.0	611.7	2.86%	6.08%
SOUTHWEST MARSHALL	205500	SWM_115KV_1	115	7476.5	10054.9	7690.5	10666.6	214.0	611.7	2.86%	6.08%
SOUTHWEST MARSHALL	205503	SWM_115KV_C2	115	7401.0	9918.4	7610.4	10512.6	209.4	594.2	2.83%	5.99%
SOUTHWEST MARSHALL	205502	SWM_115KV_C1	115	7401.0	9918.4	7610.4	10512.6	209.4	594.2	2.83%	5.99%
MARSHALL (EREP)	170500	MAET_115KV	115	6054.4	8204.3	6192.8	8608.4	138.4	404.1	2.29%	4.93%
MARSHALL (EREP)	170501	MAE_115KV	115	5529.1	7520.2	5643.5	7857.5	114.4	337.3	2.07%	4.49%
LYON COUNTY (NSPM)	168316	LYC_IB_TR09	115	17869.9	16494.8	18389.7	17172.1	519.8	677.3	2.91%	4.11%
LYON COUNTY (NSPM)	168315	LYC_IB_MSH	115	17869.9	16494.8	18389.7	17172.1	519.8	677.3	2.91%	4.11%
LYON COUNTY (NSPM)	168314	LYC_IB_LAY2	115	17869.9	16494.8	18389.7	17172.1	519.8	677.3	2.91%	4.11%
LYON COUNTY (NSPM)	168313	LYC_IB_LAY1	115	17869.9	16494.8	18389.7	17172.1	519.8	677.3	2.91%	4.11%
LYON COUNTY (NSPM)	168311	LYC_IB_CAP2	115	17869.9	16494.8	18389.7	17172.1	519.8	677.3	2.91%	4.11%
LYON COUNTY (NSPM)	168310	LYC_IB_CAP1	115	17869.9	16494.8	18389.7	17172.1	519.8	677.3	2.91%	4.11%
LYON COUNTY (NSPM)	168307	LYC_CAP	115	17869.9	16494.8	18389.7	17172.1	519.8	677.3	2.91%	4.11%
LYON COUNTY (NSPM)	168306	LYC_115KV_2	115	17869.9	16494.8	18389.7	17172.1	519.8	677.3	2.91%	4.11%
LYON COUNTY (NSPM)	168305	LYC_115KV_1	115	17869.9	16494.8	18389.7	17172.1	519.8	677.3	2.91%	4.11%
LYON COUNTY (NSPM)	168309	LYC_CAP2	115	16639.9	15471.5	17088.2	16062.5	448.3	591.0	2.69%	3.82%
LYON COUNTY (NSPM)	168308	LYC_CAP1	115	16639.9	15471.5	17088.2	16062.5	448.3	591.0	2.69%	3.82%
LAKE YANKTON (NSPM)	162315	LAY_IB_SWM	115	10565.9	10842.1	10726.5	11102.0	160.6	259.9	1.52%	2.40%
LAKE YANKTON (NSPM)	162314	LAY_IB_LYC2	115	10565.9	10842.1	10726.5	11102.0	160.6	259.9	1.52%	2.40%
LAKE YANKTON (NSPM)	162313	LAY_IB_LYC1	115	10565.9	10842.1	10726.5	11102.0	160.6	259.9	1.52%	2.40%
LAKE YANKTON (NSPM)	162312	LAY_IB_CHB	115	10565.9	10842.1	10726.5	11102.0	160.6	259.9	1.52%	2.40%
LAKE YANKTON (NSPM)	162311	LAY_IB_CAP4	115	10565.9	10842.1	10726.5	11102.0	160.6	259.9	1.52%	2.40%
LAKE YANKTON (NSPM)	162310	LAY_IB_CAP3	115	10565.9	10842.1	10726.5	11102.0	160.6	259.9	1.52%	2.40%
LAKE YANKTON (NSPM)	162309	LAY_IB_CAP2	115	10565.9	10842.1	10726.5	11102.0	160.6	259.9	1.52%	2.40%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J391

Substation	Faulted Bus			Benchmark Case without J391 Project		Study Case with J391 Project		Amps Change with J391 vs Benchmark		% Change with J391 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
LAKE YANKTON (NSPM)	162308	LAY_IB_CAP1	115	10565.9	10842.1	10726.5	11102.0	160.6	259.9	1.52%	2.40%
LAKE YANKTON (NSPM)	162307	LAY_IB_BRI	115	10565.9	10842.1	10726.5	11102.0	160.6	259.9	1.52%	2.40%
LAKE YANKTON (NSPM)	162306	LAY_CAP	115	10565.9	10842.1	10726.5	11102.0	160.6	259.9	1.52%	2.40%
LAKE YANKTON (NSPM)	162301	LAY_115KV_2	115	10565.9	10842.1	10726.5	11102.0	160.6	259.9	1.52%	2.40%
LAKE YANKTON (NSPM)	162300	LAY_115KV_1	115	10565.9	10842.1	10726.5	11102.0	160.6	259.9	1.52%	2.40%
LAKE YANKTON (NSPM)	162305	LAY_C4_115KV	115	10122.2	10375.9	10269.0	10613.1	146.8	237.2	1.45%	2.29%
LAKE YANKTON (NSPM)	162304	LAY_C3_115KV	115	10122.2	10375.9	10269.0	10613.1	146.8	237.2	1.45%	2.29%
LAKE YANKTON (NSPM)	162303	LAY_C2_115KV	115	10122.2	10375.9	10269.0	10613.1	146.8	237.2	1.45%	2.29%
LAKE YANKTON (NSPM)	162302	LAY_C1_115KV	115	10122.2	10375.9	10269.0	10613.1	146.8	237.2	1.45%	2.29%
LYON COUNTY (NSPM)	168304	LYC_IB_TR09	345	9133.8	10335.6	9216.0	10495.5	82.2	159.9	0.90%	1.55%
LYON COUNTY (NSPM)	168303	LYC_IB_CMT2	345	9133.8	10335.6	9216.0	10495.5	82.2	159.9	0.90%	1.55%
LYON COUNTY (NSPM)	168302	LYC_IB_BOK1	345	9133.8	10335.6	9216.0	10495.5	82.2	159.9	0.90%	1.55%
LYON COUNTY (NSPM)	168301	LYC_345KV_2	345	9133.8	10335.6	9216.0	10495.5	82.2	159.9	0.90%	1.55%
LYON COUNTY (NSPM)	168300	LYC_345KV_1	345	9133.8	10335.6	9216.0	10495.5	82.2	159.9	0.90%	1.55%
LYON COUNTY (NSPM)	168323	LYC_TR09_TER	34.5	0.0	15799.4	0.0	15997.1	0.0	197.7	0.00%	1.25%
LYON COUNTY (NSPM)	168322	LYC_IB_RB9	34.5	0.0	15799.4	0.0	15997.1	0.0	197.7	0.00%	1.25%
MARSHALL (EREP)	170502	MAE_69KV	69	3985.6	3865.7	4016.5	3912.0	30.9	46.3	0.78%	1.20%
LAKE YANKTON (NSPM)	162319	LAY_IB_TR01	34.5	14255.3	15576.9	14333.6	15725.8	78.3	148.9	0.55%	0.96%
LAKE YANKTON (NSPM)	162318	LAY_FDR311	34.5	14255.3	15576.9	14333.6	15725.8	78.3	148.9	0.55%	0.96%
LAKE YANKTON (NSPM)	162317	LAY_34_5KV	34.5	14255.3	15576.9	14333.6	15725.8	78.3	148.9	0.55%	0.96%
HAZEL CREEK (NSPM)	148702	HZC_IB_LYC	345	6640.3	7500.1	6676.6	7571.0	36.3	70.9	0.55%	0.95%
HAZEL CREEK (NSPM)	148700	HZC_345KV_1	345	6640.3	7500.1	6676.6	7571.0	36.3	70.9	0.55%	0.95%
ELLSBOROUGH (GRE)	133700	ELBT_115KV	115	5399.3	7487.8	5421.2	7556.5	21.9	68.7	0.41%	0.92%
ELLSBOROUGH (GRE)	133701	ELB_115KV	115	5393.5	7481.9	5415.3	7550.5	21.8	68.6	0.40%	0.92%
CEDAR MOUNTAIN (GRE)	119105	CMT_IB_TR01	345	8623.7	10886.1	8656.9	10967.6	33.2	81.5	0.38%	0.75%
CEDAR MOUNTAIN (GRE)	119104	CMT_IB_LYC2	345	8623.7	10886.1	8656.9	10967.6	33.2	81.5	0.38%	0.75%
CEDAR MOUNTAIN (GRE)	119103	CMT_IB_HNA2	345	8623.7	10886.1	8656.9	10967.6	33.2	81.5	0.38%	0.75%
CEDAR MOUNTAIN (GRE)	119102	CMT_IB_HNA1	345	8623.7	10886.1	8656.9	10967.6	33.2	81.5	0.38%	0.75%
CEDAR MOUNTAIN (GRE)	119101	CMT_345KV_2	345	8623.7	10886.1	8656.9	10967.6	33.2	81.5	0.38%	0.75%
CEDAR MOUNTAIN (GRE)	119100	CMT_345KV_1	345	8623.7	10886.1	8656.9	10967.6	33.2	81.5	0.38%	0.75%
LYON COUNTY (NSPM)	168321	LYC_IB_TSS	69	8909.0	8565.9	8951.1	8627.4	42.1	61.5	0.47%	0.72%
LYON COUNTY (NSPM)	168320	LYC_IB_TR01	69	8909.0	8565.9	8951.1	8627.4	42.1	61.5	0.47%	0.72%
LYON COUNTY (NSPM)	168319	LYC_IB_MNV	69	8909.0	8565.9	8951.1	8627.4	42.1	61.5	0.47%	0.72%
LYON COUNTY (NSPM)	168318	LYC_IB_MLY	69	8909.0	8565.9	8951.1	8627.4	42.1	61.5	0.47%	0.72%
LYON COUNTY (NSPM)	168317	LYC_69KV_1	69	8909.0	8565.9	8951.1	8627.4	42.1	61.5	0.47%	0.72%
GREEN VALLEY (OTP)	146100	GVY_69KV	69	7880.5	8085.9	7912.3	8139.5	31.8	53.6	0.40%	0.66%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J391

Substation	Faulted Bus			Benchmark Case without J391 Project		Study Case with J391 Project		Amps Change with J391 vs Benchmark		% Change with J391 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
GRANITE FALLS (WAPA)	145110	GRA_115KV	115	16933.0	16960.6	17002.0	17067.3	69.0	106.7	0.41%	0.63%
SOUTHWEST MARSHALL	205509	SWM_13_8KV_2	13.8	0.0	11206.3	0.0	11275.6	0.0	69.3	0.00%	0.62%
SOUTHWEST MARSHALL	205508	SWM_13_8KV_1	13.8	12242.8	11174.9	12292.9	11243.7	50.1	68.8	0.41%	0.62%
MINNESOTA VALLEY (NS	176504	MNV_230KV_6	230	13199.8	12461.0	13255.5	12536.6	55.7	75.6	0.42%	0.61%
MINNESOTA VALLEY (NS	176503	MNV_230KV_5	230	13199.8	12461.0	13255.5	12536.6	55.7	75.6	0.42%	0.61%
MINNESOTA VALLEY (NS	176502	MNV_230KV_2	230	13199.8	12461.0	13255.5	12536.6	55.7	75.6	0.42%	0.61%
MINNESOTA VALLEY (NS	176501	MNV_230KV_1	230	13199.8	12461.0	13255.5	12536.6	55.7	75.6	0.42%	0.61%
MINNESOTA VALLEY (NS	176500	MNVT_GRA_PTH	230	13112.2	12427.7	13167.0	12502.5	54.8	74.8	0.42%	0.60%
GRANITE FALLS (WAPA)	145109	GRA_IB_WTT	230	13471.7	12612.4	13528.3	12687.8	56.6	75.4	0.42%	0.60%
GRANITE FALLS (WAPA)	145108	GRA_IB_WMR	230	13471.7	12612.4	13528.3	12687.8	56.6	75.4	0.42%	0.60%
GRANITE FALLS (WAPA)	145107	GRA_IB_MOS	230	13471.7	12612.4	13528.3	12687.8	56.6	75.4	0.42%	0.60%
GRANITE FALLS (WAPA)	145106	GRA_IB_MNV2	230	13471.7	12612.4	13528.3	12687.8	56.6	75.4	0.42%	0.60%
GRANITE FALLS (WAPA)	145105	GRA_IB_MNV1	230	13471.7	12612.4	13528.3	12687.8	56.6	75.4	0.42%	0.60%
GRANITE FALLS (WAPA)	145104	GRA_IB_KV8A	230	13471.7	12612.4	13528.3	12687.8	56.6	75.4	0.42%	0.60%
GRANITE FALLS (WAPA)	145103	GRA_IB_KV3A	230	13471.7	12612.4	13528.3	12687.8	56.6	75.4	0.42%	0.60%
GRANITE FALLS (WAPA)	145102	GRA_IB_BAR	230	13471.7	12612.4	13528.3	12687.8	56.6	75.4	0.42%	0.60%
GRANITE FALLS (WAPA)	145101	GRA_230KV_2	230	13471.7	12612.4	13528.3	12687.8	56.6	75.4	0.42%	0.60%
GRANITE FALLS (WAPA)	145100	GRA_230KV_1	230	13471.7	12612.4	13528.3	12687.8	56.6	75.4	0.42%	0.60%
LAKE YANKTON (NSPM)	162322	LAY_TR01_TER	13.8	0.0	25669.2	0.0	25821.7	0.0	152.5	0.00%	0.59%
HAZEL CREEK (NSPM)	148705	HZC_IB_MNV	230	11142.8	11233.3	11185.7	11299.8	42.9	66.5	0.39%	0.59%
HAZEL CREEK (NSPM)	148703	HZC_230KV_1	230	11142.8	11233.3	11185.7	11299.8	42.9	66.5	0.39%	0.59%
BUFFALO RIDGE (NSPM)	114403	BRI_115KV_4	115	10071.7	9254.4	10112.0	9306.3	40.3	51.9	0.40%	0.56%
BUFFALO RIDGE (NSPM)	114402	BRI_115KV_3	115	10071.7	9254.4	10112.0	9306.3	40.3	51.9	0.40%	0.56%
BUFFALO RIDGE (NSPM)	114401	BRI_115KV_2	115	10071.7	9254.4	10112.0	9306.3	40.3	51.9	0.40%	0.56%
BUFFALO RIDGE (NSPM)	114400	BRI_115KV_1	115	10071.7	9254.4	10112.0	9306.3	40.3	51.9	0.40%	0.56%
BROOKINGS COUNTY (NS	113206	BOK_IB_WHI1	345	9860.1	10230.5	9894.6	10287.0	34.5	56.5	0.35%	0.55%
BROOKINGS COUNTY (NS	113205	BOK_IB_TR10	345	9860.1	10230.5	9894.6	10287.0	34.5	56.5	0.35%	0.55%
BROOKINGS COUNTY (NS	113204	BOK_IB_TR09	345	9860.1	10230.5	9894.6	10287.0	34.5	56.5	0.35%	0.55%
BROOKINGS COUNTY (NS	113201	BOK_345KV_2	345	9860.1	10230.5	9894.6	10287.0	34.5	56.5	0.35%	0.55%
BROOKINGS COUNTY (NS	113200	BOK_345KV_1	345	9860.1	10230.5	9894.6	10287.0	34.5	56.5	0.35%	0.55%
WHITE (WAPA)	225606	WHI_IB_WTT	345	9870.5	10247.6	9904.9	10304.0	34.4	56.4	0.35%	0.55%
WHITE (WAPA)	225605	WHI_IB_TR01	345	9870.5	10247.6	9904.9	10304.0	34.4	56.4	0.35%	0.55%
WHITE (WAPA)	225604	WHI_IB_SPK	345	9870.5	10247.6	9904.9	10304.0	34.4	56.4	0.35%	0.55%
WHITE (WAPA)	225603	WHI_IB_BOK2	345	9870.5	10247.6	9904.9	10304.0	34.4	56.4	0.35%	0.55%
WHITE (WAPA)	225602	WHI_IB_BOK1	345	9870.5	10247.6	9904.9	10304.0	34.4	56.4	0.35%	0.55%
WHITE (WAPA)	225601	WHI_345KV_2	345	9870.5	10247.6	9904.9	10304.0	34.4	56.4	0.35%	0.55%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J391

Substation	Faulted Bus			Benchmark Case without J391 Project		Study Case with J391 Project		Amps Change with J391 vs Benchmark		% Change with J391 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
WHITE (WAPA)	225600	WHI_345KV_1	345	9870.5	10247.6	9904.9	10304.0	34.4	56.4	0.35%	0.55%
LYON COUNTY (NSPM)	6051	J400_COL	34.5	8920.4	8682.9	8946.7	8724.3	26.3	41.4	0.29%	0.48%
MINNESOTA VALLEY (NS	176516	MNV_IB_TR06	115	17843.4	15997.0	17902.1	16069.2	58.7	72.2	0.33%	0.45%
MINNESOTA VALLEY (NS	176515	MNV_IB_TR05	115	17843.4	15997.0	17902.1	16069.2	58.7	72.2	0.33%	0.45%
MINNESOTA VALLEY (NS	176514	MNV_IB_MAT	115	17843.4	15997.0	17902.1	16069.2	58.7	72.2	0.33%	0.45%
MINNESOTA VALLEY (NS	176513	MNV_IB_GRA	115	17843.4	15997.0	17902.1	16069.2	58.7	72.2	0.33%	0.45%
MINNESOTA VALLEY (NS	176512	MNV_IB_FRA	115	17843.4	15997.0	17902.1	16069.2	58.7	72.2	0.33%	0.45%
MINNESOTA VALLEY (NS	176511	MNV_IB_CAP2	115	17843.4	15997.0	17902.1	16069.2	58.7	72.2	0.33%	0.45%
MINNESOTA VALLEY (NS	176510	MNV_IB_CAP1	115	17843.4	15997.0	17902.1	16069.2	58.7	72.2	0.33%	0.45%
MINNESOTA VALLEY (NS	176509	MNV_115KV_CB	115	17843.4	15997.0	17902.1	16069.2	58.7	72.2	0.33%	0.45%
MINNESOTA VALLEY (NS	176506	MNV_115KV_2	115	17843.4	15997.0	17902.1	16069.2	58.7	72.2	0.33%	0.45%
MINNESOTA VALLEY (NS	176505	MNV_115KV_1	115	17843.4	15997.0	17902.1	16069.2	58.7	72.2	0.33%	0.45%
MINNESOTA VALLEY (NS	176508	MNV_115KV_C2	115	16601.4	14993.5	16651.7	15056.4	50.3	62.9	0.30%	0.42%
MINNESOTA VALLEY (NS	176507	MNV_115KV_C1	115	16601.4	14993.5	16651.7	15056.4	50.3	62.9	0.30%	0.42%
CHANARAMBIE (NSPM)	120107	CHB_IB_TR04	115	10796.2	9437.7	10829.7	9476.9	33.5	39.2	0.31%	0.42%
CHANARAMBIE (NSPM)	120106	CHB_IB_TR03	115	10796.2	9437.7	10829.7	9476.9	33.5	39.2	0.31%	0.42%
CHANARAMBIE (NSPM)	120105	CHB_IB_TR02	115	10796.2	9437.7	10829.7	9476.9	33.5	39.2	0.31%	0.42%
CHANARAMBIE (NSPM)	120104	CHB_IB_PIP	115	10796.2	9437.7	10829.7	9476.9	33.5	39.2	0.31%	0.42%
CHANARAMBIE (NSPM)	120103	CHB_IB_LAY	115	10796.2	9437.7	10829.7	9476.9	33.5	39.2	0.31%	0.42%
CHANARAMBIE (NSPM)	120102	CHB_IB_FTN	115	10796.2	9437.7	10829.7	9476.9	33.5	39.2	0.31%	0.42%
CHANARAMBIE (NSPM)	120101	CHB_115KV_2	115	10796.2	9437.7	10829.7	9476.9	33.5	39.2	0.31%	0.42%
CHANARAMBIE (NSPM)	120100	CHB_115KV_1	115	10796.2	9437.7	10829.7	9476.9	33.5	39.2	0.31%	0.42%
ERIE ROAD (MARSHALL)	135601	ERD_13_8KV_1	13.8	7068.0	6881.9	7084.2	6910.3	16.2	28.4	0.23%	0.41%
ERIE ROAD (MARSHALL)	135602	ERD_13_8KV_2	13.8	7069.8	6885.4	7085.9	6913.8	16.1	28.4	0.23%	0.41%
BROOKINGS COUNTY (NS	113212	BOK_IB_YNK2	115	21001.1	19047.4	21063.4	19124.6	62.3	77.2	0.30%	0.41%
BROOKINGS COUNTY (NS	113211	BOK_IB_YNK1	115	21001.1	19047.4	21063.4	19124.6	62.3	77.2	0.30%	0.41%
BROOKINGS COUNTY (NS	113210	BOK_IB_TR10	115	21001.1	19047.4	21063.4	19124.6	62.3	77.2	0.30%	0.41%
BROOKINGS COUNTY (NS	113209	BOK_115KV_2	115	21001.1	19047.4	21063.4	19124.6	62.3	77.2	0.30%	0.41%
BROOKINGS COUNTY (NS	113208	BOK_115KV_1	115	21001.1	19047.4	21063.4	19124.6	62.3	77.2	0.30%	0.41%
YANKEE (NSPM)	229507	YNK_IB_TR02	115	11584.8	11979.0	11611.1	12021.8	26.3	42.8	0.23%	0.36%
YANKEE (NSPM)	229506	YNK_IB_TR01	115	11584.8	11979.0	11611.1	12021.8	26.3	42.8	0.23%	0.36%
YANKEE (NSPM)	229504	YNK_IB_BRI	115	11584.8	11979.0	11611.1	12021.8	26.3	42.8	0.23%	0.36%
YANKEE (NSPM)	229502	YNK_IB_BOK1	115	11584.8	11979.0	11611.1	12021.8	26.3	42.8	0.23%	0.36%
YANKEE (NSPM)	229501	YNK_115KV_2	115	11584.8	11979.0	11611.1	12021.8	26.3	42.8	0.23%	0.36%
YANKEE (NSPM)	229500	YNK_115KV_1	115	11584.8	11979.0	11611.1	12021.8	26.3	42.8	0.23%	0.36%
SOUTHEAST (MARSHALL)	205201	SEA_13_8KV_4	13.8	7169.6	6975.2	7183.2	6999.5	13.6	24.3	0.19%	0.35%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J391

Substation	Faulted Bus			Benchmark Case without J391 Project		Study Case with J391 Project		Amps Change with J391 vs Benchmark		% Change with J391 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
BUFFALO RIDGE (NSPM)	114450	BRI_IB_TR02	34.5	27308.7	20676.5	27391.0	20747.3	82.3	70.8	0.30%	0.34%
BUFFALO RIDGE (NSPM)	114449	BRI_IB_TR01	34.5	27308.7	20676.5	27391.0	20747.3	82.3	70.8	0.30%	0.34%
BUFFALO RIDGE (NSPM)	114448	BRI_FDR323	34.5	27308.7	20676.5	27391.0	20747.3	82.3	70.8	0.30%	0.34%
BUFFALO RIDGE (NSPM)	114447	BRI_FDR322	34.5	27308.7	20676.5	27391.0	20747.3	82.3	70.8	0.30%	0.34%
BUFFALO RIDGE (NSPM)	114446	BRI_FDR321	34.5	27308.7	20676.5	27391.0	20747.3	82.3	70.8	0.30%	0.34%
BUFFALO RIDGE (NSPM)	114445	BRI_FDR313	34.5	27308.7	20676.5	27391.0	20747.3	82.3	70.8	0.30%	0.34%
BUFFALO RIDGE (NSPM)	114444	BRI_FDR312	34.5	27308.7	20676.5	27391.0	20747.3	82.3	70.8	0.30%	0.34%
BUFFALO RIDGE (NSPM)	114443	BRI_FDR311	34.5	27308.7	20676.5	27391.0	20747.3	82.3	70.8	0.30%	0.34%
BUFFALO RIDGE (NSPM)	114436	BRI_34_5KV_2	34.5	27308.7	20676.5	27391.0	20747.3	82.3	70.8	0.30%	0.34%
BUFFALO RIDGE (NSPM)	114435	BRI_34_5KV_1	34.5	27308.7	20676.5	27391.0	20747.3	82.3	70.8	0.30%	0.34%
PIPESTONE (NSPM)	189603	PIP_IB_SPK	115	6267.0	7780.3	6275.4	7802.0	8.4	21.7	0.13%	0.28%
PIPESTONE (NSPM)	189602	PIP_IB_CHB	115	6267.0	7780.3	6275.4	7802.0	8.4	21.7	0.13%	0.28%
PIPESTONE (NSPM)	189601	PIP_IB_BRI	115	6267.0	7780.3	6275.4	7802.0	8.4	21.7	0.13%	0.28%
PIPESTONE (NSPM)	189600	PIP_115KV_1	115	6267.0	7780.3	6275.4	7802.0	8.4	21.7	0.13%	0.28%
CEDAR MOUNTAIN (GRE)	119106	CMT_115KV_1	115	15184.2	13591.2	15211.9	13625.4	27.7	34.2	0.18%	0.25%
WATERTOWN (WAPA)	221500	WTT_345KV	345	7985.4	8475.9	7997.5	8496.7	12.1	20.8	0.15%	0.25%
CHANARAMBIE (NSPM)	120130	CHB_IB_TR02	34.5	25012.9	19681.0	25063.2	19728.8	50.3	47.8	0.20%	0.24%
CHANARAMBIE (NSPM)	120129	CHB_IB_TR01	34.5	25012.9	19681.0	25063.2	19728.8	50.3	47.8	0.20%	0.24%
CHANARAMBIE (NSPM)	120123	CHB_FDR323	34.5	25012.9	19681.0	25063.2	19728.8	50.3	47.8	0.20%	0.24%
CHANARAMBIE (NSPM)	120122	CHB_FDR322	34.5	25012.9	19681.0	25063.2	19728.8	50.3	47.8	0.20%	0.24%
CHANARAMBIE (NSPM)	120121	CHB_FDR321	34.5	25012.9	19681.0	25063.2	19728.8	50.3	47.8	0.20%	0.24%
CHANARAMBIE (NSPM)	120120	CHB_FDR313	34.5	25012.9	19681.0	25063.2	19728.8	50.3	47.8	0.20%	0.24%
CHANARAMBIE (NSPM)	120119	CHB_FDR312	34.5	25012.9	19681.0	25063.2	19728.8	50.3	47.8	0.20%	0.24%
CHANARAMBIE (NSPM)	120117	CHB_FDR311	34.5	25012.9	19681.0	25063.2	19728.8	50.3	47.8	0.20%	0.24%
CHANARAMBIE (NSPM)	120109	CHB_34_5KV_2	34.5	25012.9	19681.0	25063.2	19728.8	50.3	47.8	0.20%	0.24%
CHANARAMBIE (NSPM)	120108	CHB_34_5KV_1	34.5	25012.9	19681.0	25063.2	19728.8	50.3	47.8	0.20%	0.24%
CHANARAMBIE (NSPM)	120132	CHB_IB_TR04	34.5	27360.4	22957.1	27410.5	23011.8	50.1	54.7	0.18%	0.24%
CHANARAMBIE (NSPM)	120131	CHB_IB_TR03	34.5	27360.4	22957.1	27410.5	23011.8	50.1	54.7	0.18%	0.24%
CHANARAMBIE (NSPM)	120127	CHB_FDR_CAP3	34.5	27360.4	22957.1	27410.5	23011.8	50.1	54.7	0.18%	0.24%
CHANARAMBIE (NSPM)	120126	CHB_FDR341	34.5	27360.4	22957.1	27410.5	23011.8	50.1	54.7	0.18%	0.24%
CHANARAMBIE (NSPM)	120125	CHB_FDR332	34.5	27360.4	22957.1	27410.5	23011.8	50.1	54.7	0.18%	0.24%
CHANARAMBIE (NSPM)	120124	CHB_FDR331	34.5	27360.4	22957.1	27410.5	23011.8	50.1	54.7	0.18%	0.24%
CHANARAMBIE (NSPM)	120111	CHB_34_5KV_4	34.5	27360.4	22957.1	27410.5	23011.8	50.1	54.7	0.18%	0.24%
CHANARAMBIE (NSPM)	120110	CHB_34_5KV_3	34.5	27360.4	22957.1	27410.5	23011.8	50.1	54.7	0.18%	0.24%
MILROY (REDWOOD)	175801	MLY_69KV_2	69	3034.6	4407.7	3036.7	4417.9	2.1	10.2	0.07%	0.23%
MILROY (REDWOOD)	175800	MLY_69KV_1	69	3034.6	4407.7	3036.7	4417.9	2.1	10.2	0.07%	0.23%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J391

Substation	Faulted Bus			Benchmark Case without J391 Project		Study Case with J391 Project		Amps Change with J391 vs Benchmark		% Change with J391 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
WATERTOWN (WAPA)	221501	WTT_230KV	230	11200.1	12521.0	11213.7	12547.5	13.6	26.5	0.12%	0.21%
LAKE YANKTON (NSPM)	162316	LAY_69KV_2	69	2392.9	2229.0	2395.8	2233.6	2.9	4.6	0.12%	0.21%
MARSHALL (EREP)	170503	MAE_13_8KV	13.8	0.0	5089.6	0.0	5099.6	0.0	10.0	0.00%	0.20%
HELENA (NSPM)	149406	HNA_IB_SSL	345	16899.3	21724.7	16915.8	21767.2	16.5	42.5	0.10%	0.20%
HELENA (NSPM)	149405	HNA_IB_CMT2	345	16899.3	21724.7	16915.8	21767.2	16.5	42.5	0.10%	0.20%
HELENA (NSPM)	149404	HNA_IB_CMT1	345	16899.3	21724.7	16915.8	21767.2	16.5	42.5	0.10%	0.20%
HELENA (NSPM)	149403	HNA_IB_CHA	345	16899.3	21724.7	16915.8	21767.2	16.5	42.5	0.10%	0.20%
HELENA (NSPM)	149402	HNA_IB_BLL	345	16899.3	21724.7	16915.8	21767.2	16.5	42.5	0.10%	0.20%
HELENA (NSPM)	149401	HNA_345KV_2	345	16899.3	21724.7	16915.8	21767.2	16.5	42.5	0.10%	0.20%
HELENA (NSPM)	149400	HNA_345KV_1	345	16899.3	21724.7	16915.8	21767.2	16.5	42.5	0.10%	0.20%
SARATOGA (MARSHALL)	199402	SAR_GEN01	13.8	14701.1	14170.3	14717.0	14197.3	15.9	27.0	0.11%	0.19%
SARATOGA (MARSHALL)	199401	SAR_FDR21	13.8	14701.1	14170.3	14717.0	14197.3	15.9	27.0	0.11%	0.19%
FRANKLIN (NSPM)	140104	FRA_IB_TR05	115	10237.0	11303.7	10247.4	11324.6	10.4	20.9	0.10%	0.18%
FRANKLIN (NSPM)	140103	FRA_IB_MNV	115	10237.0	11303.7	10247.4	11324.6	10.4	20.9	0.10%	0.18%
FRANKLIN (NSPM)	140102	FRA_IB_FTR	115	10237.0	11303.7	10247.4	11324.6	10.4	20.9	0.10%	0.18%
FRANKLIN (NSPM)	140101	FRA_115KV_2	115	10237.0	11303.7	10247.4	11324.6	10.4	20.9	0.10%	0.18%
FRANKLIN (NSPM)	140100	FRA_115KV_1	115	10237.0	11303.7	10247.4	11324.6	10.4	20.9	0.10%	0.18%
YELLOW MEDICINE (NSP	229700	YLM_69KV	69	2911.4	4264.5	2912.9	4272.3	1.5	7.8	0.05%	0.18%
MINNESOTA VALLEY (NS	176525	MNV_IB_TR12	69	10279.2	9505.7	10290.9	9521.9	11.7	16.2	0.11%	0.17%
MINNESOTA VALLEY (NS	176524	MNV_IB_TR11	69	10279.2	9505.7	10290.9	9521.9	11.7	16.2	0.11%	0.17%
MINNESOTA VALLEY (NS	176523	MNV_IB_TR02	69	10279.2	9505.7	10290.9	9521.9	11.7	16.2	0.11%	0.17%
MINNESOTA VALLEY (NS	176522	MNV_69KV_474	69	10279.2	9505.7	10290.9	9521.9	11.7	16.2	0.11%	0.17%
MINNESOTA VALLEY (NS	176521	MNV_69KV_473	69	10279.2	9505.7	10290.9	9521.9	11.7	16.2	0.11%	0.17%
MINNESOTA VALLEY (NS	176520	MNV_69KV_472	69	10279.2	9505.7	10290.9	9521.9	11.7	16.2	0.11%	0.17%
MINNESOTA VALLEY (NS	176519	MNV_69KV_470	69	10279.2	9505.7	10290.9	9521.9	11.7	16.2	0.11%	0.17%
MINNESOTA VALLEY (NS	176518	MNV_69KV_2	69	10279.2	9505.7	10290.9	9521.9	11.7	16.2	0.11%	0.17%
MINNESOTA VALLEY (NS	176517	MNV_69KV_1	69	10279.2	9505.7	10290.9	9521.9	11.7	16.2	0.11%	0.17%
WALNUT GROVE (REDWOO	220100	WLGV_69KV	69	2359.6	3329.1	2360.7	3334.7	1.1	5.6	0.05%	0.17%
FENTON (NSPM)	137608	FTN_IB_TR05	115	10068.1	10410.9	10078.2	10428.4	10.1	17.5	0.10%	0.17%
FENTON (NSPM)	137606	FTN_IB_NOB2	115	10068.1	10410.9	10078.2	10428.4	10.1	17.5	0.10%	0.17%
FENTON (NSPM)	137605	FTN_IB_NOB1	115	10068.1	10410.9	10078.2	10428.4	10.1	17.5	0.10%	0.17%
FENTON (NSPM)	137604	FTN_IB_CHB	115	10068.1	10410.9	10078.2	10428.4	10.1	17.5	0.10%	0.17%
FENTON (NSPM)	137603	FTN_115_TR02	115	10068.1	10410.9	10078.2	10428.4	10.1	17.5	0.10%	0.17%
FENTON (NSPM)	137602	FTN_115_TR01	115	10068.1	10410.9	10078.2	10428.4	10.1	17.5	0.10%	0.17%
FENTON (NSPM)	137601	FTN_115KV_2	115	10068.1	10410.9	10078.2	10428.4	10.1	17.5	0.10%	0.17%
FENTON (NSPM)	137600	FTN_115KV_1	115	10068.1	10410.9	10078.2	10428.4	10.1	17.5	0.10%	0.17%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J391

Substation	Faulted Bus			Benchmark Case without J391 Project		Study Case with J391 Project		Amps Change with J391 vs Benchmark		% Change with J391 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
WOOD LAKE TAP (NSPM)	228900	WDLT_69KV	69	2888.0	4228.2	2889.2	4235.1	1.2	6.9	0.04%	0.16%
BUFFALO RIDGE (NSPM)	114453	BRI_TR02_TER	13.8	0.0	28316.7	0.0	28362.8	0.0	46.1	0.00%	0.16%
BUFFALO RIDGE (NSPM)	114452	BRI_TR01_TER	13.8	0.0	28229.2	0.0	28275.0	0.0	45.8	0.00%	0.16%
GRANITE FALLS CITY (	145200	GRFT_69KV	69	8857.7	8785.9	8865.8	8799.3	8.1	13.4	0.09%	0.15%
PANTHER (GRE)	186502	PTH_IB_MNV	230	4907.4	6153.0	4910.8	6162.2	3.4	9.2	0.07%	0.15%
PANTHER (GRE)	186501	PTH_IB_MCL	230	4907.4	6153.0	4910.8	6162.2	3.4	9.2	0.07%	0.15%
PANTHER (GRE)	186500	PTH_230KV	230	4907.4	6153.0	4910.8	6162.2	3.4	9.2	0.07%	0.15%
WILLMAR (GRE)	226501	WMR_IB_PAT	230	4806.3	5485.5	4810.0	5493.5	3.7	8.0	0.08%	0.15%
WILLMAR (GRE)	226500	WMR_230KV	230	4806.3	5485.5	4810.0	5493.5	3.7	8.0	0.08%	0.15%
BLAIR (WAPA)	111300	BAR_230KV	230	5996.2	8461.1	5999.7	8473.3	3.5	12.2	0.06%	0.14%
MAYNARD XMSN (NSPM)	171703	MAT_IB_MNV	115	5891.8	7305.9	5895.5	7316.1	3.7	10.2	0.06%	0.14%
MAYNARD XMSN (NSPM)	171702	MAT_IB_BSN	115	5891.8	7305.9	5895.5	7316.1	3.7	10.2	0.06%	0.14%
MAYNARD XMSN (NSPM)	171700	MAT_115KV_1	115	5891.8	7305.9	5895.5	7316.1	3.7	10.2	0.06%	0.14%
TRACY SW STA (NSPM)	214401	TSS_69KV_C1	69	2157.5	3047.0	2158.2	3051.2	0.7	4.2	0.03%	0.14%
TRACY SW STA (NSPM)	214404	TSS_IB_LYC	69	2159.6	3051.2	2160.3	3055.4	0.7	4.2	0.03%	0.14%
TRACY SW STA (NSPM)	214403	TSS_IB_FTN	69	2159.6	3051.2	2160.3	3055.4	0.7	4.2	0.03%	0.14%
TRACY SW STA (NSPM)	214402	TSS_IB_CAP	69	2159.6	3051.2	2160.3	3055.4	0.7	4.2	0.03%	0.14%
TRACY SW STA (NSPM)	214400	TSS_69KV	69	2159.6	3051.2	2160.3	3055.4	0.7	4.2	0.03%	0.14%
GRANITE FALLS CITY (	145201	GRF_69KV	69	7483.2	7902.0	7488.5	7912.6	5.3	10.6	0.07%	0.13%
TRACY (NSPM)	214300	TRA_69KV	69	2062.3	2931.9	2062.9	2935.8	0.6	3.9	0.03%	0.13%
HONNER (EREPC)	152201	HNR_115KV	115	4290.9	6484.8	4292.4	6492.2	1.5	7.4	0.03%	0.11%
HONNER (EREPC)	152200	HNRT_115KV	115	4290.9	6484.8	4292.4	6492.2	1.5	7.4	0.03%	0.11%
BUSH PARK (MUNI)	115100	BUPT_69KV	69	6098.8	6683.8	6102.0	6691.0	3.2	7.2	0.05%	0.11%
SHERIDAN (GRE)	202200	SHDT_69KV	69	2126.2	3425.0	2126.4	3428.5	0.2	3.5	0.01%	0.10%
BUSH PARK (MUNI)	115101	BUP_69KV	69	5501.3	6252.6	5503.7	6258.7	2.4	6.1	0.04%	0.10%
LAKE SARAH (NOBLES)	162100	LSAT_69KV	69	1843.1	2715.9	1843.3	2718.5	0.2	2.6	0.01%	0.10%
GRANITE FALLS (WAPA)	145112	GRA_IB_KV8A	13.8	0.0	25948.4	0.0	25971.4	0.0	23.0	0.00%	0.09%
FRANKLIN (NSPM)	140116	FRA_IB_WNU	69	10696.2	10921.0	10701.1	10930.0	4.9	9.0	0.05%	0.08%
FRANKLIN (NSPM)	140115	FRA_IB_WIP	69	10696.2	10921.0	10701.1	10930.0	4.9	9.0	0.05%	0.08%
FRANKLIN (NSPM)	140114	FRA_IB_TR06	69	10696.2	10921.0	10701.1	10930.0	4.9	9.0	0.05%	0.08%
FRANKLIN (NSPM)	140113	FRA_IB_TR05	69	10696.2	10921.0	10701.1	10930.0	4.9	9.0	0.05%	0.08%
FRANKLIN (NSPM)	140112	FRA_IB_LYC	69	10696.2	10921.0	10701.1	10930.0	4.9	9.0	0.05%	0.08%
FRANKLIN (NSPM)	140111	FRA_IB_BIS	69	10696.2	10921.0	10701.1	10930.0	4.9	9.0	0.05%	0.08%
FRANKLIN (NSPM)	140110	FRA_IB_4N111	69	10696.2	10921.0	10701.1	10930.0	4.9	9.0	0.05%	0.08%
FRANKLIN (NSPM)	140107	FRA_69KV_2	69	10696.2	10921.0	10701.1	10930.0	4.9	9.0	0.05%	0.08%
FRANKLIN (NSPM)	140106	FRA_69KV_1	69	10696.2	10921.0	10701.1	10930.0	4.9	9.0	0.05%	0.08%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J391

Substation	Faulted Bus			Benchmark Case without J391 Project		Study Case with J391 Project		Amps Change with J391 vs Benchmark		% Change with J391 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
CEDAR MOUNTAIN (GRE)	119108	CMT_34_5KV_1	34.5	0.0	18192.3	0.0	18207.1	0.0	14.8	0.00%	0.08%
WATERTOWN (WAPA)	221502	WTT_115KV	115	12962.3	11824.0	12969.6	11833.6	7.3	9.6	0.06%	0.08%
WABASSO (GRE)	219202	WBS_SHD_RWO	69	2003.2	3274.5	2003.2	3276.9	0.0	2.4	0.00%	0.07%
TEPPEOTA (NSPM)	212600	TPO_69KV	69	1734.2	2584.3	1734.3	2586.1	0.1	1.8	0.01%	0.07%
CHANARAMBIE (NSPM)	120135	CHB_TR01_TER	13.8	0.0	19296.0	0.0	19309.2	0.0	13.2	0.00%	0.07%
CHANARAMBIE (NSPM)	120136	CHB_TR02_TER	13.8	0.0	19289.1	0.0	19302.2	0.0	13.1	0.00%	0.07%
PAYNESVILLE TRANSMIS	187100	PAT_230KV	230	4093.1	4103.4	4094.6	4106.1	1.5	2.7	0.04%	0.07%
CURRIE (NOB)	126800	CUR_69KV_1	69	1738.2	2586.2	1738.1	2587.8	-0.1	1.6	-0.01%	0.06%
MINNESOTA VALLEY (NS	176532	MNV_TR06_TER	13.8	0.0	25929.9	0.0	25945.6	0.0	15.7	0.00%	0.06%
MCLEOD (GRE)	172402	MCL_IB_PTH	230	4990.4	5995.0	4991.7	5998.6	1.3	3.6	0.03%	0.06%
MCLEOD (GRE)	172401	MCL_IB_BLL	230	4990.4	5995.0	4991.7	5998.6	1.3	3.6	0.03%	0.06%
MCLEOD (GRE)	172400	MCL_230KV	230	4990.4	5995.0	4991.7	5998.6	1.3	3.6	0.03%	0.06%
KERKHOVEN (GRE)	171701	MAT_BSN_WMR	115	4483.1	5810.5	4483.9	5813.9	0.8	3.4	0.02%	0.06%
BROOKINGS COUNTY (NS	113216	BOK_TR10_TER	13.8	0.0	30911.0	0.0	30927.6	0.0	16.6	0.00%	0.05%
MAYNARD XMSN (NSPM)	171706	MAT_IB_CLC	69	5009.1	5074.2	5010.2	5076.8	1.1	2.6	0.02%	0.05%
MAYNARD XMSN (NSPM)	171705	MAT_CLC_FIC	69	5009.1	5074.2	5010.2	5076.8	1.1	2.6	0.02%	0.05%
MAYNARD XMSN (NSPM)	171704	MAT_69KV_1	69	5009.1	5074.2	5010.2	5076.8	1.1	2.6	0.02%	0.05%
MAYNARD (NSPM)	171500	MYN_69KV	69	4889.9	5003.3	4891.0	5005.8	1.1	2.5	0.02%	0.05%
MAYNARD SS (NSPM)	171600	MSS_69KV	69	4669.8	5023.6	4670.7	5026.1	0.9	2.5	0.02%	0.05%
CHANARAMBIE (NSPM)	120137	CHB_TR03_TER	13.8	0.0	18762.5	0.0	18771.7	0.0	9.2	0.00%	0.05%
SLAYTON (NOBLES)	203500	SLT_69KV	69	2030.4	2881.5	2030.4	2882.9	0.0	1.4	0.00%	0.05%
SLAYTON WEST (NSPM)	203601	SLW_69KV	69	2054.3	2904.2	2054.3	2905.6	0.0	1.4	0.00%	0.05%
SLAYTON WEST (NSPM)	203600	SLWT_69KV	69	2060.4	2910.7	2060.4	2912.1	0.0	1.4	0.00%	0.05%
LAKE SARAH (NOBLES)	162101	LSA_69KV	69	1216.7	1879.0	1217.2	1879.9	0.5	0.9	0.04%	0.05%
MORRIS (WAPA)	178200	MOS_230KV	230	3805.7	4689.1	3806.3	4691.3	0.6	2.2	0.02%	0.05%
HADLEY (NSPM)	146800	HAD_69KV	69	2467.7	3278.9	2467.7	3280.4	0.0	1.5	0.00%	0.05%
BROOKINGS COUNTY (NS	113214	BOK_TR09_TER	34.5	0.0	10656.0	0.0	10660.7	0.0	4.7	0.00%	0.04%
BROOKINGS COUNTY (NS	113213	BOK_TR09_REA	34.5	0.0	10656.0	0.0	10660.7	0.0	4.7	0.00%	0.04%
SACRED HEART (NSPM)	198700	SCHT_69KV	69	2881.1	4172.8	2861.7	4174.5	-19.4	1.7	-0.67%	0.04%
CHANARAMBIE (NSPM)	120138	CHB_TR04_TER	13.8	0.0	16687.7	0.0	16694.2	0.0	6.5	0.00%	0.04%
SACRED HEART (NSPM)	198701	SCH_69KV	69	2851.4	4133.0	2832.3	4134.6	-19.1	1.6	-0.67%	0.04%
WILLMAR (GRE)	226503	WMR_IB_MAT	115	4543.7	4736.9	4544.5	4738.7	0.8	1.8	0.02%	0.04%
WILLMAR (GRE)	226502	WMR_115KV	115	4543.7	4736.9	4544.5	4738.7	0.8	1.8	0.02%	0.04%
BIG STONE (OTP)	109601	BST_230KV	230	9405.8	7494.3	9408.6	7497.1	2.8	2.8	0.03%	0.04%
WILLMAR (GRE)	226504	WMR_69KV	69	9567.2	8843.8	9569.3	8847.1	2.1	3.3	0.02%	0.04%
WABASSO (GRE)	219201	WBS_69KV	69	1970.5	3291.4	1971.1	3292.6	0.6	1.2	0.03%	0.04%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J391

Substation	Faulted Bus			Benchmark Case without J391 Project		Study Case with J391 Project		Amps Change with J391 vs Benchmark		% Change with J391 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
PANTHER (GRE)	186505	PTH_IB_TR06	69	7083.4	6926.8	7084.7	6929.3	1.3	2.5	0.02%	0.04%
PANTHER (GRE)	186504	PTH_69KV_2	69	7083.4	6926.8	7084.7	6929.3	1.3	2.5	0.02%	0.04%
PANTHER (GRE)	186503	PTH_69KV_1	69	7083.4	6926.8	7084.7	6929.3	1.3	2.5	0.02%	0.04%
MINNESOTA VALLEY (NS	176531	MNV_TR05_TER	13.8	0.0	19096.1	0.0	19102.9	0.0	6.8	0.00%	0.04%
HAZEL CREEK (NSPM)	148707	HZC_TR09_TER	13.8	0.0	21491.9	0.0	21499.1	0.0	7.2	0.00%	0.03%
HAZEL CREEK (NSPM)	148706	HZC_IB_RB9	13.8	0.0	21491.9	0.0	21499.1	0.0	7.2	0.00%	0.03%
LYON COUNTY (NSPM)	168325	LYC_TR01_TER	13.8	0.0	6488.6	0.0	6490.7	0.0	2.1	0.00%	0.03%
HURON (WAPA)	153200	HRN_230KV	230	8053.1	8922.6	8054.4	8925.3	1.3	2.7	0.02%	0.03%
WILLMAR SOUTH (WMU)	226800	WMS_69KV	69	7165.9	7649.8	7166.7	7652.1	0.8	2.3	0.01%	0.03%
TRACY SW STA (NSPM)	214406	TSS_FDR61	13.8	2167.3	2068.7	2167.7	2069.3	0.4	0.6	0.02%	0.03%
TRACY SW STA (NSPM)	214405	TSS_13_8KV	13.8	2167.3	2068.7	2167.7	2069.3	0.4	0.6	0.02%	0.03%
FORT RIDGELY (NSPM)	139710	FTR_IB_WNU	115	5173.9	6077.5	5174.3	6079.2	0.4	1.7	0.01%	0.03%
FORT RIDGELY (NSPM)	139709	FTR_IB_WLM	115	5173.9	6077.5	5174.3	6079.2	0.4	1.7	0.01%	0.03%
FORT RIDGELY (NSPM)	139708	FTR_IB_FRA	115	5173.9	6077.5	5174.3	6079.2	0.4	1.7	0.01%	0.03%
FORT RIDGELY (NSPM)	139707	FTR_IB_CAP2	115	5173.9	6077.5	5174.3	6079.2	0.4	1.7	0.01%	0.03%
FORT RIDGELY (NSPM)	139706	FTR_IB_CAP1	115	5173.9	6077.5	5174.3	6079.2	0.4	1.7	0.01%	0.03%
FORT RIDGELY (NSPM)	139705	FTR_IB_C2	115	5173.9	6077.5	5174.3	6079.2	0.4	1.7	0.01%	0.03%
FORT RIDGELY (NSPM)	139704	FTR_IB_C1	115	5173.9	6077.5	5174.3	6079.2	0.4	1.7	0.01%	0.03%
FORT RIDGELY (NSPM)	139701	FTR_115KV_2	115	5173.9	6077.5	5174.3	6079.2	0.4	1.7	0.01%	0.03%
FORT RIDGELY (NSPM)	139700	FTR_115KV_1	115	5173.9	6077.5	5174.3	6079.2	0.4	1.7	0.01%	0.03%
WATERTOWN (WAPA)	221503	WTT_TR01_TER	13.8	0.0	36591.6	0.0	36601.5	0.0	9.9	0.00%	0.03%
YELLOW MEDICINE (NSP	229702	YLM_FDR211	23	939.2	1122.9	939.3	1123.2	0.1	0.3	0.01%	0.03%
KERKHOVEN (GRE)	158900	KER_115KV_1	115	3183.6	4538.5	3184.3	4539.6	0.7	1.1	0.02%	0.02%
WATERBURY (GRE)	221304	WRB_IB_SMM	69	2089.0	3511.3	2089.4	3512.1	0.4	0.8	0.02%	0.02%
WATERBURY (GRE)	221303	WRB_IB_LYC	69	2089.0	3511.3	2089.4	3512.1	0.4	0.8	0.02%	0.02%
WATERBURY (GRE)	221302	WRB_IB_JHN	69	2089.0	3511.3	2089.4	3512.1	0.4	0.8	0.02%	0.02%
WATERBURY (GRE)	221301	WRB_IB_DOT	69	2089.0	3511.3	2089.4	3512.1	0.4	0.8	0.02%	0.02%
WATERBURY (GRE)	221300	WRB_69KV_1	69	2089.0	3511.3	2089.4	3512.1	0.4	0.8	0.02%	0.02%
TROY SW STA (NSPM)	215703	TRS_IB_MNV	69	2989.5	4405.7	2990.2	4406.7	0.7	1.0	0.02%	0.02%
TROY SW STA (NSPM)	215702	TRS_IB_FRA	69	2989.5	4405.7	2990.2	4406.7	0.7	1.0	0.02%	0.02%
TROY SW STA (NSPM)	215701	TRS_IB_BIS	69	2989.5	4405.7	2990.2	4406.7	0.7	1.0	0.02%	0.02%
TROY SW STA (NSPM)	215700	TRS_69KV	69	2989.5	4405.7	2990.2	4406.7	0.7	1.0	0.02%	0.02%
CANBY (OTP)	116901	CBY_115KV	115	3061.2	4123.5	3061.8	4124.4	0.6	0.9	0.02%	0.02%
GREEN VALLEY (OTP)	146102	GVY_12_5KV	12.5	1502.9	1486.2	1503.1	1486.5	0.2	0.3	0.01%	0.02%
BIG STONE (OTP)	109602	BST_115KV	115	11626.3	9764.4	11627.8	9766.2	1.5	1.8	0.01%	0.02%
DANUBE (NSPM)	127200	DAN_69KV	69	2627.8	3917.2	2628.3	3917.9	0.5	0.7	0.02%	0.02%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J391

Substation	Faulted Bus			Benchmark Case without J391 Project		Study Case with J391 Project		Amps Change with J391 vs Benchmark		% Change with J391 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
TORONTO (OTP)	214000	TOR_115KV	115	2803.4	3819.7	2803.9	3820.3	0.5	0.6	0.02%	0.02%
RENVILLE (NSPM)	194100	RNV_69KV	69	2255.4	3397.5	2255.9	3398.0	0.5	0.5	0.02%	0.01%
EMMET TAP (EREP)	135100	ETPT_69KV	69	2258.0	3402.8	2258.5	3403.3	0.5	0.5	0.02%	0.01%
CROOKS (RS)	125800	CKS_69KV	69	2271.3	3428.6	2271.8	3429.1	0.5	0.5	0.02%	0.01%
TRACY (NSPM)	214303	TRA_FDR02	4.16	3522.0	3431.6	3522.3	3432.1	0.3	0.5	0.01%	0.01%
TRACY (NSPM)	214302	TRA_FDR01	4.16	3522.0	3431.6	3522.3	3432.1	0.3	0.5	0.01%	0.01%
TRACY (NSPM)	214301	TRA_4_16KV	4.16	3522.0	3431.6	3522.3	3432.1	0.3	0.5	0.01%	0.01%
GRANITE FALLS CITY (	145202	GRF_4_16KV	4.16	11305.7	10993.3	11306.8	10994.9	1.1	1.6	0.01%	0.01%
CROOKS TAP (NSPM)	125901	CKT_IB_CAP1	69	2298.8	3465.0	2299.2	3465.5	0.4	0.5	0.02%	0.01%
CROOKS TAP (NSPM)	125900	CKTT_69KV	69	2298.8	3465.0	2299.2	3465.5	0.4	0.5	0.02%	0.01%
MAYNARD XMSN (NSPM)	171707	MAT_TR01_TER	13.8	0.0	4264.1	0.0	4264.7	0.0	0.6	0.00%	0.01%
CLARA CITY (NSPM)	122100	CLC_69KV	69	2196.6	2866.1	2197.2	2866.5	0.6	0.4	0.03%	0.01%
SUGAR BEET PLANT (ER	210102	SBP_PLANT	4.16	18105.1	16534.5	18106.9	16536.6	1.8	2.1	0.01%	0.01%
EMMET (RS)	135000	EMT_69KV	69	2080.9	3161.7	2081.3	3162.1	0.4	0.4	0.02%	0.01%
EMMET (NSPM)	134901	EMM_IB_CAP1	69	2080.9	3161.7	2081.3	3162.1	0.4	0.4	0.02%	0.01%
EMMET (NSPM)	134900	EMM_69KV	69	2080.9	3161.7	2081.3	3162.1	0.4	0.4	0.02%	0.01%
MONTEVIDEO (NSPM)	177408	MTV_FDR03	4.16	10125.3	8978.0	10126.3	8979.1	1.0	1.1	0.01%	0.01%
MONTEVIDEO (NSPM)	177407	MTV_FDR02	4.16	10125.3	8978.0	10126.3	8979.1	1.0	1.1	0.01%	0.01%
MONTEVIDEO (NSPM)	177406	MTV_FDR01	4.16	10125.3	8978.0	10126.3	8979.1	1.0	1.1	0.01%	0.01%
MONTEVIDEO (NSPM)	177405	MTV_4_2KV	4.16	10125.3	8978.0	10126.3	8979.1	1.0	1.1	0.01%	0.01%
SUGAR BEET PLANT (ER	210100	SBP_FUSE	69	2169.4	3290.6	2169.8	3291.0	0.4	0.4	0.02%	0.01%
CROOKS (RS)	125801	CKS_12_5KV	12.5	4643.7	4153.2	4644.1	4153.7	0.4	0.5	0.01%	0.01%
CLARA CITY (NSPM)	122102	CLC_FDR221	23.9	2897.1	2511.6	2897.4	2511.9	0.3	0.3	0.01%	0.01%
CLARA CITY (NSPM)	122101	CLC_23_9KV	23.9	2897.1	2511.6	2897.4	2511.9	0.3	0.3	0.01%	0.01%
CANBY (OTP)	116902	CBY_41_6KV	41.6	377.6	867.9	377.6	868.0	0.0	0.1	0.00%	0.01%
FRANKLIN (NSPM)	140121	FRA_TR06_TER	13.8	0.0	5749.9	0.0	5750.5	0.0	0.6	0.00%	0.01%
FRANKLIN (NSPM)	140120	FRA_TR05_TER	13.8	0.0	5063.8	0.0	5064.3	0.0	0.5	0.00%	0.01%
HONNER (EREPC)	152202	HNR_12_5KV	12.5	4372.7	4070.1	4373.0	4070.5	0.3	0.4	0.01%	0.01%
SUGAR BEET PLANT (ER	210101	SBP_MAIN	69	2076.2	3163.4	2076.6	3163.7	0.4	0.3	0.02%	0.01%
WILLMAR (GRE)	226505	WMR_TR01_TER	12.5	0.0	7528.9	0.0	7529.6	0.0	0.7	0.00%	0.01%
MARIETTA (OTP)	170300	MTA_115KV	115	3688.1	3781.9	3688.7	3782.2	0.6	0.3	0.02%	0.01%
CLARA CITY (NSPM)	122105	CLC_FDR22	12.5	2858.1	2588.3	2858.3	2588.5	0.2	0.2	0.01%	0.01%
CLARA CITY (NSPM)	122104	CLC_FDR21	12.5	2858.1	2588.3	2858.3	2588.5	0.2	0.2	0.01%	0.01%
CLARA CITY (NSPM)	122103	CLC_12_5KV	12.5	2858.1	2588.3	2858.3	2588.5	0.2	0.2	0.01%	0.01%
RENVILLE (NSPM)	194102	RNV_FDR21	12.5	2984.0	2831.7	2984.2	2831.9	0.2	0.2	0.01%	0.01%
RENVILLE (NSPM)	194101	RNV_12_5KV	12.5	2984.0	2831.7	2984.2	2831.9	0.2	0.2	0.01%	0.01%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J391

Substation	Faulted Bus			Benchmark Case without J391 Project		Study Case with J391 Project		Amps Change with J391 vs Benchmark		% Change with J391 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
ORTONVILLE (OTP)	185601	OVL_115KV	115	6770.3	7119.8	6770.4	7120.3	0.1	0.5	0.00%	0.01%
SACRED HEART (NSPM)	198703	SCH_FDR211	23	1775.3	1457.9	1775.4	1458.0	0.1	0.1	0.01%	0.01%
SACRED HEART (NSPM)	198702	SCH_23KV	23	1775.3	1457.9	1775.4	1458.0	0.1	0.1	0.01%	0.01%
DANUBE (NSPM)	127202	DAN_FDR21	12.5	3387.5	3092.9	3387.7	3093.1	0.2	0.2	0.01%	0.01%
DANUBE (NSPM)	127201	DAN_12_5KV	12.5	3387.5	3092.9	3387.7	3093.1	0.2	0.2	0.01%	0.01%
SACRED HEART (NSPM)	198706	SCH_FDR01	4.16	4229.1	4961.4	4229.2	4961.7	0.1	0.3	0.00%	0.01%
SACRED HEART (NSPM)	198705	SCH_4_16KV	4.16	4229.1	4961.4	4229.2	4961.7	0.1	0.3	0.00%	0.01%
MONTEVIDEO (NSPM)	177404	MTV_FDR22	12.5	2267.1	2042.5	2267.2	2042.6	0.1	0.1	0.00%	0.00%
MONTEVIDEO (NSPM)	177403	MTV_FDR21	12.5	2267.1	2042.5	2267.2	2042.6	0.1	0.1	0.00%	0.00%
MONTEVIDEO (NSPM)	177402	MTV_12_5KV	12.5	2267.1	2042.5	2267.2	2042.6	0.1	0.1	0.00%	0.00%
FIESTA CITY (NSPM)	137804	FIC_IB_CAP	69	1632.8	2282.2	1633.1	2282.3	0.3	0.1	0.02%	0.00%
FIESTA CITY (NSPM)	137803	FIC_69KV	69	1632.8	2282.2	1633.1	2282.3	0.3	0.1	0.02%	0.00%
FIESTA CITY (NSPM)	137800	FICT_69KV_1	69	1643.0	2293.3	1643.3	2293.4	0.3	0.1	0.02%	0.00%
WATERTOWN (WAPA)	221505	WTT_TR03_TER	13.8	0.0	20295.0	0.0	20295.5	0.0	0.5	0.00%	0.00%
HUTCHINSON (MUNI)	153408	HUT_IB_WMR	69	8045.3	8277.9	8045.9	8278.1	0.6	0.2	0.01%	0.00%
HUTCHINSON (MUNI)	153407	HUT_IB_WIP	69	8045.3	8277.9	8045.9	8278.1	0.6	0.2	0.01%	0.00%
HUTCHINSON (MUNI)	153406	HUT_IB_VCT	69	8045.3	8277.9	8045.9	8278.1	0.6	0.2	0.01%	0.00%
HUTCHINSON (MUNI)	153405	HUT_IB_TR01	69	8045.3	8277.9	8045.9	8278.1	0.6	0.2	0.01%	0.00%
HUTCHINSON (MUNI)	153404	HUT_69KV	69	8045.3	8277.9	8045.9	8278.1	0.6	0.2	0.01%	0.00%
WATERTOWN (WAPA)	221504	WTT_TR02_TER	13.8	0.0	20302.8	0.0	20303.2	0.0	0.4	0.00%	0.00%
BENSON (OTP)	108703	BSN_115KV_4	115	4705.9	5117.8	4706.3	5117.9	0.4	0.1	0.01%	0.00%
BENSON (OTP)	108702	BSN_115KV_3	115	4705.9	5117.8	4706.3	5117.9	0.4	0.1	0.01%	0.00%
BENSON (OTP)	108701	BSN_115KV_2	115	4705.9	5117.8	4706.3	5117.9	0.4	0.1	0.01%	0.00%
BENSON (OTP)	108700	BSN_115KV_1	115	4705.9	5117.8	4706.3	5117.9	0.4	0.1	0.01%	0.00%
FARGO (WAPA)	136700	FAR_230KV	230	9433.3	9320.4	9433.5	9320.5	0.2	0.1	0.00%	0.00%
MAYNARD (NSPM)	171502	MYN_FDR21	12.5	1625.5	1520.3	1625.6	1520.3	0.1	0.0	0.01%	0.00%
MAYNARD (NSPM)	171501	MYN_12_5KV	12.5	1625.5	1520.3	1625.6	1520.3	0.1	0.0	0.01%	0.00%
MONTEVIDEO (NSPM)	177400	MTV_69KV	69	1847.9	1918.2	1848.4	1918.2	0.5	0.0	0.03%	0.00%
MILROY (REDWOOD)	175803	MLY_12_5KV_2	12.5	574.1	569.8	574.1	569.8	0.0	0.0	0.00%	0.00%
MILROY (REDWOOD)	175802	MLY_12_5KV_1	12.5	574.1	569.8	574.1	569.8	0.0	0.0	0.00%	0.00%
KANDIYOHI (GRE)	157800	KDIT_69KV	69	2125.8	3135.2	2126.1	3135.2	0.3	0.0	0.01%	0.00%
JOHNSONVILLE (GRE)	157500	JHN_69KV_1	69	1262.4	2047.0	1262.6	2047.0	0.2	0.0	0.02%	0.00%
GREEN VALLEY (OTP)	146101	GVY_41_6KV	41.6	546.3	378.0	546.3	378.0	0.0	0.0	0.00%	0.00%
SPICER (GRE)	206000	SPIT_69KV_1	69	1681.6	2569.1	1681.7	2569.1	0.1	0.0	0.01%	0.00%
FIESTA CITY (NSPM)	137802	FICT_69KV_3	69	1609.4	1752.3	1609.8	1752.3	0.4	0.0	0.02%	0.00%
BIG STONE (OTP)	109604	BST_TR01_TER	13.8	0.0	27817.9	0.0	27817.7	0.0	-0.2	0.00%	0.00%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J391

Substation	Faulted Bus			Benchmark Case without J391 Project		Study Case with J391 Project		Amps Change with J391 vs Benchmark		% Change with J391 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
WILLMAR (GRE)	226506	WMR_TR02_TER	12.5	0.0	16767.8	0.0	16767.6	0.0	-0.2	0.00%	0.00%
SUMMIT (GRE)	210300	SMM_69KV_1	69	2552.3	4455.3	2552.5	4455.2	0.2	-0.1	0.01%	0.00%
LAKE YANKTON (NSPM)	162321	LAY_FDR61	13.8	3693.1	3260.0	3695.6	3259.9	2.5	-0.1	0.07%	0.00%
LAKE YANKTON (NSPM)	162320	LAY_13_8KV	13.8	3693.1	3260.0	3695.6	3259.9	2.5	-0.1	0.07%	0.00%
GRANITE FALLS (WAPA)	145111	GRA_IB_KV3A	13.8	0.0	5586.1	0.0	5585.8	0.0	-0.3	0.00%	-0.01%
PANTHER (GRE)	186506	PTH_TR06_TER	13.8	0.0	9742.2	0.0	9741.6	0.0	-0.6	0.00%	-0.01%
DOTSON (GRE)	129200	DOT_69KV_1	69	1864.4	3078.9	1864.5	3078.7	0.1	-0.2	0.01%	-0.01%
YELLOW MEDICINE (NSP	229701	YLM_23KV	23	2921.1	2752.4	2922.2	2752.2	1.1	-0.2	0.04%	-0.01%
SLAYTON WEST (NSPM)	203605	SLW_FDR62	13.8	4933.2	4323.2	4934.2	4322.5	1.0	-0.7	0.02%	-0.02%
SLAYTON WEST (NSPM)	203603	SLW_FDR61	13.8	4933.2	4323.2	4934.2	4322.5	1.0	-0.7	0.02%	-0.02%
SLAYTON WEST (NSPM)	203602	SLW_13_8KV_1	13.8	4933.2	4323.2	4934.2	4322.5	1.0	-0.7	0.02%	-0.02%
MINNESOTA VALLEY (NS	176533	MNV_TR11_TER	13.8	0.0	4858.2	0.0	4857.4	0.0	-0.8	0.00%	-0.02%
MINNESOTA VALLEY (NS	176534	MNV_TR12_TER	13.8	0.0	4631.3	0.0	4630.5	0.0	-0.8	0.00%	-0.02%
MINNESOTA VALLEY (NS	176527	MNV_FDR211	23.9	2919.1	2822.9	2919.5	2822.4	0.4	-0.5	0.01%	-0.02%
MINNESOTA VALLEY (NS	176526	MNV_23_9KV_1	23.9	2919.1	2822.9	2919.5	2822.4	0.4	-0.5	0.01%	-0.02%
YELLOW MEDICINE (NSP	229704	YLM_FDR212	23	1527.5	1878.9	1527.8	1878.5	0.3	-0.4	0.02%	-0.02%
LAKE YANKTON (NSPM)	162323	LAY_TR02_TER	13.8	0.0	2628.7	0.0	2628.1	0.0	-0.6	0.00%	-0.02%
ELLSBOROUGH (GRE)	133703	ELB_FDR01	12.5	3182.7	3176.9	3183.6	3176.1	0.9	-0.8	0.03%	-0.03%
ELLSBOROUGH (GRE)	133702	ELB_12_5KV	12.5	3196.7	3190.8	3197.7	3189.9	1.0	-0.9	0.03%	-0.03%
NORTH SEVENTH STREET	58071	J391_TAP	115	-	-	8086.2	10539.2				
NORTH SEVENTH STREET	58070	J391_GEN	13.8	-	-	32890.5	30228.2				

J400 Short Circuit Study

Introduction

A short circuit analysis was performed by Siemens PTI to assess impact of the J400 generating facility (solar PV) on the adequacy of existing circuit breakers and related equipment in the Study Project area.

Short Circuit Model

A CAPE short circuit database including positive, negative and zero sequence parameters of the Xcel system and its neighboring systems was provided by the MISO. This starting short circuit model is listed below:

- Short Circuit Model: "NSP_1_5_2016.GDB"

The J400 short circuit study model was developed as follows:

- Applied MRES provided response file to update model in the Marshall area.
- Added J391, J426 generating facilities with online status.
- Added the J400 generating facility with its sequence parameters at Lyon County 115 kV substation. The associated 115-34.5 kV GSU (Z=7.5% at 39 MVA, X/R is 17.6, YG-YG) and 34.5-0.342 kV pad mount transformers (Z=6% at 63 MVA, X/R is 7.1, D-YG) were also added.
- Per CAPE's manual, solar generation project should be modeled the same way as Type 4 wind generation. The J400 solar project was modeled as Type 4 controlled power and current-limited generator. The project has the maximum fault current limit of 400 amps at 115 kV side of the transformer. For Type 4 machine (current-limited generator), the shunt impedance is not required in the model because the power and voltage determine the current.

Short Circuit Analysis

Short circuit analysis was performed on the study case (with the J400 project) and benchmark case (without the J400 project). Classical short circuit solution option was used in the calculation. The following fault simulation options were used in the short circuit analysis:

- Prefault voltage was set to "1.00 per unit with multiplier of 1"
- Current limited generator set to "Enforce machine current limits"
- All loads, shunts and transformer magnetizing branches were ignored.

Buses within 8-bus distance from the POI of J400 project were considered as the Study Project area. Three-phase (3PH) and Single Line to Ground (SLG) faults were simulated in the Study Project area. The results of short circuit currents with J400 (study case) and without J400 (benchmark case) are listed in the below Table.

With addition of the J400 generating facility, the maximum increase in the 3PH short circuit current is 2.57% (400.7 amps) at Lyon County 34.5 kV substation bus and 2.38% (373.4

amps) at the Lyon County 115 kV substation bus. The maximum increase in the SLG short circuit current is 2.37% (425.5 amps) at the Lyon County 115 kV substation bus.

Summary of Short Circuit Analysis

As shown in the below Table, the change in fault current at buses around the Study Project area is relatively small. Based on the Transmission Owner's short circuit criteria, interconnection of the J400 generation project does not cause any Transmission Owner short circuit constraints.

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
LYON COUNTY (NSPM)	168323	LYC_TR09_TER	34.5	0.0	15596.4	0.0	15997.1	0.0	400.7	0.00%	2.57%
LYON COUNTY (NSPM)	168322	LYC_IB_RB9	34.5	0.0	15596.4	0.0	15997.1	0.0	400.7	0.00%	2.57%
LYON COUNTY (NSPM)	168309	LYC_CAP2	115	16692.8	15689.1	17088.2	16062.5	395.4	373.4	2.37%	2.38%
LYON COUNTY (NSPM)	168308	LYC_CAP1	115	16692.8	15689.1	17088.2	16062.5	395.4	373.4	2.37%	2.38%
LYON COUNTY (NSPM)	168316	LYC_IB_TR09	115	17964.2	16806.8	18389.7	17172.1	425.5	365.3	2.37%	2.17%
LYON COUNTY (NSPM)	168315	LYC_IB_MSH	115	17964.2	16806.8	18389.7	17172.1	425.5	365.3	2.37%	2.17%
LYON COUNTY (NSPM)	168314	LYC_IB_LAY2	115	17964.2	16806.8	18389.7	17172.1	425.5	365.3	2.37%	2.17%
LYON COUNTY (NSPM)	168313	LYC_IB_LAY1	115	17964.2	16806.8	18389.7	17172.1	425.5	365.3	2.37%	2.17%
LYON COUNTY (NSPM)	168311	LYC_IB_CAP2	115	17964.2	16806.8	18389.7	17172.1	425.5	365.3	2.37%	2.17%
LYON COUNTY (NSPM)	168310	LYC_IB_CAP1	115	17964.2	16806.8	18389.7	17172.1	425.5	365.3	2.37%	2.17%
LYON COUNTY (NSPM)	168307	LYC_CAP	115	17964.2	16806.8	18389.7	17172.1	425.5	365.3	2.37%	2.17%
LYON COUNTY (NSPM)	168306	LYC_115KV_2	115	17964.2	16806.8	18389.7	17172.1	425.5	365.3	2.37%	2.17%
LYON COUNTY (NSPM)	168305	LYC_115KV_1	115	17964.2	16806.8	18389.7	17172.1	425.5	365.3	2.37%	2.17%
SOUTHEAST (MARSHALL)	205201	SEA_13_8KV_4	13.8	7044.6	6864.4	7183.2	6999.5	138.6	135.1	1.97%	1.97%
MARSHALL SW STATION	170603	MSH_IB_SEA	115	9586.9	12303.5	9778.7	12545.6	191.8	242.1	2.00%	1.97%
MARSHALL SW STATION	170602	MSH_IB_NSV	115	9586.9	12303.5	9778.7	12545.6	191.8	242.1	2.00%	1.97%
MARSHALL SW STATION	170601	MSH_IB_LYC	115	9586.9	12303.5	9778.7	12545.6	191.8	242.1	2.00%	1.97%
MARSHALL SW STATION	170600	MSH_115KV	115	9586.9	12303.5	9778.7	12545.6	191.8	242.1	2.00%	1.97%
SOUTHEAST (MARSHALL)	205200	SEA_115KV	115	8039.9	10800.6	8197.8	11010.1	157.9	209.5	1.96%	1.94%
SOUTHWEST MARSHALL	205509	SWM_13_8KV_2	13.8	0.0	11064.8	0.0	11275.6	0.0	210.8	0.00%	1.91%
SOUTHWEST MARSHALL	205508	SWM_13_8KV_1	13.8	12063.2	11033.6	12292.9	11243.7	229.7	210.1	1.90%	1.90%
NORTH SEVENTH STREET	183200	NSV_115KV_1	115	8726.4	11627.8	8894.7	11849.1	168.3	221.3	1.93%	1.90%
ERIE ROAD (MARSHALL)	135602	ERD_13_8KV_2	13.8	6953.9	6784.9	7085.9	6913.8	132.0	128.9	1.90%	1.90%
ERIE ROAD (MARSHALL)	135601	ERD_13_8KV_1	13.8	6952.2	6781.5	7084.2	6910.3	132.0	128.8	1.90%	1.90%
SOUTHWEST MARSHALL	205503	SWM_115KV_C2	115	7468.4	10318.1	7610.4	10512.6	142.0	194.5	1.90%	1.89%
SOUTHWEST MARSHALL	205502	SWM_115KV_C1	115	7468.4	10318.1	7610.4	10512.6	142.0	194.5	1.90%	1.89%
SOUTHWEST MARSHALL	205507	SWM_IB_TR01	115	7547.0	10469.3	7690.5	10666.6	143.5	197.3	1.90%	1.88%
SOUTHWEST MARSHALL	205506	SWM_IB_SEA	115	7547.0	10469.3	7690.5	10666.6	143.5	197.3	1.90%	1.88%
SOUTHWEST MARSHALL	205505	SWM_IB_SAR	115	7547.0	10469.3	7690.5	10666.6	143.5	197.3	1.90%	1.88%
SOUTHWEST MARSHALL	205504	SWM_IB_LAY	115	7547.0	10469.3	7690.5	10666.6	143.5	197.3	1.90%	1.88%
SOUTHWEST MARSHALL	205501	SWM_115KV_2	115	7547.0	10469.3	7690.5	10666.6	143.5	197.3	1.90%	1.88%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
SOUTHWEST MARSHALL	205500	SWM_115KV_1	115	7547.0	10469.3	7690.5	10666.6	143.5	197.3	1.90%	1.88%
NORTH SEVENTH STREET	58071	J391_TAP	115	7934.9	10344.3	8086.2	10539.2	151.3	194.9	1.91%	1.88%
ERIE ROAD (MARSHALL)	135600	ERD_115KV	115	8396.4	11264.2	8555.7	11475.3	159.3	211.1	1.90%	1.87%
SARATOGA (MARSHALL)	199400	SAR_115KV	115	7504.1	10320.2	7645.8	10513.1	141.7	192.9	1.89%	1.87%
LYON COUNTY (NSPM)	168321	LYC_IB_TSS	69	8790.3	8472.3	8951.1	8627.4	160.8	155.1	1.83%	1.83%
LYON COUNTY (NSPM)	168320	LYC_IB_TR01	69	8790.3	8472.3	8951.1	8627.4	160.8	155.1	1.83%	1.83%
LYON COUNTY (NSPM)	168319	LYC_IB_MNV	69	8790.3	8472.3	8951.1	8627.4	160.8	155.1	1.83%	1.83%
LYON COUNTY (NSPM)	168318	LYC_IB_MLY	69	8790.3	8472.3	8951.1	8627.4	160.8	155.1	1.83%	1.83%
LYON COUNTY (NSPM)	168317	LYC_69KV_1	69	8790.3	8472.3	8951.1	8627.4	160.8	155.1	1.83%	1.83%
GREEN VALLEY (OTP)	146100	GVY_69KV	69	7771.5	7994.6	7912.3	8139.5	140.8	144.9	1.81%	1.81%
MARSHALL (EREP)	170502	MAE_69KV	69	3947.5	3844.8	4016.5	3912.0	69.0	67.2	1.75%	1.75%
MARSHALL (EREP)	170503	MAE_13_8KV	13.8	0.0	5012.1	0.0	5099.6	0.0	87.5	0.00%	1.75%
MARSHALL (EREP)	170501	MAE_115KV	115	5546.7	7723.5	5643.5	7857.5	96.8	134.0	1.75%	1.73%
MARSHALL (EREP)	170500	MAET_115KV	115	6086.5	8461.9	6192.8	8608.4	106.3	146.5	1.75%	1.73%
LYON COUNTY (NSPM)	168325	LYC_TR01_TER	13.8	0.0	6380.7	0.0	6490.7	0.0	110.0	0.00%	1.72%
LAKE YANKTON (NSPM)	162321	LAY_FDR61	13.8	3695.6	3206.2	3695.6	3259.9	0.0	53.7	0.00%	1.67%
LAKE YANKTON (NSPM)	162320	LAY_13_8KV	13.8	3695.6	3206.2	3695.6	3259.9	0.0	53.7	0.00%	1.67%
LAKE YANKTON (NSPM)	162322	LAY_TR01_TER	13.8	0.0	25396.4	0.0	25821.7	0.0	425.3	0.00%	1.67%
LAKE YANKTON (NSPM)	162319	LAY_IB_TR01	34.5	14097.6	15466.8	14333.6	15725.8	236.0	259.0	1.67%	1.67%
LAKE YANKTON (NSPM)	162318	LAY_FDR311	34.5	14097.6	15466.8	14333.6	15725.8	236.0	259.0	1.67%	1.67%
LAKE YANKTON (NSPM)	162317	LAY_34_5KV	34.5	14097.6	15466.8	14333.6	15725.8	236.0	259.0	1.67%	1.67%
BALATON (NSPM)	105700	BLN_13_8KV	13.8	1565.8	2051.8	1565.8	2086.1	0.0	34.3	0.00%	1.67%
LAKE YANKTON (NSPM)	162323	LAY_TR02_TER	13.8	0.0	2584.9	0.0	2628.1	0.0	43.2	0.00%	1.67%
LAKE YANKTON (NSPM)	162316	LAY_69KV_2	69	2356.4	2196.9	2395.8	2233.6	39.4	36.7	1.67%	1.67%
LAKE YANKTON (NSPM)	162305	LAY_C4_115KV	115	10100.0	10439.1	10269.0	10613.1	169.0	174.0	1.67%	1.67%
LAKE YANKTON (NSPM)	162304	LAY_C3_115KV	115	10100.0	10439.1	10269.0	10613.1	169.0	174.0	1.67%	1.67%
LAKE YANKTON (NSPM)	162303	LAY_C2_115KV	115	10100.0	10439.1	10269.0	10613.1	169.0	174.0	1.67%	1.67%
LAKE YANKTON (NSPM)	162302	LAY_C1_115KV	115	10100.0	10439.1	10269.0	10613.1	169.0	174.0	1.67%	1.67%
LAKE YANKTON (NSPM)	162315	LAY_IB_SWM	115	10550.0	10920.2	10726.5	11102.0	176.5	181.8	1.67%	1.66%
LAKE YANKTON (NSPM)	162314	LAY_IB_LYC2	115	10550.0	10920.2	10726.5	11102.0	176.5	181.8	1.67%	1.66%
LAKE YANKTON (NSPM)	162313	LAY_IB_LYC1	115	10550.0	10920.2	10726.5	11102.0	176.5	181.8	1.67%	1.66%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
LAKE YANKTON (NSPM)	162312	LAY_IB_CHB	115	10550.0	10920.2	10726.5	11102.0	176.5	181.8	1.67%	1.66%
LAKE YANKTON (NSPM)	162311	LAY_IB_CAP4	115	10550.0	10920.2	10726.5	11102.0	176.5	181.8	1.67%	1.66%
LAKE YANKTON (NSPM)	162310	LAY_IB_CAP3	115	10550.0	10920.2	10726.5	11102.0	176.5	181.8	1.67%	1.66%
LAKE YANKTON (NSPM)	162309	LAY_IB_CAP2	115	10550.0	10920.2	10726.5	11102.0	176.5	181.8	1.67%	1.66%
LAKE YANKTON (NSPM)	162308	LAY_IB_CAP1	115	10550.0	10920.2	10726.5	11102.0	176.5	181.8	1.67%	1.66%
LAKE YANKTON (NSPM)	162307	LAY_IB_BRI	115	10550.0	10920.2	10726.5	11102.0	176.5	181.8	1.67%	1.66%
LAKE YANKTON (NSPM)	162306	LAY_CAP	115	10550.0	10920.2	10726.5	11102.0	176.5	181.8	1.67%	1.66%
LAKE YANKTON (NSPM)	162301	LAY_115KV_2	115	10550.0	10920.2	10726.5	11102.0	176.5	181.8	1.67%	1.66%
LAKE YANKTON (NSPM)	162300	LAY_115KV_1	115	10550.0	10920.2	10726.5	11102.0	176.5	181.8	1.67%	1.66%
WALNUT GROVE (REDWOO	220100	WLGV_69KV	69	2324.3	3283.4	2360.7	3334.7	36.4	51.3	1.57%	1.56%
MILROY (REDWOOD)	175801	MLY_69KV_2	69	2990.7	4351.1	3036.7	4417.9	46.0	66.8	1.54%	1.54%
MILROY (REDWOOD)	175800	MLY_69KV_1	69	2990.7	4351.1	3036.7	4417.9	46.0	66.8	1.54%	1.54%
TRACY (NSPM)	214300	TRA_69KV	69	2032.3	2892.3	2062.9	2935.8	30.6	43.5	1.51%	1.50%
TRACY SW STA (NSPM)	214404	TSS_IB_LYC	69	2128.3	3010.2	2160.3	3055.4	32.0	45.2	1.50%	1.50%
TRACY SW STA (NSPM)	214403	TSS_IB_FTN	69	2128.3	3010.2	2160.3	3055.4	32.0	45.2	1.50%	1.50%
TRACY SW STA (NSPM)	214402	TSS_IB_CAP	69	2128.3	3010.2	2160.3	3055.4	32.0	45.2	1.50%	1.50%
TRACY SW STA (NSPM)	214400	TSS_69KV	69	2128.3	3010.2	2160.3	3055.4	32.0	45.2	1.50%	1.50%
TRACY SW STA (NSPM)	214401	TSS_69KV_C1	69	2126.2	3006.1	2158.2	3051.2	32.0	45.1	1.51%	1.50%
LAKE SARAH (NOBLES)	162100	LSAT_69KV	69	1818.2	2681.5	1843.3	2718.5	25.1	37.0	1.38%	1.38%
LAKE SARAH (NOBLES)	162101	LSA_69KV	69	1217.2	1854.4	1217.2	1879.9	0.0	25.5	0.00%	1.38%
YELLOW MEDICINE (NSP	229704	YLM_FDR212	23	1527.8	1853.3	1527.8	1878.5	0.0	25.2	0.00%	1.36%
YELLOW MEDICINE (NSP	229701	YLM_23KV	23	2922.2	2715.4	2922.2	2752.2	0.0	36.8	0.00%	1.36%
YELLOW MEDICINE (NSP	229700	YLM_69KV	69	2873.9	4215.4	2912.9	4272.3	39.0	56.9	1.36%	1.35%
ELLSBOROUGH (GRE)	133703	ELB_FDR01	12.5	3183.6	3135.7	3183.6	3176.1	0.0	40.4	0.00%	1.29%
ELLSBOROUGH (GRE)	133702	ELB_12_5KV	12.5	3197.7	3149.4	3197.7	3189.9	0.0	40.5	0.00%	1.29%
ELLSBOROUGH (GRE)	133701	ELB_115KV	115	5346.6	7454.8	5415.3	7550.5	68.7	95.7	1.28%	1.28%
ELLSBOROUGH (GRE)	133700	ELBT_115KV	115	5352.4	7460.8	5421.2	7556.5	68.8	95.7	1.29%	1.28%
WOOD LAKE TAP (NSPM)	228900	WDLT_69KV	69	2852.7	4181.7	2889.2	4235.1	36.5	53.4	1.28%	1.28%
SHERIDAN (GRE)	202200	SHDT_69KV	69	2100.2	3386.2	2126.4	3428.5	26.2	42.3	1.25%	1.25%
TEPPEOTA (NSPM)	212600	TPO_69KV	69	1713.1	2554.6	1734.3	2586.1	21.2	31.5	1.24%	1.23%
CURRIE (NOB)	126800	CUR_69KV_1	69	1717.5	2557.1	1738.1	2587.8	20.6	30.7	1.20%	1.20%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
WABASSO (GRE)	219202	WBS_SHD_RWO	69	1980.9	3240.5	2003.2	3276.9	22.3	36.4	1.13%	1.12%
NORTH SEVENTH STREET	58070	J391_GEN	13.8	32552.1	29917.2	32890.5	30228.2	338.4	311.0	1.04%	1.04%
LYON COUNTY (NSPM)	168304	LYC_IB_TR09	345	9123.3	10389.0	9216.0	10495.5	92.7	106.5	1.02%	1.03%
LYON COUNTY (NSPM)	168303	LYC_IB_CMT2	345	9123.3	10389.0	9216.0	10495.5	92.7	106.5	1.02%	1.03%
LYON COUNTY (NSPM)	168302	LYC_IB_BOK1	345	9123.3	10389.0	9216.0	10495.5	92.7	106.5	1.02%	1.03%
LYON COUNTY (NSPM)	168301	LYC_345KV_2	345	9123.3	10389.0	9216.0	10495.5	92.7	106.5	1.02%	1.03%
LYON COUNTY (NSPM)	168300	LYC_345KV_1	345	9123.3	10389.0	9216.0	10495.5	92.7	106.5	1.02%	1.03%
SLAYTON (NOBLES)	203500	SLT_69KV	69	2010.3	2854.4	2030.4	2882.9	20.1	28.5	1.00%	1.00%
SLAYTON WEST (NSPM)	203605	SLW_FDR62	13.8	4934.2	4280.1	4934.2	4322.5	0.0	42.4	0.00%	0.99%
SLAYTON WEST (NSPM)	203603	SLW_FDR61	13.8	4934.2	4280.1	4934.2	4322.5	0.0	42.4	0.00%	0.99%
SLAYTON WEST (NSPM)	203602	SLW_13_8KV_1	13.8	4934.2	4280.1	4934.2	4322.5	0.0	42.4	0.00%	0.99%
SLAYTON WEST (NSPM)	203601	SLW_69KV	69	2034.1	2877.1	2054.3	2905.6	20.2	28.5	0.99%	0.99%
SLAYTON WEST (NSPM)	203600	SLWT_69KV	69	2040.2	2883.6	2060.4	2912.1	20.2	28.5	0.99%	0.99%
BUFFALO RIDGE (NSPM)	114403	BRI_115KV_4	115	10017.2	9219.3	10112.0	9306.3	94.8	87.0	0.95%	0.94%
BUFFALO RIDGE (NSPM)	114402	BRI_115KV_3	115	10017.2	9219.3	10112.0	9306.3	94.8	87.0	0.95%	0.94%
BUFFALO RIDGE (NSPM)	114401	BRI_115KV_2	115	10017.2	9219.3	10112.0	9306.3	94.8	87.0	0.95%	0.94%
BUFFALO RIDGE (NSPM)	114400	BRI_115KV_1	115	10017.2	9219.3	10112.0	9306.3	94.8	87.0	0.95%	0.94%
SARATOGA (MARSHALL)	199402	SAR_GEN01	13.8	14580.0	14065.2	14717.0	14197.3	137.0	132.1	0.94%	0.94%
SARATOGA (MARSHALL)	199401	SAR_FDR21	13.8	14580.0	14065.2	14717.0	14197.3	137.0	132.1	0.94%	0.94%
BUFFALO RIDGE (NSPM)	114440	BRI_BRAVO_2	34.5	969.3	1613.5	969.3	1628.5	0.0	15.0	0.00%	0.93%
SHAOKATAN II (NSPM)	201618	SKT_INTSUB	34.5	866.5	1442.8	866.5	1456.2	0.0	13.4	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114451	BRI_ZULU_1	34.5	866.5	1442.8	866.5	1456.2	0.0	13.4	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114429	BRI_322_C3	34.5	3220.9	4861.5	3220.9	4906.6	0.0	45.1	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114434	BRI_323_C4	34.5	2625.0	4054.2	2625.0	4091.8	0.0	37.6	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114430	BRI_322_C4	34.5	2629.1	4054.2	2629.1	4091.8	0.0	37.6	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114422	BRI_321_C5	34.5	2119.4	3419.3	2119.4	3451.0	0.0	31.7	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114438	BRI_ALPHZULU	34.5	1072.6	1812.2	1072.6	1829.0	0.0	16.8	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114437	BRI_ALPHA	34.5	1072.6	1812.2	1072.6	1829.0	0.0	16.8	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114442	BRI_CHARLIE2	34.5	1493.6	2394.8	1493.6	2417.0	0.0	22.2	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114410	BRI_311_C3	34.5	3439.6	4952.3	3439.6	4998.2	0.0	45.9	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114424	BRI_321_C7	34.5	1679.7	2762.3	1679.7	2787.9	0.0	25.6	0.00%	0.93%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
BUFFALO RIDGE (NSPM)	114419	BRI_321_C2	34.5	7703.5	9894.7	7774.9	9986.4	71.4	91.7	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114450	BRI_IB_TR02	34.5	27139.5	20556.8	27391.0	20747.3	251.5	190.5	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114449	BRI_IB_TR01	34.5	27139.5	20556.8	27391.0	20747.3	251.5	190.5	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114448	BRI_FDR323	34.5	27139.5	20556.8	27391.0	20747.3	251.5	190.5	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114447	BRI_FDR322	34.5	27139.5	20556.8	27391.0	20747.3	251.5	190.5	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114446	BRI_FDR321	34.5	27139.5	20556.8	27391.0	20747.3	251.5	190.5	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114445	BRI_FDR313	34.5	27139.5	20556.8	27391.0	20747.3	251.5	190.5	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114444	BRI_FDR312	34.5	27139.5	20556.8	27391.0	20747.3	251.5	190.5	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114443	BRI_FDR311	34.5	27139.5	20556.8	27391.0	20747.3	251.5	190.5	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114436	BRI_34_5KV_2	34.5	27139.5	20556.8	27391.0	20747.3	251.5	190.5	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114435	BRI_34_5KV_1	34.5	27139.5	20556.8	27391.0	20747.3	251.5	190.5	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114408	BRI321_TAP	34.5	1221.8	2050.4	1221.8	2069.4	0.0	19.0	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114427	BRI_322_C1	34.5	25135.5	19879.4	25368.4	20063.6	232.9	184.2	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114455	BRI_CHA_480V	0.48	99043.4	151340.5	99043.4	152742.8	0.0	1402.3	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114431	BRI_323_C1	34.5	26301.0	20280.5	26544.7	20468.4	243.7	187.9	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114417	BRI_321_C1	34.5	25218.7	19905.1	25452.3	20089.5	233.6	184.4	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114421	BRI_321_C4	34.5	2397.0	3821.4	2397.0	3856.8	0.0	35.4	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114426	BRI_321_C9	34.5	1428.4	2375.2	1428.4	2397.2	0.0	22.0	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114432	BRI_323_C2	34.5	5473.3	7602.2	5524.0	7672.6	50.7	70.4	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114433	BRI_323_C3	34.5	3199.2	4837.9	3199.2	4882.7	0.0	44.8	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114420	BRI_321_C3	34.5	3137.5	4848.8	3137.5	4893.7	0.0	44.9	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114423	BRI_321_C6	34.5	1867.1	3045.4	1867.1	3073.6	0.0	28.2	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114409	BRI_311_C2	34.5	6463.4	8349.3	6523.3	8426.6	59.9	77.3	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114428	BRI_322_C2	34.5	5658.2	7801.1	5710.7	7873.3	52.5	72.2	0.93%	0.93%
BUFFALO RIDGE (NSPM)	114404	BRI311_DELTA	34.5	1878.7	2874.2	1878.7	2900.8	0.0	26.6	0.00%	0.93%
BUFFALO RIDGE (NSPM)	114452	BRI_TR01_TER	13.8	0.0	28016.0	0.0	28275.0	0.0	259.0	0.00%	0.92%
BUFFALO RIDGE (NSPM)	114453	BRI_TR02_TER	13.8	0.0	28103.0	0.0	28362.8	0.0	259.8	0.00%	0.92%
BUFFALO RIDGE (NSPM)	114418	BRI_321_C10	34.5	1307.2	2185.5	1307.2	2205.7	0.0	20.2	0.00%	0.92%
BUFFALO RIDGE (NSPM)	114405	BRI311_ECHO	34.5	1646.7	2543.0	1646.7	2566.5	0.0	23.5	0.00%	0.92%
BUFFALO RIDGE (NSPM)	114425	BRI_321_C8	34.5	1550.7	2564.7	1550.7	2588.4	0.0	23.7	0.00%	0.92%
BUFFALO RIDGE (NSPM)	114439	BRI_BRAVO_1	34.5	968.3	1613.5	968.3	1628.4	0.0	14.9	0.00%	0.92%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
BUFFALO RIDGE (NSPM)	114441	BRI_CHARLIE1	34.5	1496.1	2394.9	1496.1	2417.0	0.0	22.1	0.00%	0.92%
HAZEL CREEK (NSPM)	148702	HZC_IB_LYC	345	6616.3	7502.5	6676.6	7571.0	60.3	68.5	0.91%	0.91%
HAZEL CREEK (NSPM)	148700	HZC_345KV_1	345	6616.3	7502.5	6676.6	7571.0	60.3	68.5	0.91%	0.91%
HADLEY (NSPM)	146800	HAD_69KV	69	2445.7	3251.2	2467.7	3280.4	22.0	29.2	0.90%	0.90%
WABASSO (GRE)	219201	WBS_69KV	69	1971.1	3263.5	1971.1	3292.6	0.0	29.1	0.00%	0.89%
BUFFALO RIDGE (NSPM)	114407	BRI312_GOLF	34.5	957.0	1582.2	957.0	1596.2	0.0	14.0	0.00%	0.88%
THOLEN (NSPM)	212800	THN_34_5KV	34.5	1101.0	1798.3	1101.0	1814.2	0.0	15.9	0.00%	0.88%
BUFFALO RIDGE (NSPM)	114415	BRI_312_C6	34.5	1439.5	2285.7	1439.5	2305.9	0.0	20.2	0.00%	0.88%
BUFFALO RIDGE (NSPM)	114413	BRI_312_C4	34.5	2100.3	3226.6	2100.3	3255.1	0.0	28.5	0.00%	0.88%
BUFFALO RIDGE (NSPM)	114406	BRI312_FOXTR	34.5	1280.7	2060.5	1280.7	2078.7	0.0	18.2	0.00%	0.88%
BUFFALO RIDGE (NSPM)	114412	BRI_312_C3	34.5	2760.3	4147.5	2760.3	4184.1	0.0	36.6	0.00%	0.88%
RUTHTON (NSPM)	198506	RTH_INTSUB	34.5	8679.5	10890.2	8756.1	10986.2	76.6	96.0	0.88%	0.88%
BUFFALO RIDGE (NSPM)	114414	BRI_312_C5	34.5	1566.8	2462.0	1566.8	2483.7	0.0	21.7	0.00%	0.88%
BUFFALO RIDGE (NSPM)	114411	BRI_312_C2	34.5	3401.6	5004.4	3401.6	5048.5	0.0	44.1	0.00%	0.88%
BUFFALO RIDGE (NSPM)	114416	BRI_312_SHI	34.5	1404.2	2236.2	1404.2	2255.9	0.0	19.7	0.00%	0.88%
RUTHTON (NSPM)	198531	RTH_RISER7	34.5	8428.5	10681.8	8502.7	10775.7	74.2	93.9	0.88%	0.88%
RUTHTON (NSPM)	198533	RTH_SECTCAB2	34.5	7737.9	8981.1	7805.6	9059.7	67.7	78.6	0.87%	0.88%
LAKE WILSON (NOB)	162200	LKW_69KV	69	2853.1	3577.7	2877.4	3608.0	24.3	30.3	0.85%	0.85%
RUTHTON (NSPM)	198530	RTH_RISER6	34.5	4720.2	6967.8	4720.2	7026.3	0.0	58.5	0.00%	0.84%
SOUTH RIDGE (NSPM)	204803	SRD_C196	69	3059.8	3728.3	3085.1	3759.2	25.3	30.9	0.83%	0.83%
CHANARAMBIE (NSPM)	120134	CHB_VIK_II	34.5	3284.3	5221.8	3284.3	5263.6	0.0	41.8	0.00%	0.80%
CHANARAMBIE (NSPM)	120135	CHB_TR01_TER	13.8	0.0	19155.9	0.0	19309.2	0.0	153.3	0.00%	0.80%
CHANARAMBIE (NSPM)	120130	CHB_IB_TR02	34.5	24864.3	19572.2	25063.2	19728.8	198.9	156.6	0.80%	0.80%
CHANARAMBIE (NSPM)	120129	CHB_IB_TR01	34.5	24864.3	19572.2	25063.2	19728.8	198.9	156.6	0.80%	0.80%
CHANARAMBIE (NSPM)	120123	CHB_FDR323	34.5	24864.3	19572.2	25063.2	19728.8	198.9	156.6	0.80%	0.80%
CHANARAMBIE (NSPM)	120122	CHB_FDR322	34.5	24864.3	19572.2	25063.2	19728.8	198.9	156.6	0.80%	0.80%
CHANARAMBIE (NSPM)	120121	CHB_FDR321	34.5	24864.3	19572.2	25063.2	19728.8	198.9	156.6	0.80%	0.80%
CHANARAMBIE (NSPM)	120120	CHB_FDR313	34.5	24864.3	19572.2	25063.2	19728.8	198.9	156.6	0.80%	0.80%
CHANARAMBIE (NSPM)	120119	CHB_FDR312	34.5	24864.3	19572.2	25063.2	19728.8	198.9	156.6	0.80%	0.80%
CHANARAMBIE (NSPM)	120117	CHB_FDR311	34.5	24864.3	19572.2	25063.2	19728.8	198.9	156.6	0.80%	0.80%
CHANARAMBIE (NSPM)	120109	CHB_34_5KV_2	34.5	24864.3	19572.2	25063.2	19728.8	198.9	156.6	0.80%	0.80%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
CHANARAMBIE (NSPM)	120108	CHB_34_5KV_1	34.5	24864.3	19572.2	25063.2	19728.8	198.9	156.6	0.80%	0.80%
CHANARAMBIE (NSPM)	120136	CHB_TR02_TER	13.8	0.0	19149.0	0.0	19302.2	0.0	153.2	0.00%	0.80%
CHANARAMBIE (NSPM)	120113	CHB_CAP2	34.5	23752.0	18876.6	23942.0	19027.6	190.0	151.0	0.80%	0.80%
CHANARAMBIE (NSPM)	120112	CHB_CAP1	34.5	23752.0	18876.6	23942.0	19027.6	190.0	151.0	0.80%	0.80%
CHANARAMBIE (NSPM)	120118	CHB_FDR311_E	34.5	3862.0	5414.0	3862.0	5457.3	0.0	43.3	0.00%	0.80%
CHANARAMBIE (NSPM)	120133	CHB_MORAINE	34.5	22911.6	18209.8	23094.8	18355.4	183.2	145.6	0.80%	0.80%
CHANARAMBIE (NSPM)	120116	CHB_ENXCO_II	34.5	23413.0	18554.6	23600.3	18702.9	187.3	148.3	0.80%	0.80%
CHANARAMBIE (NSPM)	120115	CHB_ENXCO_I	34.5	23413.0	18554.6	23600.3	18702.9	187.3	148.3	0.80%	0.80%
CHANARAMBIE (NSPM)	120107	CHB_IB_TR04	115	10743.8	9401.8	10829.7	9476.9	85.9	75.1	0.80%	0.80%
CHANARAMBIE (NSPM)	120106	CHB_IB_TR03	115	10743.8	9401.8	10829.7	9476.9	85.9	75.1	0.80%	0.80%
CHANARAMBIE (NSPM)	120105	CHB_IB_TR02	115	10743.8	9401.8	10829.7	9476.9	85.9	75.1	0.80%	0.80%
CHANARAMBIE (NSPM)	120104	CHB_IB_PIP	115	10743.8	9401.8	10829.7	9476.9	85.9	75.1	0.80%	0.80%
CHANARAMBIE (NSPM)	120103	CHB_IB_LAY	115	10743.8	9401.8	10829.7	9476.9	85.9	75.1	0.80%	0.80%
CHANARAMBIE (NSPM)	120102	CHB_IB_FTN	115	10743.8	9401.8	10829.7	9476.9	85.9	75.1	0.80%	0.80%
CHANARAMBIE (NSPM)	120101	CHB_115KV_2	115	10743.8	9401.8	10829.7	9476.9	85.9	75.1	0.80%	0.80%
CHANARAMBIE (NSPM)	120100	CHB_115KV_1	115	10743.8	9401.8	10829.7	9476.9	85.9	75.1	0.80%	0.80%
MINNESOTA VALLEY (NS	176534	MNV_TR12_TER	13.8	0.0	4596.2	0.0	4630.5	0.0	34.3	0.00%	0.75%
PIPESTONE (NSPM)	189603	PIP_IB_SPK	115	6229.0	7744.4	6275.4	7802.0	46.4	57.6	0.74%	0.74%
PIPESTONE (NSPM)	189602	PIP_IB_CHB	115	6229.0	7744.4	6275.4	7802.0	46.4	57.6	0.74%	0.74%
PIPESTONE (NSPM)	189601	PIP_IB_BRI	115	6229.0	7744.4	6275.4	7802.0	46.4	57.6	0.74%	0.74%
PIPESTONE (NSPM)	189600	PIP_115KV_1	115	6229.0	7744.4	6275.4	7802.0	46.4	57.6	0.74%	0.74%
WATERBURY (GRE)	221304	WRB_IB_SMM	69	2089.4	3486.4	2089.4	3512.1	0.0	25.7	0.00%	0.74%
WATERBURY (GRE)	221303	WRB_IB_LYC	69	2089.4	3486.4	2089.4	3512.1	0.0	25.7	0.00%	0.74%
WATERBURY (GRE)	221302	WRB_IB_JHN	69	2089.4	3486.4	2089.4	3512.1	0.0	25.7	0.00%	0.74%
WATERBURY (GRE)	221301	WRB_IB_DOT	69	2089.4	3486.4	2089.4	3512.1	0.0	25.7	0.00%	0.74%
WATERBURY (GRE)	221300	WRB_69KV_1	69	2089.4	3486.4	2089.4	3512.1	0.0	25.7	0.00%	0.74%
FIESTA CITY (NSPM)	137802	FICT_69KV_3	69	1609.8	1739.5	1609.8	1752.3	0.0	12.8	0.00%	0.74%
JOHNSONVILLE (GRE)	157500	JHN_69KV_1	69	1262.6	2032.1	1262.6	2047.0	0.0	14.9	0.00%	0.73%
BUSH PARK (MUNI)	115100	BUPT_69KV	69	6057.6	6642.4	6102.0	6691.0	44.4	48.6	0.73%	0.73%
MINNESOTA VALLEY (NS	176527	MNV_FDR211	23.9	2919.5	2801.9	2919.5	2822.4	0.0	20.5	0.00%	0.73%
MINNESOTA VALLEY (NS	176526	MNV_23_9KV_1	23.9	2919.5	2801.9	2919.5	2822.4	0.0	20.5	0.00%	0.73%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
MINNESOTA VALLEY (NS	176525	MNV_IB_TR12	69	10216.1	9452.8	10290.9	9521.9	74.8	69.1	0.73%	0.73%
MINNESOTA VALLEY (NS	176524	MNV_IB_TR11	69	10216.1	9452.8	10290.9	9521.9	74.8	69.1	0.73%	0.73%
MINNESOTA VALLEY (NS	176523	MNV_IB_TR02	69	10216.1	9452.8	10290.9	9521.9	74.8	69.1	0.73%	0.73%
MINNESOTA VALLEY (NS	176522	MNV_69KV_474	69	10216.1	9452.8	10290.9	9521.9	74.8	69.1	0.73%	0.73%
MINNESOTA VALLEY (NS	176521	MNV_69KV_473	69	10216.1	9452.8	10290.9	9521.9	74.8	69.1	0.73%	0.73%
MINNESOTA VALLEY (NS	176520	MNV_69KV_472	69	10216.1	9452.8	10290.9	9521.9	74.8	69.1	0.73%	0.73%
MINNESOTA VALLEY (NS	176519	MNV_69KV_470	69	10216.1	9452.8	10290.9	9521.9	74.8	69.1	0.73%	0.73%
MINNESOTA VALLEY (NS	176518	MNV_69KV_2	69	10216.1	9452.8	10290.9	9521.9	74.8	69.1	0.73%	0.73%
MINNESOTA VALLEY (NS	176517	MNV_69KV_1	69	10216.1	9452.8	10290.9	9521.9	74.8	69.1	0.73%	0.73%
CHANARAMBIE (NSPM)	120128	CHB_GOLF	34.5	2069.3	3407.7	2069.3	3432.6	0.0	24.9	0.00%	0.73%
BUSH PARK (MUNI)	115101	BUP_69KV	69	5463.7	6213.3	5503.7	6258.7	40.0	45.4	0.73%	0.73%
MONTEVIDEO (NSPM)	177400	MTV_69KV	69	1848.4	1904.3	1848.4	1918.2	0.0	13.9	0.00%	0.73%
CHANARAMBIE (NSPM)	120114	CHB_CAP3	34.5	25886.4	21904.2	26075.2	22064.0	188.8	159.8	0.73%	0.73%
CHANARAMBIE (NSPM)	120132	CHB_IB_TR04	34.5	27212.0	22845.2	27410.5	23011.8	198.5	166.6	0.73%	0.73%
CHANARAMBIE (NSPM)	120131	CHB_IB_TR03	34.5	27212.0	22845.2	27410.5	23011.8	198.5	166.6	0.73%	0.73%
CHANARAMBIE (NSPM)	120127	CHB_FDR_CAP3	34.5	27212.0	22845.2	27410.5	23011.8	198.5	166.6	0.73%	0.73%
CHANARAMBIE (NSPM)	120126	CHB_FDR341	34.5	27212.0	22845.2	27410.5	23011.8	198.5	166.6	0.73%	0.73%
CHANARAMBIE (NSPM)	120125	CHB_FDR332	34.5	27212.0	22845.2	27410.5	23011.8	198.5	166.6	0.73%	0.73%
CHANARAMBIE (NSPM)	120124	CHB_FDR331	34.5	27212.0	22845.2	27410.5	23011.8	198.5	166.6	0.73%	0.73%
CHANARAMBIE (NSPM)	120111	CHB_34_5KV_4	34.5	27212.0	22845.2	27410.5	23011.8	198.5	166.6	0.73%	0.73%
CHANARAMBIE (NSPM)	120110	CHB_34_5KV_3	34.5	27212.0	22845.2	27410.5	23011.8	198.5	166.6	0.73%	0.73%
GRANITE FALLS CITY (	145200	GRFT_69KV	69	8801.7	8735.8	8865.8	8799.3	64.1	63.5	0.73%	0.73%
GRANITE FALLS CITY (	145201	GRF_69KV	69	7434.4	7855.5	7488.5	7912.6	54.1	57.1	0.73%	0.73%
MINNESOTA VALLEY (NS	176533	MNV_TR11_TER	13.8	0.0	4822.5	0.0	4857.4	0.0	34.9	0.00%	0.72%
UILK (NSPM_UILK WIND	216600	UWI_69KV	69	2222.7	3013.3	2222.7	3035.0	0.0	21.7	0.00%	0.72%
CHANARAMBIE (NSPM)	120138	CHB_TR04_TER	13.8	0.0	16574.9	0.0	16694.2	0.0	119.3	0.00%	0.72%
CHANARAMBIE (NSPM)	120137	CHB_TR03_TER	13.8	0.0	18637.6	0.0	18771.7	0.0	134.1	0.00%	0.72%
WEST PIPESTONE (NSPM	223700	WPI_69KV_B1	69	2216.8	3007.2	2216.8	3028.8	0.0	21.6	0.00%	0.72%
PIPESTONE (NSPM)	189615	PIP_FDR62	13.8	5261.2	4970.3	5261.2	5006.0	0.0	35.7	0.00%	0.72%
PIPESTONE (NSPM)	189613	PIP_FDR61	13.8	5261.2	4970.3	5261.2	5006.0	0.0	35.7	0.00%	0.72%
PIPESTONE (NSPM)	189612	PIP_13_8KV	13.8	5261.2	4970.3	5261.2	5006.0	0.0	35.7	0.00%	0.72%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
PIPESTONE (NSPM)	189608	PIP_IB_WPI	69	6052.6	6113.7	6096.1	6157.6	43.5	43.9	0.72%	0.72%
PIPESTONE (NSPM)	189607	PIP_IB_TR06	69	6052.6	6113.7	6096.1	6157.6	43.5	43.9	0.72%	0.72%
PIPESTONE (NSPM)	189606	PIP_IB_TR05	69	6052.6	6113.7	6096.1	6157.6	43.5	43.9	0.72%	0.72%
PIPESTONE (NSPM)	189605	PIP_IB_FTN	69	6052.6	6113.7	6096.1	6157.6	43.5	43.9	0.72%	0.72%
PIPESTONE (NSPM)	189604	PIP_69KV_1	69	6052.6	6113.7	6096.1	6157.6	43.5	43.9	0.72%	0.72%
YANKEE (NSPM)	229515	YNK_FDR313_E	34.5	3153.6	4907.2	3153.6	4942.1	0.0	34.9	0.00%	0.71%
YANKEE (NSPM)	229513	YNK_FDR312_E	34.5	3153.6	4907.2	3153.6	4942.1	0.0	34.9	0.00%	0.71%
YANKEE (NSPM)	229511	YNK_FDR311_E	34.5	3153.6	4907.2	3153.6	4942.1	0.0	34.9	0.00%	0.71%
YANKEE (NSPM)	229520	YNK_FDR323	34.5	17922.0	15718.3	18049.3	15830.0	127.3	111.7	0.71%	0.71%
YANKEE (NSPM)	229518	YNK_FDR322	34.5	17922.0	15718.3	18049.3	15830.0	127.3	111.7	0.71%	0.71%
YANKEE (NSPM)	229516	YNK_FDR321	34.5	17922.0	15718.3	18049.3	15830.0	127.3	111.7	0.71%	0.71%
YANKEE (NSPM)	229509	YNK_34_5KV_2	34.5	17922.0	15718.3	18049.3	15830.0	127.3	111.7	0.71%	0.71%
YANKEE (NSPM)	229514	YNK_FDR313	34.5	18698.3	15704.9	18831.1	15816.5	132.8	111.6	0.71%	0.71%
YANKEE (NSPM)	229512	YNK_FDR312	34.5	18698.3	15704.9	18831.1	15816.5	132.8	111.6	0.71%	0.71%
YANKEE (NSPM)	229510	YNK_FDR311	34.5	18698.3	15704.9	18831.1	15816.5	132.8	111.6	0.71%	0.71%
YANKEE (NSPM)	229508	YNK_34_5KV_1	34.5	18698.3	15704.9	18831.1	15816.5	132.8	111.6	0.71%	0.71%
YANKEE (NSPM)	229523	YNK_TR02_TER	13.8	0.0	14143.8	0.0	14244.3	0.0	100.5	0.00%	0.71%
YANKEE (NSPM)	229522	YNK_TR01_TER	13.8	0.0	16822.4	0.0	16941.9	0.0	119.5	0.00%	0.71%
YANKEE (NSPM)	229507	YNK_IB_TR02	115	11529.3	11937.1	11611.1	12021.8	81.8	84.7	0.71%	0.71%
YANKEE (NSPM)	229506	YNK_IB_TR01	115	11529.3	11937.1	11611.1	12021.8	81.8	84.7	0.71%	0.71%
YANKEE (NSPM)	229504	YNK_IB_BRI	115	11529.3	11937.1	11611.1	12021.8	81.8	84.7	0.71%	0.71%
YANKEE (NSPM)	229502	YNK_IB_BOK1	115	11529.3	11937.1	11611.1	12021.8	81.8	84.7	0.71%	0.71%
YANKEE (NSPM)	229501	YNK_115KV_2	115	11529.3	11937.1	11611.1	12021.8	81.8	84.7	0.71%	0.71%
YANKEE (NSPM)	229500	YNK_115KV_1	115	11529.3	11937.1	11611.1	12021.8	81.8	84.7	0.71%	0.71%
YANKEE (NSPM)	229521	YNK_FDR323_E	34.5	3130.8	4907.8	3130.8	4942.6	0.0	34.8	0.00%	0.71%
YANKEE (NSPM)	229519	YNK_FDR322_E	34.5	3130.8	4907.8	3130.8	4942.6	0.0	34.8	0.00%	0.71%
YANKEE (NSPM)	229517	YNK_FDR321_E	34.5	3130.8	4907.8	3130.8	4942.6	0.0	34.8	0.00%	0.71%
FENTON (NSPM)	137612	FTN_IB_TSS	69	5713.7	5645.8	5753.6	5685.3	39.9	39.5	0.70%	0.70%
FENTON (NSPM)	137611	FTN_IB_TR05	69	5713.7	5645.8	5753.6	5685.3	39.9	39.5	0.70%	0.70%
FENTON (NSPM)	137610	FTN_IB_PIP	69	5713.7	5645.8	5753.6	5685.3	39.9	39.5	0.70%	0.70%
FENTON (NSPM)	137609	FTN_69KV	69	5713.7	5645.8	5753.6	5685.3	39.9	39.5	0.70%	0.70%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
CHANDLER (NOB)	120201	CHN_69KV	69	4344.2	4937.1	4374.5	4971.6	30.3	34.5	0.70%	0.70%
CHANDLER (NOB)	120200	CHNT_69KV	69	4559.0	5106.1	4590.9	5141.7	31.9	35.6	0.70%	0.70%
VALLEY VIEW (NSPM)	217601	VVW_69KV	69	3168.3	4311.0	3190.3	4340.9	22.0	29.9	0.69%	0.69%
VALLEY VIEW (NSPM)	217600	VVWT_69KV	69	3173.3	4315.1	3195.3	4345.0	22.0	29.9	0.69%	0.69%
WEST RIDGE (NSPM)	223801	WRD_69KV	69	3368.2	4522.9	3391.5	4554.2	23.3	31.3	0.69%	0.69%
WEST RIDGE (NSPM)	223800	WRDT_69KV	69	3384.8	4553.1	3408.3	4584.6	23.5	31.5	0.69%	0.69%
CEDAR MOUNTAIN (GRE)	119105	CMT_IB_TR01	345	8597.8	10892.3	8656.9	10967.6	59.1	75.3	0.69%	0.69%
CEDAR MOUNTAIN (GRE)	119104	CMT_IB_LYC2	345	8597.8	10892.3	8656.9	10967.6	59.1	75.3	0.69%	0.69%
CEDAR MOUNTAIN (GRE)	119103	CMT_IB_HNA2	345	8597.8	10892.3	8656.9	10967.6	59.1	75.3	0.69%	0.69%
CEDAR MOUNTAIN (GRE)	119102	CMT_IB_HNA1	345	8597.8	10892.3	8656.9	10967.6	59.1	75.3	0.69%	0.69%
CEDAR MOUNTAIN (GRE)	119101	CMT_345KV_2	345	8597.8	10892.3	8656.9	10967.6	59.1	75.3	0.69%	0.69%
CEDAR MOUNTAIN (GRE)	119100	CMT_345KV_1	345	8597.8	10892.3	8656.9	10967.6	59.1	75.3	0.69%	0.69%
ROCK RIVER (NSPM)	197001	ROC_69KV	69	2766.0	4041.4	2766.0	4069.2	0.0	27.8	0.00%	0.69%
ROCK RIVER (NSPM)	197000	ROCT_69KV	69	3024.3	4333.3	3045.0	4362.9	20.7	29.6	0.68%	0.68%
SACRED HEART (NSPM)	198701	SCH_69KV	69	2832.3	4106.8	2832.3	4134.6	0.0	27.8	0.00%	0.68%
SACRED HEART (NSPM)	198700	SCHT_69KV	69	2861.7	4146.5	2861.7	4174.5	0.0	28.0	0.00%	0.68%
GRANITE FALLS (WAPA)	145112	GRA_IB_KV8A	13.8	0.0	25800.0	0.0	25971.4	0.0	171.4	0.00%	0.66%
SOUTH RIDGE (NSPM)	204802	SRD_C195	69	1373.2	2161.7	1373.2	2176.0	0.0	14.3	0.00%	0.66%
WOODSTOCK (PARSON E)	229201	WSK_69KV_1	69	2037.3	3194.2	2037.3	3215.3	0.0	21.1	0.00%	0.66%
SOUTH RIDGE (NSPM)	204801	SRD_69KV	69	1455.2	2303.0	1455.2	2318.2	0.0	15.2	0.00%	0.66%
WOODSTOCK (PARSON E)	229200	WSKT_69KV	69	2040.4	3198.2	2040.4	3219.3	0.0	21.1	0.00%	0.66%
SOUTH RIDGE (NSPM)	204800	SRDT_69KV	69	1457.0	2305.5	1457.0	2320.7	0.0	15.2	0.00%	0.66%
GRANITE FALLS (WAPA)	145110	GRA_115KV	115	16892.0	16957.1	17002.0	17067.3	110.0	110.2	0.65%	0.65%
HAZEL CREEK (NSPM)	148705	HZC_IB_MNV	230	11115.1	11228.4	11185.7	11299.8	70.6	71.4	0.64%	0.64%
HAZEL CREEK (NSPM)	148703	HZC_230KV_1	230	11115.1	11228.4	11185.7	11299.8	70.6	71.4	0.64%	0.64%
FIESTA CITY (NSPM)	137801	FICT_69KV_2	69	1631.4	2257.1	1631.4	2271.3	0.0	14.2	0.00%	0.63%
FIESTA CITY (NSPM)	137800	FICT_69KV_1	69	1643.3	2279.1	1643.3	2293.4	0.0	14.3	0.00%	0.63%
FIESTA CITY (NSPM)	137804	FIC_IB_CAP	69	1633.1	2268.1	1633.1	2282.3	0.0	14.2	0.00%	0.63%
FIESTA CITY (NSPM)	137803	FIC_69KV	69	1633.1	2268.1	1633.1	2282.3	0.0	14.2	0.00%	0.63%
MINNESOTA VALLEY (NS	176532	MNV_TR06_TER	13.8	0.0	25784.5	0.0	25945.6	0.0	161.1	0.00%	0.62%
MAYNARD SS (NSPM)	171600	MSS_69KV	69	4641.6	4994.9	4670.7	5026.1	29.1	31.2	0.63%	0.62%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
MINNESOTA VALLEY (NS	176531	MNV_TR05_TER	13.8	0.0	18984.4	0.0	19102.9	0.0	118.5	0.00%	0.62%
CEDAR MOUNTAIN (GRE)	119106	CMT_115KV_1	115	15117.7	13540.9	15211.9	13625.4	94.2	84.5	0.62%	0.62%
BROOKINGS COUNTY (NS	113214	BOK_TR09_TER	34.5	0.0	10594.8	0.0	10660.7	0.0	65.9	0.00%	0.62%
BROOKINGS COUNTY (NS	113213	BOK_TR09_REA	34.5	0.0	10594.8	0.0	10660.7	0.0	65.9	0.00%	0.62%
BROOKINGS COUNTY (NS	113212	BOK_IB_YNK2	115	20935.6	19006.7	21063.4	19124.6	127.8	117.9	0.61%	0.62%
BROOKINGS COUNTY (NS	113211	BOK_IB_YNK1	115	20935.6	19006.7	21063.4	19124.6	127.8	117.9	0.61%	0.62%
BROOKINGS COUNTY (NS	113210	BOK_IB_TR10	115	20935.6	19006.7	21063.4	19124.6	127.8	117.9	0.61%	0.62%
BROOKINGS COUNTY (NS	113209	BOK_115KV_2	115	20935.6	19006.7	21063.4	19124.6	127.8	117.9	0.61%	0.62%
BROOKINGS COUNTY (NS	113208	BOK_115KV_1	115	20935.6	19006.7	21063.4	19124.6	127.8	117.9	0.61%	0.62%
MINNESOTA VALLEY (NS	176516	MNV_IB_TR06	115	17791.9	15970.3	17902.1	16069.2	110.2	98.9	0.62%	0.62%
MINNESOTA VALLEY (NS	176515	MNV_IB_TR05	115	17791.9	15970.3	17902.1	16069.2	110.2	98.9	0.62%	0.62%
MINNESOTA VALLEY (NS	176514	MNV_IB_MAT	115	17791.9	15970.3	17902.1	16069.2	110.2	98.9	0.62%	0.62%
MINNESOTA VALLEY (NS	176513	MNV_IB_GRA	115	17791.9	15970.3	17902.1	16069.2	110.2	98.9	0.62%	0.62%
MINNESOTA VALLEY (NS	176512	MNV_IB_FRA	115	17791.9	15970.3	17902.1	16069.2	110.2	98.9	0.62%	0.62%
MINNESOTA VALLEY (NS	176511	MNV_IB_CAP2	115	17791.9	15970.3	17902.1	16069.2	110.2	98.9	0.62%	0.62%
MINNESOTA VALLEY (NS	176510	MNV_IB_CAP1	115	17791.9	15970.3	17902.1	16069.2	110.2	98.9	0.62%	0.62%
MINNESOTA VALLEY (NS	176509	MNV_115KV_CB	115	17791.9	15970.3	17902.1	16069.2	110.2	98.9	0.62%	0.62%
MINNESOTA VALLEY (NS	176506	MNV_115KV_2	115	17791.9	15970.3	17902.1	16069.2	110.2	98.9	0.62%	0.62%
MINNESOTA VALLEY (NS	176505	MNV_115KV_1	115	17791.9	15970.3	17902.1	16069.2	110.2	98.9	0.62%	0.62%
MINNESOTA VALLEY (NS	176508	MNV_115KV_C2	115	16549.1	14963.8	16651.7	15056.4	102.6	92.6	0.62%	0.62%
MINNESOTA VALLEY (NS	176507	MNV_115KV_C1	115	16549.1	14963.8	16651.7	15056.4	102.6	92.6	0.62%	0.62%
CLARA CITY (NSPM)	122100	CLC_69KV	69	2197.2	2848.9	2197.2	2866.5	0.0	17.6	0.00%	0.62%
MAYNARD XMSN (NSPM)	171705	MAT_CLC_FIC	69	4979.5	5045.7	5010.2	5076.8	30.7	31.1	0.62%	0.62%
MAYNARD XMSN (NSPM)	171706	MAT_IB_CLC	69	4979.6	5045.7	5010.2	5076.8	30.6	31.1	0.61%	0.62%
MAYNARD XMSN (NSPM)	171704	MAT_69KV_1	69	4979.6	5045.7	5010.2	5076.8	30.6	31.1	0.61%	0.62%
CEDAR MOUNTAIN (GRE)	119108	CMT_34_5KV_1	34.5	0.0	18095.6	0.0	18207.1	0.0	111.5	0.00%	0.62%
BROOKINGS COUNTY (NS	113216	BOK_TR10_TER	13.8	0.0	30738.5	0.0	30927.6	0.0	189.1	0.00%	0.62%
MAYNARD (NSPM)	171500	MYN_69KV	69	4861.0	4975.2	4891.0	5005.8	30.0	30.6	0.62%	0.62%
RENVILLE (NSPM)	194100	RNV_69KV	69	2255.9	3377.4	2255.9	3398.0	0.0	20.6	0.00%	0.61%
EMMET (RS)	135000	EMT_69KV	69	2081.3	3143.0	2081.3	3162.1	0.0	19.1	0.00%	0.61%
EMMET (NSPM)	134901	EMM_IB_CAP1	69	2081.3	3143.0	2081.3	3162.1	0.0	19.1	0.00%	0.61%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
EMMET (NSPM)	134900	EMM_69KV	69	2081.3	3143.0	2081.3	3162.1	0.0	19.1	0.00%	0.61%
EMMET TAP (EREP)	135100	ETPT_69KV	69	2258.5	3382.8	2258.5	3403.3	0.0	20.5	0.00%	0.61%
HAZEL CREEK (NSPM)	148707	HZC_TR09_TER	13.8	0.0	21372.0	0.0	21499.1	0.0	127.1	0.00%	0.59%
HAZEL CREEK (NSPM)	148706	HZC_IB_RB9	13.8	0.0	21372.0	0.0	21499.1	0.0	127.1	0.00%	0.59%
CROOKS (RS)	125800	CKS_69KV	69	2271.8	3408.9	2271.8	3429.1	0.0	20.2	0.00%	0.59%
HONNER (EREPC)	152201	HNR_115KV	115	4267.2	6454.1	4292.4	6492.2	25.2	38.1	0.59%	0.59%
HONNER (EREPC)	152200	HNRT_115KV	115	4267.2	6454.1	4292.4	6492.2	25.2	38.1	0.59%	0.59%
SUGAR BEET PLANT (ER	210100	SBP_FUSE	69	2169.8	3271.7	2169.8	3291.0	0.0	19.3	0.00%	0.59%
MINNESOTA VALLEY (NS	176504	MNV_230KV_6	230	13177.8	12463.1	13255.5	12536.6	77.7	73.5	0.59%	0.59%
MINNESOTA VALLEY (NS	176503	MNV_230KV_5	230	13177.8	12463.1	13255.5	12536.6	77.7	73.5	0.59%	0.59%
MINNESOTA VALLEY (NS	176502	MNV_230KV_2	230	13177.8	12463.1	13255.5	12536.6	77.7	73.5	0.59%	0.59%
MINNESOTA VALLEY (NS	176501	MNV_230KV_1	230	13177.8	12463.1	13255.5	12536.6	77.7	73.5	0.59%	0.59%
CROOKS TAP (NSPM)	125901	CKT_IB_CAP1	69	2299.2	3445.2	2299.2	3465.5	0.0	20.3	0.00%	0.59%
CROOKS TAP (NSPM)	125900	CKTT_69KV	69	2299.2	3445.2	2299.2	3465.5	0.0	20.3	0.00%	0.59%
SUGAR BEET PLANT (ER	210101	SBP_MAIN	69	2076.6	3145.2	2076.6	3163.7	0.0	18.5	0.00%	0.59%
MINNESOTA VALLEY (NS	176500	MNVT_GRA_PTH	230	13090.0	12429.4	13167.0	12502.5	77.0	73.1	0.59%	0.59%
BROOKINGS COUNTY (NS	113206	BOK_IB_WHI1	345	9838.2	10227.7	9894.6	10287.0	56.4	59.3	0.57%	0.58%
BROOKINGS COUNTY (NS	113205	BOK_IB_TR10	345	9838.2	10227.7	9894.6	10287.0	56.4	59.3	0.57%	0.58%
BROOKINGS COUNTY (NS	113204	BOK_IB_TR09	345	9838.2	10227.7	9894.6	10287.0	56.4	59.3	0.57%	0.58%
BROOKINGS COUNTY (NS	113201	BOK_345KV_2	345	9838.2	10227.7	9894.6	10287.0	56.4	59.3	0.57%	0.58%
BROOKINGS COUNTY (NS	113200	BOK_345KV_1	345	9838.2	10227.7	9894.6	10287.0	56.4	59.3	0.57%	0.58%
WHITE (WAPA)	225606	WHI_IB_WTT	345	9848.6	10244.7	9904.9	10304.0	56.3	59.3	0.57%	0.58%
WHITE (WAPA)	225605	WHI_IB_TR01	345	9848.6	10244.7	9904.9	10304.0	56.3	59.3	0.57%	0.58%
WHITE (WAPA)	225604	WHI_IB_SPK	345	9848.6	10244.7	9904.9	10304.0	56.3	59.3	0.57%	0.58%
WHITE (WAPA)	225603	WHI_IB_BOK2	345	9848.6	10244.7	9904.9	10304.0	56.3	59.3	0.57%	0.58%
WHITE (WAPA)	225602	WHI_IB_BOK1	345	9848.6	10244.7	9904.9	10304.0	56.3	59.3	0.57%	0.58%
WHITE (WAPA)	225601	WHI_345KV_2	345	9848.6	10244.7	9904.9	10304.0	56.3	59.3	0.57%	0.58%
WHITE (WAPA)	225600	WHI_345KV_1	345	9848.6	10244.7	9904.9	10304.0	56.3	59.3	0.57%	0.58%
FRANKLIN (NSPM)	140104	FRA_IB_TR05	115	10188.7	11259.6	10247.4	11324.6	58.7	65.0	0.58%	0.58%
FRANKLIN (NSPM)	140103	FRA_IB_MNV	115	10188.7	11259.6	10247.4	11324.6	58.7	65.0	0.58%	0.58%
FRANKLIN (NSPM)	140102	FRA_IB_FTR	115	10188.7	11259.6	10247.4	11324.6	58.7	65.0	0.58%	0.58%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
FRANKLIN (NSPM)	140101	FRA_115KV_2	115	10188.7	11259.6	10247.4	11324.6	58.7	65.0	0.58%	0.58%
FRANKLIN (NSPM)	140100	FRA_115KV_1	115	10188.7	11259.6	10247.4	11324.6	58.7	65.0	0.58%	0.58%
OAK LAKE (IBERDROLA)	184002	OAL_IB_BOK	115	6118.7	5992.9	6151.7	6027.4	33.0	34.5	0.54%	0.58%
OAK LAKE (IBERDROLA)	184001	OAL_115KV_C1	115	6118.7	5992.9	6151.7	6027.4	33.0	34.5	0.54%	0.58%
OAK LAKE (IBERDROLA)	184000	OAL_115KV_1	115	6118.7	5992.9	6151.7	6027.4	33.0	34.5	0.54%	0.58%
GRANITE FALLS (WAPA)	145109	GRA_IB_WTT	230	13450.9	12615.2	13528.3	12687.8	77.4	72.6	0.58%	0.58%
GRANITE FALLS (WAPA)	145108	GRA_IB_WMR	230	13450.9	12615.2	13528.3	12687.8	77.4	72.6	0.58%	0.58%
GRANITE FALLS (WAPA)	145107	GRA_IB_MOS	230	13450.9	12615.2	13528.3	12687.8	77.4	72.6	0.58%	0.58%
GRANITE FALLS (WAPA)	145106	GRA_IB_MNV2	230	13450.9	12615.2	13528.3	12687.8	77.4	72.6	0.58%	0.58%
GRANITE FALLS (WAPA)	145105	GRA_IB_MNV1	230	13450.9	12615.2	13528.3	12687.8	77.4	72.6	0.58%	0.58%
GRANITE FALLS (WAPA)	145104	GRA_IB_KV8A	230	13450.9	12615.2	13528.3	12687.8	77.4	72.6	0.58%	0.58%
GRANITE FALLS (WAPA)	145103	GRA_IB_KV3A	230	13450.9	12615.2	13528.3	12687.8	77.4	72.6	0.58%	0.58%
GRANITE FALLS (WAPA)	145102	GRA_IB_BAR	230	13450.9	12615.2	13528.3	12687.8	77.4	72.6	0.58%	0.58%
GRANITE FALLS (WAPA)	145101	GRA_230KV_2	230	13450.9	12615.2	13528.3	12687.8	77.4	72.6	0.58%	0.58%
GRANITE FALLS (WAPA)	145100	GRA_230KV_1	230	13450.9	12615.2	13528.3	12687.8	77.4	72.6	0.58%	0.58%
DANUBE (NSPM)	127200	DAN_69KV	69	2628.3	3896.2	2628.3	3917.9	0.0	21.7	0.00%	0.56%
MAYNARD XMSN (NSPM)	171703	MAT_IB_MNV	115	5863.3	7276.2	5895.5	7316.1	32.2	39.9	0.55%	0.55%
MAYNARD XMSN (NSPM)	171702	MAT_IB_BSN	115	5863.3	7276.2	5895.5	7316.1	32.2	39.9	0.55%	0.55%
MAYNARD XMSN (NSPM)	171700	MAT_115KV_1	115	5863.3	7276.2	5895.5	7316.1	32.2	39.9	0.55%	0.55%
CHANARAMBIE (NSPM)	5674	J426_COL	34.5	15167.7	16047.8	15250.9	16135.8	83.2	88.0	0.55%	0.55%
TROY SW STA (NSPM)	215703	TRS_IB_MNV	69	2990.2	4383.0	2990.2	4406.7	0.0	23.7	0.00%	0.54%
TROY SW STA (NSPM)	215702	TRS_IB_FRA	69	2990.2	4383.0	2990.2	4406.7	0.0	23.7	0.00%	0.54%
TROY SW STA (NSPM)	215701	TRS_IB_BIS	69	2990.2	4383.0	2990.2	4406.7	0.0	23.7	0.00%	0.54%
TROY SW STA (NSPM)	215700	TRS_69KV	69	2990.2	4383.0	2990.2	4406.7	0.0	23.7	0.00%	0.54%
TROY (RS)	215600	TRO_69KV	69	2708.3	4013.8	2708.3	4035.3	0.0	21.5	0.00%	0.54%
OAK LAKE (IBERDROLA)	184008	OAL_FDR04	34.5	16190.2	12209.4	16264.7	12274.7	74.5	65.3	0.46%	0.53%
OAK LAKE (IBERDROLA)	184007	OAL_FDR03	34.5	16190.2	12209.4	16264.7	12274.7	74.5	65.3	0.46%	0.53%
OAK LAKE (IBERDROLA)	184006	OAL_FDR02	34.5	16190.2	12209.4	16264.7	12274.7	74.5	65.3	0.46%	0.53%
OAK LAKE (IBERDROLA)	184005	OAL_FDR01	34.5	16190.2	12209.4	16264.7	12274.7	74.5	65.3	0.46%	0.53%
OAK LAKE (IBERDROLA)	184004	OAL_34_5KV_2	34.5	16190.2	12209.4	16264.7	12274.7	74.5	65.3	0.46%	0.53%
OAK LAKE (IBERDROLA)	184003	OAL_34_5KV_1	34.5	16190.2	12209.4	16264.7	12274.7	74.5	65.3	0.46%	0.53%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
WABASSO (GRE)	219200	SW_C146_NO	69	881.1	1253.9	881.1	1260.6	0.0	6.7	0.00%	0.53%
CITY OF REDWOOD FALL	122000	RFAT_69KV	69	1430.9	2044.7	1430.9	2055.6	0.0	10.9	0.00%	0.53%
FRANKLIN (NSPM)	140109	FRA_69KV_7	69	10202.4	10665.3	10256.8	10722.1	54.4	56.8	0.53%	0.53%
FRANKLIN (NSPM)	140108	FRA_69KV_4	69	10202.4	10665.3	10256.8	10722.1	54.4	56.8	0.53%	0.53%
FRANKLIN (NSPM)	140105	FRA_4N111	69	10202.4	10665.3	10256.8	10722.1	54.4	56.8	0.53%	0.53%
FRANKLIN (NSPM)	140116	FRA_IB_WNU	69	10644.4	10872.1	10701.1	10930.0	56.7	57.9	0.53%	0.53%
FRANKLIN (NSPM)	140115	FRA_IB_WIP	69	10644.4	10872.1	10701.1	10930.0	56.7	57.9	0.53%	0.53%
FRANKLIN (NSPM)	140114	FRA_IB_TR06	69	10644.4	10872.1	10701.1	10930.0	56.7	57.9	0.53%	0.53%
FRANKLIN (NSPM)	140113	FRA_IB_TR05	69	10644.4	10872.1	10701.1	10930.0	56.7	57.9	0.53%	0.53%
FRANKLIN (NSPM)	140112	FRA_IB_LYC	69	10644.4	10872.1	10701.1	10930.0	56.7	57.9	0.53%	0.53%
FRANKLIN (NSPM)	140111	FRA_IB_BIS	69	10644.4	10872.1	10701.1	10930.0	56.7	57.9	0.53%	0.53%
FRANKLIN (NSPM)	140110	FRA_IB_4N111	69	10644.4	10872.1	10701.1	10930.0	56.7	57.9	0.53%	0.53%
FRANKLIN (NSPM)	140107	FRA_69KV_2	69	10644.4	10872.1	10701.1	10930.0	56.7	57.9	0.53%	0.53%
FRANKLIN (NSPM)	140106	FRA_69KV_1	69	10644.4	10872.1	10701.1	10930.0	56.7	57.9	0.53%	0.53%
OAK LAKE (IBERDROLA)	184010	OAL_TR02_TER	13.8	0.0	20098.0	0.0	20205.0	0.0	107.0	0.00%	0.53%
OAK LAKE (IBERDROLA)	184009	OAL_TR01_TER	13.8	0.0	20110.5	0.0	20217.5	0.0	107.0	0.00%	0.53%
REDWOOD TAP (GRE)	193900	RWOT_69KV	69	1342.6	1923.9	1342.6	1934.1	0.0	10.2	0.00%	0.53%
OLIVIA WEST (MUNI)	185000	OLWT_69KV	69	3023.0	4382.2	3023.0	4405.4	0.0	23.2	0.00%	0.53%
BIRCH COOLEY (EREPC)	110000	BHC_69KV	69	5886.9	8016.5	5917.9	8058.7	31.0	42.2	0.53%	0.53%
BEAVER CREEK (NSPM)	107801	BVC_IB_CAP1	69	3053.8	4412.2	3053.8	4435.4	0.0	23.2	0.00%	0.53%
BEAVER CREEK (NSPM)	107800	BVC_69KV	69	3053.8	4412.2	3053.8	4435.4	0.0	23.2	0.00%	0.53%
HENRYVILLE (RS)	149801	HEV_69KV	69	2618.3	4004.2	2618.3	4025.2	0.0	21.0	0.00%	0.52%
NEW CITY OF OLIVIA T	180300	NCOT_69KV	69	3097.3	4457.9	3097.3	4481.2	0.0	23.3	0.00%	0.52%
KINGMAN (RS)	159500	KNG_69KV	69	3208.7	4581.0	3208.7	4604.8	0.0	23.8	0.00%	0.52%
FENTON (NSPM)	137622	FTN_FDR322_E	34.5	4666.9	6669.3	4666.9	6703.9	0.0	34.6	0.00%	0.52%
FENTON (NSPM)	137620	FTN_FDR321_E	34.5	4666.9	6669.3	4666.9	6703.9	0.0	34.6	0.00%	0.52%
FENTON (NSPM)	137618	FTN_FDR312_E	34.5	4844.3	7242.5	4844.3	7280.0	0.0	37.5	0.00%	0.52%
FENTON (NSPM)	137616	FTN_FDR311_E	34.5	4844.3	7242.5	4844.3	7280.0	0.0	37.5	0.00%	0.52%
FENTON (NSPM)	137624	FTN_IB_TR2	34.5	14968.1	12593.6	15045.6	12658.8	77.5	65.2	0.52%	0.52%
FENTON (NSPM)	137621	FTN_FDR322	34.5	14968.1	12593.6	15045.6	12658.8	77.5	65.2	0.52%	0.52%
FENTON (NSPM)	137619	FTN_FDR321	34.5	14968.1	12593.6	15045.6	12658.8	77.5	65.2	0.52%	0.52%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
FENTON (NSPM)	137614	FTN_34_5KV_2	34.5	14968.1	12593.6	15045.6	12658.8	77.5	65.2	0.52%	0.52%
FENTON (NSPM)	137625	FTN_TR01_TER	13.8	0.0	13984.7	0.0	14057.1	0.0	72.4	0.00%	0.52%
FENTON (NSPM)	137626	FTN_TR02_TER	13.8	0.0	17251.2	0.0	17340.5	0.0	89.3	0.00%	0.52%
FENTON (NSPM)	137623	FTN_IB_TR1	34.5	17011.4	14894.9	17099.4	14972.0	88.0	77.1	0.52%	0.52%
FENTON (NSPM)	137617	FTN_FDR312	34.5	17011.4	14894.9	17099.4	14972.0	88.0	77.1	0.52%	0.52%
FENTON (NSPM)	137615	FTN_FDR311	34.5	17011.4	14894.9	17099.4	14972.0	88.0	77.1	0.52%	0.52%
FENTON (NSPM)	137613	FTN_34_5KV_1	34.5	17011.4	14894.9	17099.4	14972.0	88.0	77.1	0.52%	0.52%
FENTON (NSPM)	137608	FTN_IB_TR05	115	10026.3	10374.8	10078.2	10428.4	51.9	53.6	0.52%	0.52%
FENTON (NSPM)	137606	FTN_IB_NOB2	115	10026.3	10374.8	10078.2	10428.4	51.9	53.6	0.52%	0.52%
FENTON (NSPM)	137605	FTN_IB_NOB1	115	10026.3	10374.8	10078.2	10428.4	51.9	53.6	0.52%	0.52%
FENTON (NSPM)	137604	FTN_IB_CHB	115	10026.3	10374.8	10078.2	10428.4	51.9	53.6	0.52%	0.52%
FENTON (NSPM)	137603	FTN_115_TR02	115	10026.3	10374.8	10078.2	10428.4	51.9	53.6	0.52%	0.52%
FENTON (NSPM)	137602	FTN_115_TR01	115	10026.3	10374.8	10078.2	10428.4	51.9	53.6	0.52%	0.52%
FENTON (NSPM)	137601	FTN_115KV_2	115	10026.3	10374.8	10078.2	10428.4	51.9	53.6	0.52%	0.52%
FENTON (NSPM)	137600	FTN_115KV_1	115	10026.3	10374.8	10078.2	10428.4	51.9	53.6	0.52%	0.52%
HENRYVILLE (RS)	149800	HEVT_69KV	69	4431.5	6541.6	4454.3	6575.3	22.8	33.7	0.51%	0.52%
OLIVIA (MUNI)	184900	OLIT_69KV	69	3349.4	4739.9	3349.4	4764.3	0.0	24.4	0.00%	0.51%
WHITE (WAPA)	225608	WHI_TR01_TER	13.8	0.0	40732.1	0.0	40938.4	0.0	206.3	0.00%	0.51%
WHITE (WAPA)	225607	WHI_115KV	115	11136.2	9603.4	11192.2	9651.7	56.0	48.3	0.50%	0.50%
YELLOWSTONE(MCD)	229900	YEL_69KV	69	1232.5	1826.1	1232.5	1835.2	0.0	9.1	0.00%	0.50%
BUFFALO LAKE (NSPM)	114300	BFL_69KV	69	1198.7	1777.5	1198.7	1786.3	0.0	8.8	0.00%	0.50%
BIRD ISLAND (NSPM)	110203	BIS_IB_TRS	69	5004.6	6445.9	5029.4	6477.8	24.8	31.9	0.50%	0.49%
BIRD ISLAND (NSPM)	110202	BIS_IB_FRA	69	5004.6	6445.9	5029.4	6477.8	24.8	31.9	0.50%	0.49%
BIRD ISLAND (NSPM)	110201	BIS_IB_CAP	69	5004.6	6445.9	5029.4	6477.8	24.8	31.9	0.50%	0.49%
BIRD ISLAND (NSPM)	110200	BIS_69KV	69	5004.6	6445.9	5029.4	6477.8	24.8	31.9	0.50%	0.49%
HECTOR (GRE)	148900	HTRT_69KV	69	2082.6	3013.3	2082.6	3028.2	0.0	14.9	0.00%	0.49%
BROOKFIELD (MCLEOD)	113000	BKF_69KV	69	1747.5	2554.2	1747.5	2566.8	0.0	12.6	0.00%	0.49%
HECTOR (NSPM)	149000	HEC_69KV	69	1602.9	2351.8	1602.9	2363.4	0.0	11.6	0.00%	0.49%
PRESTON LAKE (MCLEOD	192000	PLK_69KV	69	1049.5	1561.9	1049.5	1569.6	0.0	7.7	0.00%	0.49%
EDEN (BRN)	131900	EDEN_69KV	69	2857.4	4148.8	2857.4	4169.2	0.0	20.4	0.00%	0.49%
MORGAN (NSPM)	178000	MGN_69KV	69	2710.6	3959.5	2710.6	3978.7	0.0	19.2	0.00%	0.48%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
PANTHER (GRE)	186505	PTH_IB_TR06	69	7051.6	6897.0	7084.7	6929.3	33.1	32.3	0.47%	0.47%
PANTHER (GRE)	186504	PTH_69KV_2	69	7051.6	6897.0	7084.7	6929.3	33.1	32.3	0.47%	0.47%
PANTHER (GRE)	186503	PTH_69KV_1	69	7051.6	6897.0	7084.7	6929.3	33.1	32.3	0.47%	0.47%
FAIRFAX TAP (MUNI)	136300	FAXT_69KV	69	2967.4	4553.2	2967.4	4574.3	0.0	21.1	0.00%	0.46%
CAIRO (RS)	116300	CAI_69KV	69	2770.2	4274.7	2770.2	4293.9	0.0	19.2	0.00%	0.45%
PANTHER (GRE)	186502	PTH_IB_MNV	230	4889.1	6135.0	4910.8	6162.2	21.7	27.2	0.44%	0.44%
PANTHER (GRE)	186501	PTH_IB_MCL	230	4889.1	6135.0	4910.8	6162.2	21.7	27.2	0.44%	0.44%
PANTHER (GRE)	186500	PTH_230KV	230	4889.1	6135.0	4910.8	6162.2	21.7	27.2	0.44%	0.44%
SLEEPY EYE (MUNI)	203801	SEY_69KV	69	2006.4	2960.0	2006.4	2972.8	0.0	12.8	0.00%	0.43%
WATERTOWN (WAPA)	221503	WTT_TR01_TER	13.8	0.0	36444.2	0.0	36601.5	0.0	157.3	0.00%	0.43%
SLEEPY EYE (MUNI)	203800	SEYT_69KV	69	2191.8	3200.8	2191.8	3214.6	0.0	13.8	0.00%	0.43%
KERKHOVEN (GRE)	171701	MAT_BSN_WMR	115	4464.8	5789.2	4483.9	5813.9	19.1	24.7	0.43%	0.43%
SLEEPY EYE (BRN)	203700	SLET_69KV	69	2248.3	3249.6	2248.3	3263.3	0.0	13.7	0.00%	0.42%
WATERTOWN (WAPA)	221500	WTT_345KV	345	7964.2	8461.3	7997.5	8496.7	33.3	35.4	0.42%	0.42%
BROOKINGS (WAPA)	113100	BRK_115KV	115	6148.3	7616.0	6173.1	7646.7	24.8	30.7	0.40%	0.40%
WILLMAR (GRE)	226503	WMR_IB_MAT	115	4526.2	4719.7	4544.5	4738.7	18.3	19.0	0.40%	0.40%
WILLMAR (GRE)	226502	WMR_115KV	115	4526.2	4719.7	4544.5	4738.7	18.3	19.0	0.40%	0.40%
HOME (BRN)	152100	HOM_69KV	69	2556.6	3597.2	2556.6	3611.6	0.0	14.4	0.00%	0.40%
ESSIG (NSPM)	135800	ESG_69KV	69	3037.4	4138.7	3037.4	4154.6	0.0	15.9	0.00%	0.38%
GIBBON (NSPM)	142400	GIB_69KV	69	2491.7	3820.7	2491.7	3835.3	0.0	14.6	0.00%	0.38%
WATERTOWN (WAPA)	221501	WTT_230KV	230	11171.1	12499.8	11213.7	12547.5	42.6	47.7	0.38%	0.38%
SEARLES TAP (BRN)	200400	SRTT_69KV	69	4807.6	5883.7	4807.6	5905.0	0.0	21.3	0.00%	0.36%
NEW ULM (BRN)	181500	NWU_69KV	69	5027.5	6072.8	5027.5	6094.7	0.0	21.9	0.00%	0.36%
FORT RIDGELY (NSPM)	139710	FTR_IB_WNU	115	5155.8	6057.4	5174.3	6079.2	18.5	21.8	0.36%	0.36%
FORT RIDGELY (NSPM)	139709	FTR_IB_WLM	115	5155.8	6057.4	5174.3	6079.2	18.5	21.8	0.36%	0.36%
FORT RIDGELY (NSPM)	139708	FTR_IB_FRA	115	5155.8	6057.4	5174.3	6079.2	18.5	21.8	0.36%	0.36%
FORT RIDGELY (NSPM)	139707	FTR_IB_CAP2	115	5155.8	6057.4	5174.3	6079.2	18.5	21.8	0.36%	0.36%
FORT RIDGELY (NSPM)	139706	FTR_IB_CAP1	115	5155.8	6057.4	5174.3	6079.2	18.5	21.8	0.36%	0.36%
FORT RIDGELY (NSPM)	139705	FTR_IB_C2	115	5155.8	6057.4	5174.3	6079.2	18.5	21.8	0.36%	0.36%
FORT RIDGELY (NSPM)	139704	FTR_IB_C1	115	5155.8	6057.4	5174.3	6079.2	18.5	21.8	0.36%	0.36%
FORT RIDGELY (NSPM)	139701	FTR_115KV_2	115	5155.8	6057.4	5174.3	6079.2	18.5	21.8	0.36%	0.36%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
FORT RIDGELY (NSPM)	139700	FTR_115KV_1	115	5155.8	6057.4	5174.3	6079.2	18.5	21.8	0.36%	0.36%
WEST NEW ULM (NSPM)	223505	WNU_IB_TR05	69	6437.0	7156.6	6459.8	7182.0	22.8	25.4	0.35%	0.35%
WEST NEW ULM (NSPM)	223504	WNU_IB_FTR	69	6437.0	7156.6	6459.8	7182.0	22.8	25.4	0.35%	0.35%
WEST NEW ULM (NSPM)	223503	WNU_IB_FRA	69	6437.0	7156.6	6459.8	7182.0	22.8	25.4	0.35%	0.35%
WEST NEW ULM (NSPM)	223502	WNU_69KV	69	6437.0	7156.6	6459.8	7182.0	22.8	25.4	0.35%	0.35%
KERKHOVEN (GRE)	158900	KER_115KV_1	115	3184.3	4523.6	3184.3	4539.6	0.0	16.0	0.00%	0.35%
CANBY (OTP)	116901	CBY_115KV	115	3061.8	4110.2	3061.8	4124.4	0.0	14.2	0.00%	0.35%
FROEHLICH (WESCO WIN	140700	FRHT_69KV	69	2774.6	4155.8	2774.6	4170.1	0.0	14.3	0.00%	0.34%
CORNISH (BRN)	124600	CNS_69KV	69	2984.8	4410.7	2984.8	4425.3	0.0	14.6	0.00%	0.33%
TORONTO (OTP)	214000	TOR_115KV	115	2803.9	3807.9	2803.9	3820.3	0.0	12.4	0.00%	0.33%
DOTSON (GRE)	129200	DOT_69KV_1	69	1864.5	3069.1	1864.5	3078.7	0.0	9.6	0.00%	0.31%
WINTHROP (NSPM)	228304	WIP_IB_HUT	69	3483.6	5176.4	3483.6	5192.3	0.0	15.9	0.00%	0.31%
WINTHROP (NSPM)	228303	WIP_IB_FTR	69	3483.6	5176.4	3483.6	5192.3	0.0	15.9	0.00%	0.31%
WINTHROP (NSPM)	228302	WIP_IB_FRA	69	3483.6	5176.4	3483.6	5192.3	0.0	15.9	0.00%	0.31%
WINTHROP (NSPM)	228301	WIP_IB_ARL	69	3483.6	5176.4	3483.6	5192.3	0.0	15.9	0.00%	0.31%
WINTHROP (NSPM)	228300	WIP_69KV	69	3483.6	5176.4	3483.6	5192.3	0.0	15.9	0.00%	0.31%
SUMMIT (GRE)	210300	SMM_69KV_1	69	2552.5	4441.8	2552.5	4455.2	0.0	13.4	0.00%	0.30%
NOBLES COUNTY (NSPM)	182036	NOB_TR10_TER	34.5	0.0	12789.1	0.0	12826.8	0.0	37.7	0.00%	0.29%
NOBLES COUNTY (NSPM)	182035	NOB_TR09_TER	34.5	0.0	12803.3	0.0	12841.0	0.0	37.7	0.00%	0.29%
NOBLES COUNTY (NSPM)	182034	NOB_IB_TR02	34.5	22865.8	19264.1	22933.0	19320.8	67.2	56.7	0.29%	0.29%
NOBLES COUNTY (NSPM)	182031	NOB_FDR323	34.5	22865.8	19264.1	22933.0	19320.8	67.2	56.7	0.29%	0.29%
NOBLES COUNTY (NSPM)	182030	NOB_FDR322_M	34.5	22865.8	19264.1	22933.0	19320.8	67.2	56.7	0.29%	0.29%
NOBLES COUNTY (NSPM)	182028	NOB_FDR322	34.5	22865.8	19264.1	22933.0	19320.8	67.2	56.7	0.29%	0.29%
NOBLES COUNTY (NSPM)	182027	NOB_FDR321_M	34.5	22865.8	19264.1	22933.0	19320.8	67.2	56.7	0.29%	0.29%
NOBLES COUNTY (NSPM)	182025	NOB_FDR321	34.5	22865.8	19264.1	22933.0	19320.8	67.2	56.7	0.29%	0.29%
NOBLES COUNTY (NSPM)	182016	NOB_34_5KV_2	34.5	22865.8	19264.1	22933.0	19320.8	67.2	56.7	0.29%	0.29%
NOBLES COUNTY (NSPM)	182033	NOB_IB_TR01	34.5	22533.2	19202.9	22599.5	19259.4	66.3	56.5	0.29%	0.29%
NOBLES COUNTY (NSPM)	182023	NOB_FDR313	34.5	22533.2	19202.9	22599.5	19259.4	66.3	56.5	0.29%	0.29%
NOBLES COUNTY (NSPM)	182022	NOB_FDR312_M	34.5	22533.2	19202.9	22599.5	19259.4	66.3	56.5	0.29%	0.29%
NOBLES COUNTY (NSPM)	182020	NOB_FDR312	34.5	22533.2	19202.9	22599.5	19259.4	66.3	56.5	0.29%	0.29%
NOBLES COUNTY (NSPM)	182019	NOB_FDR311_M	34.5	22533.2	19202.9	22599.5	19259.4	66.3	56.5	0.29%	0.29%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
NOBLES COUNTY (NSPM)	182017	NOB_FDR311	34.5	22533.2	19202.9	22599.5	19259.4	66.3	56.5	0.29%	0.29%
NOBLES COUNTY (NSPM)	182015	NOB_34_5KV_1	34.5	22533.2	19202.9	22599.5	19259.4	66.3	56.5	0.29%	0.29%
NOBLES COUNTY (NSPM)	182014	NOB_IB_TR10	115	22321.2	20578.0	22386.8	20638.5	65.6	60.5	0.29%	0.29%
NOBLES COUNTY (NSPM)	182013	NOB_IB_TR09	115	22321.2	20578.0	22386.8	20638.5	65.6	60.5	0.29%	0.29%
NOBLES COUNTY (NSPM)	182012	NOB_IB_TR02	115	22321.2	20578.0	22386.8	20638.5	65.6	60.5	0.29%	0.29%
NOBLES COUNTY (NSPM)	182011	NOB_IB_TR01	115	22321.2	20578.0	22386.8	20638.5	65.6	60.5	0.29%	0.29%
NOBLES COUNTY (NSPM)	182010	NOB_IB_FTN2	115	22321.2	20578.0	22386.8	20638.5	65.6	60.5	0.29%	0.29%
NOBLES COUNTY (NSPM)	182009	NOB_IB_FTN1	115	22321.2	20578.0	22386.8	20638.5	65.6	60.5	0.29%	0.29%
NOBLES COUNTY (NSPM)	182007	NOB_IB_C1	115	22321.2	20578.0	22386.8	20638.5	65.6	60.5	0.29%	0.29%
NOBLES COUNTY (NSPM)	182005	NOB_115KV_2	115	22321.2	20578.0	22386.8	20638.5	65.6	60.5	0.29%	0.29%
NOBLES COUNTY (NSPM)	182004	NOB_115KV_1	115	22321.2	20578.0	22386.8	20638.5	65.6	60.5	0.29%	0.29%
NOBLES COUNTY (NSPM)	182038	NOB_TR02_TER	13.8	0.0	16638.2	0.0	16687.1	0.0	48.9	0.00%	0.29%
NOBLES COUNTY (NSPM)	182037	NOB_TR01_TER	13.8	0.0	16721.4	0.0	16770.5	0.0	49.1	0.00%	0.29%
NOBLES COUNTY (NSPM)	182008	NOB_IB_CAP	115	19817.1	18430.4	19875.3	18484.5	58.2	54.1	0.29%	0.29%
NOBLES COUNTY (NSPM)	182006	NOB_115KV_C1	115	19817.1	18430.4	19875.3	18484.5	58.2	54.1	0.29%	0.29%
MARIETTA (OTP)	170300	MTA_115KV	115	3688.7	3772.1	3688.7	3782.2	0.0	10.1	0.00%	0.27%
SPLIT ROCK (NSPM)	206104	SPK_IB_WHI	345	12337.4	13035.7	12370.0	13070.1	32.6	34.4	0.26%	0.26%
SPLIT ROCK (NSPM)	206103	SPK_IB_SOC	345	12337.4	13035.7	12370.0	13070.1	32.6	34.4	0.26%	0.26%
SPLIT ROCK (NSPM)	206102	SPK_IB_NOB	345	12337.4	13035.7	12370.0	13070.1	32.6	34.4	0.26%	0.26%
SPLIT ROCK (NSPM)	206101	SPK_345KV_2	345	12337.4	13035.7	12370.0	13070.1	32.6	34.4	0.26%	0.26%
SPLIT ROCK (NSPM)	206100	SPK_345KV_1	345	12337.4	13035.7	12370.0	13070.1	32.6	34.4	0.26%	0.26%
NOBLES COUNTY (NSPM)	182003	NOB_IB_SPK	345	9071.3	9571.6	9094.1	9595.6	22.8	24.0	0.25%	0.25%
NOBLES COUNTY (NSPM)	182002	NOB_IB_LAJ	345	9071.3	9571.6	9094.1	9595.6	22.8	24.0	0.25%	0.25%
NOBLES COUNTY (NSPM)	182001	NOB_345KV_2	345	9071.3	9571.6	9094.1	9595.6	22.8	24.0	0.25%	0.25%
NOBLES COUNTY (NSPM)	182000	NOB_345KV_1	345	9071.3	9571.6	9094.1	9595.6	22.8	24.0	0.25%	0.25%
HELENA (NSPM)	149406	HNA_IB_SSL	345	16874.0	21713.3	16915.8	21767.2	41.8	53.9	0.25%	0.25%
HELENA (NSPM)	149405	HNA_IB_CMT2	345	16874.0	21713.3	16915.8	21767.2	41.8	53.9	0.25%	0.25%
HELENA (NSPM)	149404	HNA_IB_CMT1	345	16874.0	21713.3	16915.8	21767.2	41.8	53.9	0.25%	0.25%
HELENA (NSPM)	149403	HNA_IB_CHA	345	16874.0	21713.3	16915.8	21767.2	41.8	53.9	0.25%	0.25%
HELENA (NSPM)	149402	HNA_IB_BLL	345	16874.0	21713.3	16915.8	21767.2	41.8	53.9	0.25%	0.25%
HELENA (NSPM)	149401	HNA_345KV_2	345	16874.0	21713.3	16915.8	21767.2	41.8	53.9	0.25%	0.25%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
HELENA (NSPM)	149400	HNA_345KV_1	345	16874.0	21713.3	16915.8	21767.2	41.8	53.9	0.25%	0.25%
SHEAS LAKE (NSPM)	201803	SSL_IB_WLM	345	14107.5	17910.3	14139.5	17951.0	32.0	40.7	0.23%	0.23%
SHEAS LAKE (NSPM)	201802	SSL_345KV_T9	345	14107.5	17910.3	14139.5	17951.0	32.0	40.7	0.23%	0.23%
SHEAS LAKE (NSPM)	201801	SSL_345KV_2	345	14107.5	17910.3	14139.5	17951.0	32.0	40.7	0.23%	0.23%
SHEAS LAKE (NSPM)	201800	SSL_345KV_1	345	14107.5	17910.3	14139.5	17951.0	32.0	40.7	0.23%	0.23%
SHEAS LAKE (NSPM)	201804	SSL_115KV_1	115	13859.6	12691.3	13890.0	12719.2	30.4	27.9	0.22%	0.22%
SHEAS LAKE (NSPM)	201809	SSL_TR09_TER	34.5	0.0	9716.1	0.0	9737.3	0.0	21.2	0.00%	0.22%
SPLIT ROCK (NSPM)	206129	SPK_TR07_TER	13.8	0.0	34079.7	0.0	34151.2	0.0	71.5	0.00%	0.21%
SPLIT ROCK (NSPM)	206128	SPK_TR06_TER	36.2	0.0	7130.3	0.0	7144.9	0.0	14.6	0.00%	0.20%
PRAIRIE ROSE (ENEL)	191200	PIR_115KV	115	3897.4	3137.5	3897.4	3143.9	0.0	6.4	0.00%	0.20%
BIG STONE (OTP)	109602	BST_115KV	115	11604.2	9746.4	11627.8	9766.2	23.6	19.8	0.20%	0.20%
SPLIT ROCK (NSPM)	206111	SPK_CAP2	115	35864.8	32132.1	35936.8	32196.7	72.0	64.6	0.20%	0.20%
SPLIT ROCK (NSPM)	206110	SPK_CAP1	115	35864.8	32132.1	35936.8	32196.7	72.0	64.6	0.20%	0.20%
SPLIT ROCK (NSPM)	206127	SPK_IB_WSF	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206126	SPK_IB_TR11	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206125	SPK_IB_TR10	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206124	SPK_IB_TR07	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206123	SPK_IB_TR06	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206122	SPK_IB_PIR	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206121	SPK_IB_PIP	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206120	SPK_IB_LAW2	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206119	SPK_IB_LAW1	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206118	SPK_IB_FLS	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206117	SPK_IB_CHC	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206116	SPK_IB_CAP2	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206115	SPK_IB_CAP1	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206114	SPK_IB_CAP	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206113	SPK_IB_ANS2	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206112	SPK_IB_ANS1	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206109	SPK_CAP	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
SPLIT ROCK (NSPM)	206108	SPK_115KV_2	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
SPLIT ROCK (NSPM)	206107	SPK_115KV_1	115	42097.4	37046.7	42181.9	37121.1	84.5	74.4	0.20%	0.20%
ANGUS ANSON (NSPM)	102503	ANS_IB_TR41	115	38666.8	35340.6	38744.0	35411.1	77.2	70.5	0.20%	0.20%
ANGUS ANSON (NSPM)	102502	ANS_IB_GSU4	115	38666.8	35340.6	38744.0	35411.1	77.2	70.5	0.20%	0.20%
ANGUS ANSON (NSPM)	102501	ANS_115KV_2	115	38666.8	35340.6	38744.0	35411.1	77.2	70.5	0.20%	0.20%
ANGUS ANSON (NSPM)	102500	ANS_115KV_1	115	37092.5	34253.5	37165.8	34321.2	73.3	67.7	0.20%	0.20%
FALLS (NSPM)	136603	FLS_IB_TR02	115	10565.6	14720.9	10586.4	14749.9	20.8	29.0	0.20%	0.20%
FALLS (NSPM)	136602	FLS_IB_SPK	115	10565.6	14720.9	10586.4	14749.9	20.8	29.0	0.20%	0.20%
FALLS (NSPM)	136601	FLS_115KV_2	115	10565.6	14720.9	10586.4	14749.9	20.8	29.0	0.20%	0.20%
FALLS (NSPM)	136600	FLS_115KV_1	115	10565.6	14720.9	10586.4	14749.9	20.8	29.0	0.20%	0.20%
WEST SIOUX FALLS (NS	224204	WSF_IB_SPK	115	11038.3	14671.8	11059.8	14700.4	21.5	28.6	0.19%	0.19%
WEST SIOUX FALLS (NS	224203	WSF_115KV_6	115	11038.3	14671.8	11059.8	14700.4	21.5	28.6	0.19%	0.19%
WEST SIOUX FALLS (NS	224202	WSF_115KV_4	115	11038.3	14671.8	11059.8	14700.4	21.5	28.6	0.19%	0.19%
WEST SIOUX FALLS (NS	224201	WSF_115KV_2	115	11038.3	14671.8	11059.8	14700.4	21.5	28.6	0.19%	0.19%
WEST SIOUX FALLS (NS	224200	WSF_115KV_1	115	11038.3	14671.8	11059.8	14700.4	21.5	28.6	0.19%	0.19%
CHERRY CREEK (NSPM)	120608	CHC_IB_CAP1	115	10012.2	13615.1	10031.4	13641.2	19.2	26.1	0.19%	0.19%
CHERRY CREEK (NSPM)	120607	CHC_IB_C1	115	10012.2	13615.1	10031.4	13641.2	19.2	26.1	0.19%	0.19%
CHERRY CREEK (NSPM)	120605	CHC_115KV_6	115	10012.2	13615.1	10031.4	13641.2	19.2	26.1	0.19%	0.19%
CHERRY CREEK (NSPM)	120604	CHC_115KV_5	115	10012.2	13615.1	10031.4	13641.2	19.2	26.1	0.19%	0.19%
CHERRY CREEK (NSPM)	120603	CHC_115KV_4	115	10012.2	13615.1	10031.4	13641.2	19.2	26.1	0.19%	0.19%
CHERRY CREEK (NSPM)	120602	CHC_115KV_3	115	10012.2	13615.1	10031.4	13641.2	19.2	26.1	0.19%	0.19%
CHERRY CREEK (NSPM)	120601	CHC_115KV_2	115	10012.2	13615.1	10031.4	13641.2	19.2	26.1	0.19%	0.19%
CHERRY CREEK (NSPM)	120600	CHC_115KV_1	115	10012.2	13615.1	10031.4	13641.2	19.2	26.1	0.19%	0.19%
LAWRENCE (NSPM)	163104	LAW_115KV_5	115	29065.7	29523.4	29120.8	29579.4	55.1	56.0	0.19%	0.19%
LAWRENCE (NSPM)	163103	LAW_115KV_4	115	29065.7	29523.4	29120.8	29579.4	55.1	56.0	0.19%	0.19%
LAWRENCE (NSPM)	163102	LAW_115KV_3	115	29065.7	29523.4	29120.8	29579.4	55.1	56.0	0.19%	0.19%
LAWRENCE (NSPM)	163101	LAW_115KV_2	115	29065.7	29523.4	29120.8	29579.4	55.1	56.0	0.19%	0.19%
LAWRENCE (NSPM)	163100	LAW_115KV_1	115	29065.7	29523.4	29120.8	29579.4	55.1	56.0	0.19%	0.19%
SPLIT ROCK (NSPM)	206131	SPK_TR11_TER	13.8	0.0	27871.5	0.0	27923.6	0.0	52.1	0.00%	0.19%
SPLIT ROCK (NSPM)	206130	SPK_TR10_TER	13.8	0.0	27857.1	0.0	27909.1	0.0	52.0	0.00%	0.19%
BENSON (OTP)	108703	BSN_115KV_4	115	4706.3	5108.5	4706.3	5117.9	0.0	9.4	0.00%	0.18%
BENSON (OTP)	108702	BSN_115KV_3	115	4706.3	5108.5	4706.3	5117.9	0.0	9.4	0.00%	0.18%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
BENSON (OTP)	108701	BSN_115KV_2	115	4706.3	5108.5	4706.3	5117.9	0.0	9.4	0.00%	0.18%
BENSON (OTP)	108700	BSN_115KV_1	115	4706.3	5108.5	4706.3	5117.9	0.0	9.4	0.00%	0.18%
SPLIT ROCK (NSPM)	206106	SPK_161KV	161	8335.5	7958.6	8350.2	7972.6	14.7	14.0	0.18%	0.18%
CHUB LAKE (GRE)	121305	CHA_IB_TR03	345	14224.7	17966.3	14248.5	17996.3	23.8	30.0	0.17%	0.17%
CHUB LAKE (GRE)	121304	CHA_IB_TR01	345	14224.7	17966.3	14248.5	17996.3	23.8	30.0	0.17%	0.17%
CHUB LAKE (GRE)	121303	CHA_IB_HNA1	345	14224.7	17966.3	14248.5	17996.3	23.8	30.0	0.17%	0.17%
CHUB LAKE (GRE)	121302	CHA_IB_HMP1	345	14224.7	17966.3	14248.5	17996.3	23.8	30.0	0.17%	0.17%
CHUB LAKE (GRE)	121301	CHA_345KV_2	345	14224.7	17966.3	14248.5	17996.3	23.8	30.0	0.17%	0.17%
CHUB LAKE (GRE)	121300	CHA_345KV_1	345	14224.7	17966.3	14248.5	17996.3	23.8	30.0	0.17%	0.17%
WILMARTH (NSPM)	227404	WLM_IB_SSL	345	16073.2	16811.5	16099.1	16838.6	25.9	27.1	0.16%	0.16%
WILMARTH (NSPM)	227403	WLM_IB_MEC	345	16073.2	16811.5	16099.1	16838.6	25.9	27.1	0.16%	0.16%
WILMARTH (NSPM)	227402	WLM_IB_LFD	345	16073.2	16811.5	16099.1	16838.6	25.9	27.1	0.16%	0.16%
WILMARTH (NSPM)	227401	WLM_345KV_2	345	16073.2	16811.5	16099.1	16838.6	25.9	27.1	0.16%	0.16%
WILMARTH (NSPM)	227400	WLM_345KV_1	345	16073.2	16811.5	16099.1	16838.6	25.9	27.1	0.16%	0.16%
SPLIT ROCK (NSPM)	206105	SPK_230KV	230	12154.8	12230.4	12174.5	12250.1	19.7	19.7	0.16%	0.16%
BIG STONE (OTP)	109603	BST_GEN01	23.9	63094.8	76113.4	63193.8	76232.8	99.0	119.4	0.16%	0.16%
SCOTT COUNTY (NSPM)	200303	SCO_IB_TR09	345	20537.9	24240.8	20568.4	24276.9	30.5	36.1	0.15%	0.15%
SCOTT COUNTY (NSPM)	200302	SCO_IB_HNA	345	20537.9	24240.8	20568.4	24276.9	30.5	36.1	0.15%	0.15%
SCOTT COUNTY (NSPM)	200301	SCO_345KV_2	345	20537.9	24240.8	20568.4	24276.9	30.5	36.1	0.15%	0.15%
SCOTT COUNTY (NSPM)	200300	SCO_345KV_1	345	20537.9	24240.8	20568.4	24276.9	30.5	36.1	0.15%	0.15%
SCOTT COUNTY (NSPM)	200319	SCO_IB_WWK	115	45090.4	46668.7	45149.4	46729.7	59.0	61.0	0.13%	0.13%
SCOTT COUNTY (NSPM)	200318	SCO_IB_TR10	115	45090.4	46668.7	45149.4	46729.7	59.0	61.0	0.13%	0.13%
SCOTT COUNTY (NSPM)	200317	SCO_IB_TR09	115	45090.4	46668.7	45149.4	46729.7	59.0	61.0	0.13%	0.13%
SCOTT COUNTY (NSPM)	200316	SCO_IB_TR02	115	45090.4	46668.7	45149.4	46729.7	59.0	61.0	0.13%	0.13%
SCOTT COUNTY (NSPM)	200315	SCO_IB_TR01	115	45090.4	46668.7	45149.4	46729.7	59.0	61.0	0.13%	0.13%
SCOTT COUNTY (NSPM)	200314	SCO_IB_MRR	115	45090.4	46668.7	45149.4	46729.7	59.0	61.0	0.13%	0.13%
SCOTT COUNTY (NSPM)	200313	SCO_IB_CAR	115	45090.4	46668.7	45149.4	46729.7	59.0	61.0	0.13%	0.13%
SCOTT COUNTY (NSPM)	200312	SCO_IB_CAP2	115	45090.4	46668.7	45149.4	46729.7	59.0	61.0	0.13%	0.13%
SCOTT COUNTY (NSPM)	200311	SCO_IB_CAP1	115	45090.4	46668.7	45149.4	46729.7	59.0	61.0	0.13%	0.13%
SCOTT COUNTY (NSPM)	200310	SCO_IB_BLL	115	45090.4	46668.7	45149.4	46729.7	59.0	61.0	0.13%	0.13%
SCOTT COUNTY (NSPM)	200309	SCO_IB_BLC	115	45090.4	46668.7	45149.4	46729.7	59.0	61.0	0.13%	0.13%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
SCOTT COUNTY (NSPM)	200308	SCO_IB_BDS	115	45090.4	46668.7	45149.4	46729.7	59.0	61.0	0.13%	0.13%
SCOTT COUNTY (NSPM)	200307	SCO_CB_115KV	115	45090.4	46668.7	45149.4	46729.7	59.0	61.0	0.13%	0.13%
SCOTT COUNTY (NSPM)	200306	SCO_115KV_2	115	45090.4	46668.7	45149.4	46729.7	59.0	61.0	0.13%	0.13%
SCOTT COUNTY (NSPM)	200305	SCO_115KV_1	115	45090.4	46668.7	45149.4	46729.7	59.0	61.0	0.13%	0.13%
SCOTT COUNTY (NSPM)	200329	SCO_TR09_TER	34.5	0.0	14920.1	0.0	14939.3	0.0	19.2	0.00%	0.13%
SCOTT COUNTY (NSPM)	200330	SCO_TR10_TER	34.5	0.0	24827.8	0.0	24859.6	0.0	31.8	0.00%	0.13%
CHUB LAKE (GRE)	121313	CHA_IB_TR02	115	26410.1	27490.4	26440.3	27521.8	30.2	31.4	0.11%	0.11%
CHUB LAKE (GRE)	121312	CHA_IB_TR01	115	26410.1	27490.4	26440.3	27521.8	30.2	31.4	0.11%	0.11%
CHUB LAKE (GRE)	121311	CHA_IB_FUT	115	26410.1	27490.4	26440.3	27521.8	30.2	31.4	0.11%	0.11%
CHUB LAKE (GRE)	121310	CHA_IB_FEP	115	26410.1	27490.4	26440.3	27521.8	30.2	31.4	0.11%	0.11%
CHUB LAKE (GRE)	121309	CHA_IB_BRV	115	26410.1	27490.4	26440.3	27521.8	30.2	31.4	0.11%	0.11%
CHUB LAKE (GRE)	121308	CHA_IB_ALK	115	26410.1	27490.4	26440.3	27521.8	30.2	31.4	0.11%	0.11%
CHUB LAKE (GRE)	121307	CHA_115KV_2	115	26410.1	27490.4	26440.3	27521.8	30.2	31.4	0.11%	0.11%
CHUB LAKE (GRE)	121306	CHA_115KV_1	115	26410.1	27490.4	26440.3	27521.8	30.2	31.4	0.11%	0.11%
BLUE LAKE (NSPM)	111905	BLL_IB_SCO1	345	26036.0	30376.1	26065.2	30410.2	29.2	34.1	0.11%	0.11%
BLUE LAKE (NSPM)	111904	BLL_IB_PKL	345	26036.0	30376.1	26065.2	30410.2	29.2	34.1	0.11%	0.11%
BLUE LAKE (NSPM)	111903	BLL_IB_IVH	345	26036.0	30376.1	26065.2	30410.2	29.2	34.1	0.11%	0.11%
BLUE LAKE (NSPM)	111902	BLL_IB_EDP	345	26036.0	30376.1	26065.2	30410.2	29.2	34.1	0.11%	0.11%
BLUE LAKE (NSPM)	111901	BLL_345KV_2	345	26036.0	30376.1	26065.2	30410.2	29.2	34.1	0.11%	0.11%
BLUE LAKE (NSPM)	111900	BLL_345KV_1	345	26036.0	30376.1	26065.2	30410.2	29.2	34.1	0.11%	0.11%
CHUB LAKE (GRE)	121316	CHA_TR01_TER	34.5	0.0	20259.3	0.0	20282.0	0.0	22.7	0.00%	0.11%
CHUB LAKE (GRE)	121315	CHA_REAC1	34.5	0.0	20259.3	0.0	20282.0	0.0	22.7	0.00%	0.11%
HAMPTON (NSPM)	147003	HMP_IB_PRI	345	17988.1	22670.5	18008.1	22695.8	20.0	25.3	0.11%	0.11%
HAMPTON (NSPM)	147002	HMP_IB_CHA1	345	17988.1	22670.5	18008.1	22695.8	20.0	25.3	0.11%	0.11%
HAMPTON (NSPM)	147001	HMP_345KV_2	345	17988.1	22670.5	18008.1	22695.8	20.0	25.3	0.11%	0.11%
HAMPTON (NSPM)	147000	HMP_345KV_1	345	17988.1	22670.5	18008.1	22695.8	20.0	25.3	0.11%	0.11%
ANGUS ANSON (NSPM)	102504	ANS_GEN04	18	7.9	88218.8	7.9	88315.4	0.0	96.6	0.00%	0.11%
MANKATO ENERGY CENTE	169403	MEC_GEN03	20	11.5	124518.9	11.5	124636.6	0.0	117.7	0.00%	0.09%
SIOUX CITY (WAPA)	202700	SOC_345KV	345	12160.7	13965.2	12172.1	13978.3	11.4	13.1	0.09%	0.09%
MANKATO ENERGY CENTE	169405	MEC_GEN02	15	8.1	103617.1	8.1	103706.6	0.0	89.5	0.00%	0.09%
YELLOW MEDICINE (NSP	229705	YLM_FDR212_E	23	537.1	732.2	537.1	732.2	0.0	0.0	0.00%	0.00%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
YELLOW MEDICINE (NSP	229703	YLM_FDR211_E	23	405.2	530.0	405.2	530.0	0.0	0.0	0.00%	0.00%
YELLOW MEDICINE (NSP	229702	YLM_FDR211	23	939.3	1123.2	939.3	1123.2	0.0	0.0	0.00%	0.00%
WOODSTOCK (PARSON E)	229202	WSK_GEN01	34.5	3312.4	2743.2	3312.4	2743.2	0.0	0.0	0.00%	0.00%
VALLEY VIEW (NSPM)	217602	VVW_34_5KV	34.5	1478.2	1340.2	1478.2	1340.2	0.0	0.0	0.00%	0.00%
UILK (NSPM_UILK WIND	216601	UWI_13_8KV	13.8	2359.5	2248.7	2359.5	2248.7	0.0	0.0	0.00%	0.00%
TRACY SW STA (NSPM)	214406	TSS_FDR61	13.8	2167.7	2069.3	2167.7	2069.3	0.0	0.0	0.00%	0.00%
TRACY SW STA (NSPM)	214405	TSS_13_8KV	13.8	2167.7	2069.3	2167.7	2069.3	0.0	0.0	0.00%	0.00%
TRACY (NSPM)	214303	TRA_FDR02	4.16	3522.3	3432.1	3522.3	3432.1	0.0	0.0	0.00%	0.00%
TRACY (NSPM)	214302	TRA_FDR01	4.16	3522.3	3432.1	3522.3	3432.1	0.0	0.0	0.00%	0.00%
TRACY (NSPM)	214301	TRA_4_16KV	4.16	3522.3	3432.1	3522.3	3432.1	0.0	0.0	0.00%	0.00%
SUGAR BEET PLANT (ER	210102	SBP_PLANT	4.16	18106.9	16536.6	18106.9	16536.6	0.0	0.0	0.00%	0.00%
STEWART (NSPM)	209101	STW_12_5KV	12.5	2816.0	2433.4	2816.0	2433.4	0.0	0.0	0.00%	0.00%
STEWART (NSPM)	209100	STW_69KV	69	881.3	1316.5	881.3	1316.5	0.0	0.0	0.00%	0.00%
SOUTH RIDGE (NSPM)	204807	SRD_TR01_TER	2.4	0.0	7868.0	0.0	7868.0	0.0	0.0	0.00%	0.00%
SOUTH RIDGE (NSPM)	204805	SRD_FDR211	23.9	1764.2	1349.5	1764.2	1349.5	0.0	0.0	0.00%	0.00%
SOUTH RIDGE (NSPM)	204804	SRD_23KV	23.9	1764.2	1349.5	1764.2	1349.5	0.0	0.0	0.00%	0.00%
SLAYTON WEST (NSPM)	203606	SLW_FDR62_E	13.8	1747.9	2427.1	1747.9	2427.1	0.0	0.0	0.00%	0.00%
SLAYTON WEST (NSPM)	203604	SLW_FDR61_E	13.8	1747.9	2427.1	1747.9	2427.1	0.0	0.0	0.00%	0.00%
SHAOKATAN II (NSPM)	201622	SKT_RISER4	34.5	832.5	1242.5	832.5	1242.5	0.0	0.0	0.00%	0.00%
SACRED HEART (NSPM)	198706	SCH_FDR01	4.16	4229.2	4961.7	4229.2	4961.7	0.0	0.0	0.00%	0.00%
SACRED HEART (NSPM)	198705	SCH_4_16KV	4.16	4229.2	4961.7	4229.2	4961.7	0.0	0.0	0.00%	0.00%
SACRED HEART (NSPM)	198704	SCH_GNDTR	23	0.0	356.1	0.0	356.1	0.0	0.0	0.00%	0.00%
SACRED HEART (NSPM)	198703	SCH_FDR211	23	1775.4	1458.0	1775.4	1458.0	0.0	0.0	0.00%	0.00%
SACRED HEART (NSPM)	198702	SCH_23KV	23	1775.4	1458.0	1775.4	1458.0	0.0	0.0	0.00%	0.00%
ROCK RIVER (NSPM)	197007	ROC_FDR91	23	2039.1	1850.9	2039.1	1850.9	0.0	0.0	0.00%	0.00%
ROCK RIVER (NSPM)	197005	ROC_FDR90	23	2039.1	1850.9	2039.1	1850.9	0.0	0.0	0.00%	0.00%
ROCK RIVER (NSPM)	197004	ROC_23KV	23	2039.1	1850.9	2039.1	1850.9	0.0	0.0	0.00%	0.00%
RENVILLE (NSPM)	194103	RNV_FDR21_E	12.5	1213.8	1562.3	1213.8	1562.3	0.0	0.0	0.00%	0.00%
RENVILLE (NSPM)	194102	RNV_FDR21	12.5	2984.2	2831.9	2984.2	2831.9	0.0	0.0	0.00%	0.00%
RENVILLE (NSPM)	194101	RNV_12_5KV	12.5	2984.2	2831.9	2984.2	2831.9	0.0	0.0	0.00%	0.00%
PIPESTONE (NSPM)	189621	PIP_TR05_TER	2.4	0.0	23001.3	0.0	23001.3	0.0	0.0	0.00%	0.00%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
PIPESTONE (NSPM)	189620	PIP_IB_TR02	4.16	13939.8	12751.2	13939.8	12751.2	0.0	0.0	0.00%	0.00%
PIPESTONE (NSPM)	189619	PIP_FDR03	4.16	13939.8	12751.2	13939.8	12751.2	0.0	0.0	0.00%	0.00%
PIPESTONE (NSPM)	189618	PIP_FDR01	4.16	13939.8	12751.2	13939.8	12751.2	0.0	0.0	0.00%	0.00%
PIPESTONE (NSPM)	189617	PIP_TR06_TER	13.8	0.0	4018.7	0.0	4018.7	0.0	0.0	0.00%	0.00%
PIPESTONE (NSPM)	189611	PIP_IB_TR03	23	1742.0	1612.5	1742.0	1612.5	0.0	0.0	0.00%	0.00%
PIPESTONE (NSPM)	189609	PIP_FDR90	23	1742.0	1612.5	1742.0	1612.5	0.0	0.0	0.00%	0.00%
MORGAN (NSPM)	178002	MGN_FDR211	23.9	3108.4	2754.7	3108.4	2754.7	0.0	0.0	0.00%	0.00%
MORGAN (NSPM)	178001	MGN_23_9KV	23.9	3108.4	2754.7	3108.4	2754.7	0.0	0.0	0.00%	0.00%
MONTEVIDEO (NSPM)	177408	MTV_FDR03	4.16	10126.3	8979.1	10126.3	8979.1	0.0	0.0	0.00%	0.00%
MONTEVIDEO (NSPM)	177407	MTV_FDR02	4.16	10126.3	8979.1	10126.3	8979.1	0.0	0.0	0.00%	0.00%
MONTEVIDEO (NSPM)	177406	MTV_FDR01	4.16	10126.3	8979.1	10126.3	8979.1	0.0	0.0	0.00%	0.00%
MONTEVIDEO (NSPM)	177405	MTV_4_2KV	4.16	10126.3	8979.1	10126.3	8979.1	0.0	0.0	0.00%	0.00%
MONTEVIDEO (NSPM)	177404	MTV_FDR22	12.5	2267.2	2042.6	2267.2	2042.6	0.0	0.0	0.00%	0.00%
MONTEVIDEO (NSPM)	177403	MTV_FDR21	12.5	2267.2	2042.6	2267.2	2042.6	0.0	0.0	0.00%	0.00%
MONTEVIDEO (NSPM)	177402	MTV_12_5KV	12.5	2267.2	2042.6	2267.2	2042.6	0.0	0.0	0.00%	0.00%
MONTEVIDEO (NSPM)	177401	MTV_GNDTR	13.8	0.0	1524.7	0.0	1524.7	0.0	0.0	0.00%	0.00%
MINNESOTA VALLEY (NS	176530	MNV_FDR211_2	23.9	531.1	715.1	531.1	715.1	0.0	0.0	0.00%	0.00%
MINNESOTA VALLEY (NS	176529	MNV_FDR211_1	23.9	998.2	1268.9	998.2	1268.9	0.0	0.0	0.00%	0.00%
MINNESOTA VALLEY (NS	176528	MNV_FDR211X	23.9	1806.7	2190.5	1806.7	2190.5	0.0	0.0	0.00%	0.00%
MILROY (REDWOOD)	175803	MLY_12_5KV_2	12.5	574.1	569.8	574.1	569.8	0.0	0.0	0.00%	0.00%
MILROY (REDWOOD)	175802	MLY_12_5KV_1	12.5	574.1	569.8	574.1	569.8	0.0	0.0	0.00%	0.00%
MAYNARD XMSN (NSPM)	171707	MAT_TR01_TER	13.8	0.0	4264.7	0.0	4264.7	0.0	0.0	0.00%	0.00%
MAYNARD (NSPM)	171502	MYN_FDR21	12.5	1625.6	1520.3	1625.6	1520.3	0.0	0.0	0.00%	0.00%
MAYNARD (NSPM)	171501	MYN_12_5KV	12.5	1625.6	1520.3	1625.6	1520.3	0.0	0.0	0.00%	0.00%
HONNER (EREPC)	152202	HNR_12_5KV	12.5	4373.0	4070.5	4373.0	4070.5	0.0	0.0	0.00%	0.00%
HECTOR (NSPM)	149002	HEC_FDR01	4.16	4528.3	4181.4	4528.3	4181.4	0.0	0.0	0.00%	0.00%
HECTOR (NSPM)	149001	HEC_4_16KV	4.16	4528.3	4181.4	4528.3	4181.4	0.0	0.0	0.00%	0.00%
HADLEY (NSPM)	146807	HAD_FDR22	12.5	1684.7	1560.0	1684.7	1560.0	0.0	0.0	0.00%	0.00%
HADLEY (NSPM)	146806	HAD_FDR21	12.5	1684.7	1560.0	1684.7	1560.0	0.0	0.0	0.00%	0.00%
HADLEY (NSPM)	146805	HAD_12_5KV	12.5	1684.7	1560.0	1684.7	1560.0	0.0	0.0	0.00%	0.00%
GREEN VALLEY (OTP)	146102	GVY_12_5KV	12.5	1503.1	1486.5	1503.1	1486.5	0.0	0.0	0.00%	0.00%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
GREEN VALLEY (OTP)	146101	GVY_41_6KV	41.6	546.3	378.0	546.3	378.0	0.0	0.0	0.00%	0.00%
GRANITE FALLS CITY (	145202	GRF_4_16KV	4.16	11306.8	10994.9	11306.8	10994.9	0.0	0.0	0.00%	0.00%
GRANITE FALLS (WAPA)	145111	GRA_IB_KV3A	13.8	0.0	5585.8	0.0	5585.8	0.0	0.0	0.00%	0.00%
GIBBON (NSPM)	142402	GIB_FDR01	12.5	1679.0	1563.5	1679.0	1563.5	0.0	0.0	0.00%	0.00%
GIBBON (NSPM)	142401	GIB_12_5KV	12.5	1679.0	1563.5	1679.0	1563.5	0.0	0.0	0.00%	0.00%
FROEHLICH (WESCO WIN	140701	FRH_34_5KV	34.5	2402.5	2121.9	2402.5	2121.9	0.0	0.0	0.00%	0.00%
FRANKLIN (NSPM)	140121	FRA_TR06_TER	13.8	0.0	5750.5	0.0	5750.5	0.0	0.0	0.00%	0.00%
FRANKLIN (NSPM)	140120	FRA_TR05_TER	13.8	0.0	5064.3	0.0	5064.3	0.0	0.0	0.00%	0.00%
FIESTA CITY (NSPM)	137812	FIC_FDR31_E	12.5	942.2	1146.0	942.2	1146.0	0.0	0.0	0.00%	0.00%
FIESTA CITY (NSPM)	137811	FIC_FDR31	12.5	3638.3	3205.8	3638.3	3205.8	0.0	0.0	0.00%	0.00%
FIESTA CITY (NSPM)	137808	FIC_FDR21_E	12.5	1087.6	1206.1	1087.6	1206.1	0.0	0.0	0.00%	0.00%
FIESTA CITY (NSPM)	137807	FIC_FDR21	12.5	3638.3	3205.8	3638.3	3205.8	0.0	0.0	0.00%	0.00%
FIESTA CITY (NSPM)	137805	FIC_12_5KV_1	12.5	3638.3	3205.8	3638.3	3205.8	0.0	0.0	0.00%	0.00%
FENTON (NSPM)	137627	FTN_TR05_TER	13.8	0.0	4063.8	0.0	4063.8	0.0	0.0	0.00%	0.00%
ESSIG (NSPM)	135802	ESG_FDR01	2.4	0.0	1486.1	0.0	1486.1	0.0	0.0	0.00%	0.00%
ESSIG (NSPM)	135801	ESG_2_4KV	2.4	0.0	1486.1	0.0	1486.1	0.0	0.0	0.00%	0.00%
DANUBE (NSPM)	127203	DAN_FDR21_E	12.5	2574.1	2693.8	2574.1	2693.8	0.0	0.0	0.00%	0.00%
DANUBE (NSPM)	127202	DAN_FDR21	12.5	3387.7	3093.1	3387.7	3093.1	0.0	0.0	0.00%	0.00%
DANUBE (NSPM)	127201	DAN_12_5KV	12.5	3387.7	3093.1	3387.7	3093.1	0.0	0.0	0.00%	0.00%
CROOKS (RS)	125801	CKS_12_5KV	12.5	4644.1	4153.7	4644.1	4153.7	0.0	0.0	0.00%	0.00%
CLARA CITY (NSPM)	122105	CLC_FDR22	12.5	2858.3	2588.5	2858.3	2588.5	0.0	0.0	0.00%	0.00%
CLARA CITY (NSPM)	122104	CLC_FDR21	12.5	2858.3	2588.5	2858.3	2588.5	0.0	0.0	0.00%	0.00%
CLARA CITY (NSPM)	122103	CLC_12_5KV	12.5	2858.3	2588.5	2858.3	2588.5	0.0	0.0	0.00%	0.00%
CLARA CITY (NSPM)	122102	CLC_FDR221	23.9	2897.4	2511.9	2897.4	2511.9	0.0	0.0	0.00%	0.00%
CLARA CITY (NSPM)	122101	CLC_23_9KV	23.9	2897.4	2511.9	2897.4	2511.9	0.0	0.0	0.00%	0.00%
CHANDLER (NOB)	120202	CHN_12_5KV	12.5	5121.3	4821.1	5121.3	4821.1	0.0	0.0	0.00%	0.00%
CANBY (OTP)	116902	CBY_41_6KV	41.6	377.6	868.0	377.6	868.0	0.0	0.0	0.00%	0.00%
BUFFALO RIDGE (NSPM)	114456	BRI_ZUL_480V	0.48	57942.9	92144.4	57942.9	92144.4	0.0	0.0	0.00%	0.00%
BUFFALO LAKE (NSPM)	114302	BFL_FDR21	12.5	2897.1	2559.8	2897.1	2559.8	0.0	0.0	0.00%	0.00%
BUFFALO LAKE (NSPM)	114301	BFL_12_5_KV	12.5	2897.1	2559.8	2897.1	2559.8	0.0	0.0	0.00%	0.00%
BROWNTON (NSPM)	113805	BRW_FDR03	2.4	0.0	3186.9	0.0	3186.9	0.0	0.0	0.00%	0.00%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J400

Substation	Faulted Bus			Benchmark Case without J400 Project		Study Case with J400 Project		Amps Change with J400 vs Benchmark		% Change with J400 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
BROWNTON (NSPM)	113804	BRW_FDR01	2.4	0.0	3186.9	0.0	3186.9	0.0	0.0	0.00%	0.00%
BROWNTON (NSPM)	113803	BRW_2_4KV	2.4	0.0	3186.9	0.0	3186.9	0.0	0.0	0.00%	0.00%
BROWNTON (NSPM)	113801	BRW_69KV	69	688.5	1032.7	688.5	1032.7	0.0	0.0	0.00%	0.00%
BROWNTON (MUNI)	113701	BWN_4_16KV	4.16	4370.8	3910.2	4370.8	3910.2	0.0	0.0	0.00%	0.00%
BROWNTON (MUNI)	113700	BWNT_69KV	69	689.0	1033.3	689.0	1033.3	0.0	0.0	0.00%	0.00%
BIRD ISLAND (NSPM)	110205	BIS_FDR01	4.16	4951.6	4877.1	4951.6	4877.1	0.0	0.0	0.00%	0.00%
BIRD ISLAND (NSPM)	110204	BIS_4_16KV	4.16	4951.6	4877.1	4951.6	4877.1	0.0	0.0	0.00%	0.00%
BALATON (NSPM)	105702	BLN_FDR01	4.16	497.6	659.0	497.6	659.0	0.0	0.0	0.00%	0.00%
BALATON (NSPM)	105701	BLN_4_16KV	4.16	1086.5	1047.4	1086.5	1047.4	0.0	0.0	0.00%	0.00%
LYON COUNTY (NSPM)	6051	J400_COL	34.5			8946.7	8724.3				

Section 4
SHORT CIRCUIT ANALYSIS

4.1 Project Modeling

Leidos performed the short circuit analysis for the Project using the MDU ASPEN database provided by MISO. The database already included one step-up transformer and one generator connected at the Project POI. Leidos added another transformer and three additional units to match the Project configuration as proposed by the IC in the provided documentation to MISO. The Project was modeled using the application data (Attachment A to the Interconnection Request). Leidos used the existing step-up transformer data for the second transformer as it appeared to be based on the actual test reports per the notes included in the ASPEN database.

Figure 4-1 represents the Short Circuit model topology in ASPEN.

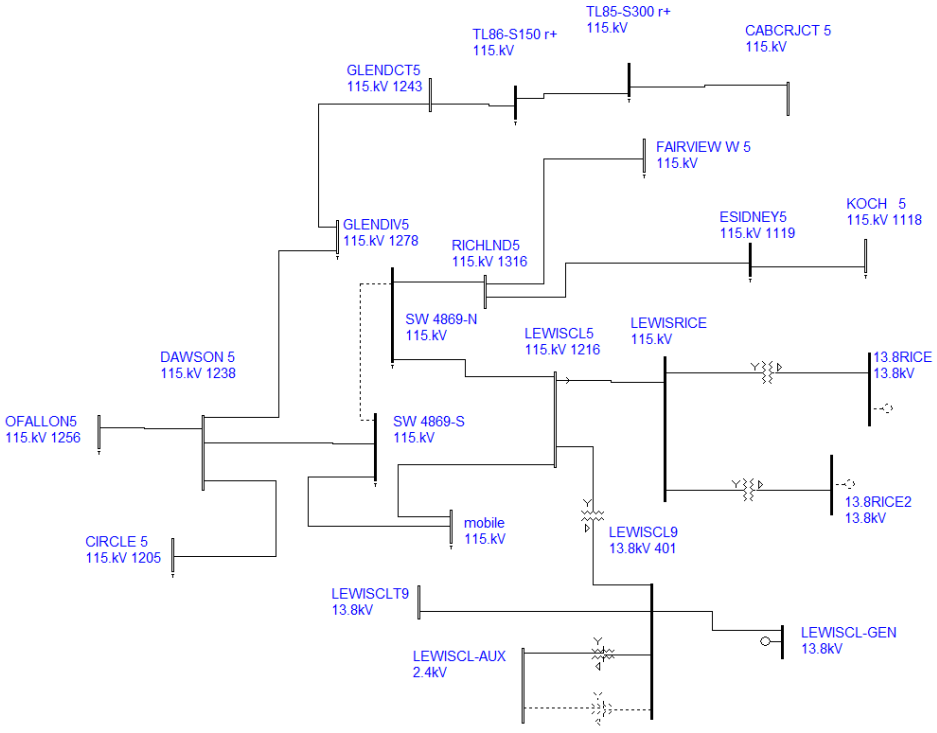


Figure 4-1. System Representation near J405 POI in the ASPEN Database

4.2 Short Circuit Results

Leidos performed the short circuit analysis, which includes a review of the available fault current at the J405 POI (Lewis 115 kV substation) and nearby substations both with and without the Project. Single-line-to-ground and three-phase faults were simulated at these substations and fault currents were documented as shown in Table 4-1.

Table 4-1
Short Circuit Results Summary

Bus Name	Base kV	Pre Project SLG (Amps)	Post Project SLG (Amps)	Delta SLG (Amps)	Pre Project 3-phase (Amps)	Post Project 3-phase (Amps)	Delta 3-phase (Amps)
LEWISRICE	115	5180.1	5824.5	644.4	4743.7	5643.0	899.3
LEWISCL5	115	5197.9	5841.4	643.5	4761.8	5660.4	898.6
MOBILE	115	5183.1	5821.8	638.7	4757.3	5653.3	896.0
RICHLND5	115	4690.9	5119.5	428.6	4787.2	5540.8	753.6
ESIDNEY5	115	3014.2	3128.3	114.1	3816.3	4147.0	330.7
FAIRVIEW W	115	3238.8	3342.8	104.0	4175.9	4488.0	312.1
KOCH 5	115	2545.0	2597.3	52.3	3474.1	3665.3	191.2
DAWSON 5	115	8959.2	9037.2	78.0	7364.3	7450.9	86.6
GLENDIV5	115	7387.2	7425.7	38.5	6850.2	6911.9	61.7

As the results show, contribution of the Project on fault currents in local area is fairly small. The Project increases three-phase fault current at the POI by approximately 900 amps and single-line-to-ground fault current by approximately 644 amps. MDU, BEPC, and WAPA reviewed the results and confirmed that the post-Project fault currents are below the breakers' interrupting capabilities at their respective substations and no breaker upgrades are required for the proposed interconnection.

J407 Generator Interconnection Fault Study
Adam Daters 6-3-15

Discussion

The following is a fault study prepared for the addition of a 200 MW wind-powered generating facility to either Hayward 161kV Substation or the Glenworth 161kV Substation. Interconnection of J407 to Hayward substation would require construction of a new breaker and ½ switching station adjacent to the existing substation. Interconnection of J407 to Glenworth will require expansion of the 161 kV ring bus to add a new terminal.

The data was collected using the program Computer Aided Protection Engineering (CAPE) by Electrocon International. Three phase, single line to ground (SLG) and double line to ground faults (DLG) were simulated at several bus positions in the surrounding areas that will be affected by the generator addition. Fault currents including all in-feeds to the fault (a worst case scenario) were tabulated and compared to the circuit breaker ratings. Only fault currents and interrupting ratings were considered in this study, no other impacts including power flows, flow capacity protection and control or otherwise were considered herein.

Assumptions

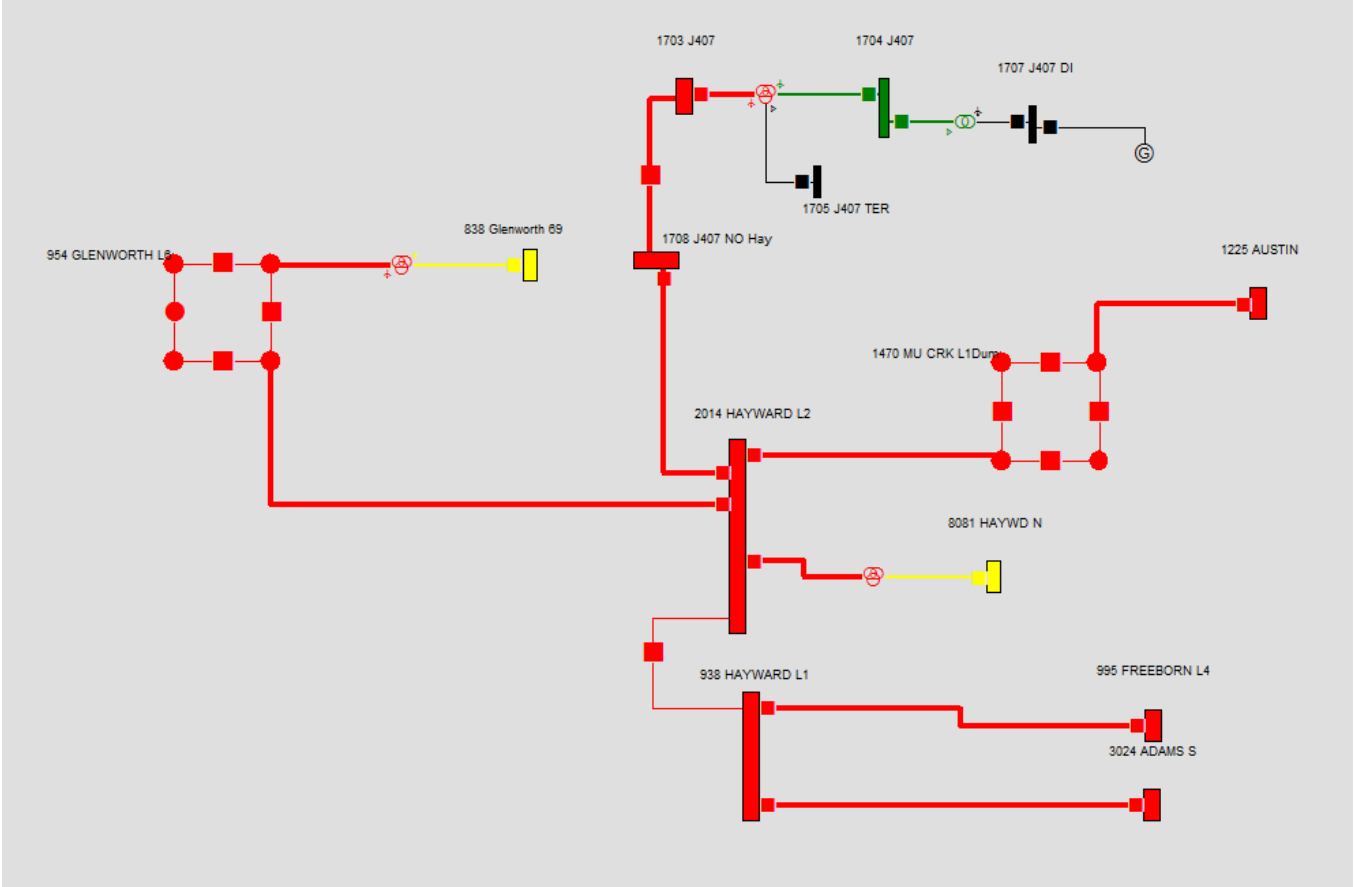
The following assumptions were used when creating the fault study model.

Generator modeling –

- A Wind Turbine equivalent generator was modeled with reactance data provided in the Interconnection Request.

System modeling –

- The collector system consisted of a GSU transformer 66/88/110 MVA 161/34.5/13.8kV Wye/Wye/Delta with 9% impedance. These changes are in both studies below.
- Study 1: Modeled a short line to connect Hayward 161kV to tie the generation into the 161kV breaker-and-half position. The collector system consisted of a GSU transformer 66/88/110 MVA 161/34.5/13.8kV Wye/Wye/Delta with 9% impedance.
- Study 2: Modeled a short line to connect Glenworth 161kV to tie the generation into the 161kV ring position.



Study 1: J407 connected at Hayward

Future and present fault values were compared with breaker ratings (Table 1) on several busses at Hayward. A tabular summary of fault duties at these busses is included below in Table 2.

Substations other than the Hayward substation did not experience fault current increases above typical equipment ratings. A tabular summary of fault duties at the adjacent 69kV substations is included below in Table 3.

Substation	Voltage (kV)	Breaker Number	Continuous	Interrupting (KA)
Hayward	161	662	1200	20
Hayward	161	660	2000	40
Hayward	161	661	2000	40
Hayward	161	667	2000	40
Hayward	161	672	2000	40
Hayward	69	665	1200	21
Hayward	69	671	1200	21
Hayward	69	616	1200	22
Hayward	69	617	2000	40
Hayward	69	663	2000	40
Hayward	69	664	2000	40
Hayward	69	666	2000	40
Hayward	69	668	3000	21
Hayward	69	669	3000	40
Hayward	69	670	1200	22

Table 1: Breaker Ratings

Fault Study Results

Maximum fault current assumes all generation on. Other options can be considered but were not included in this study.

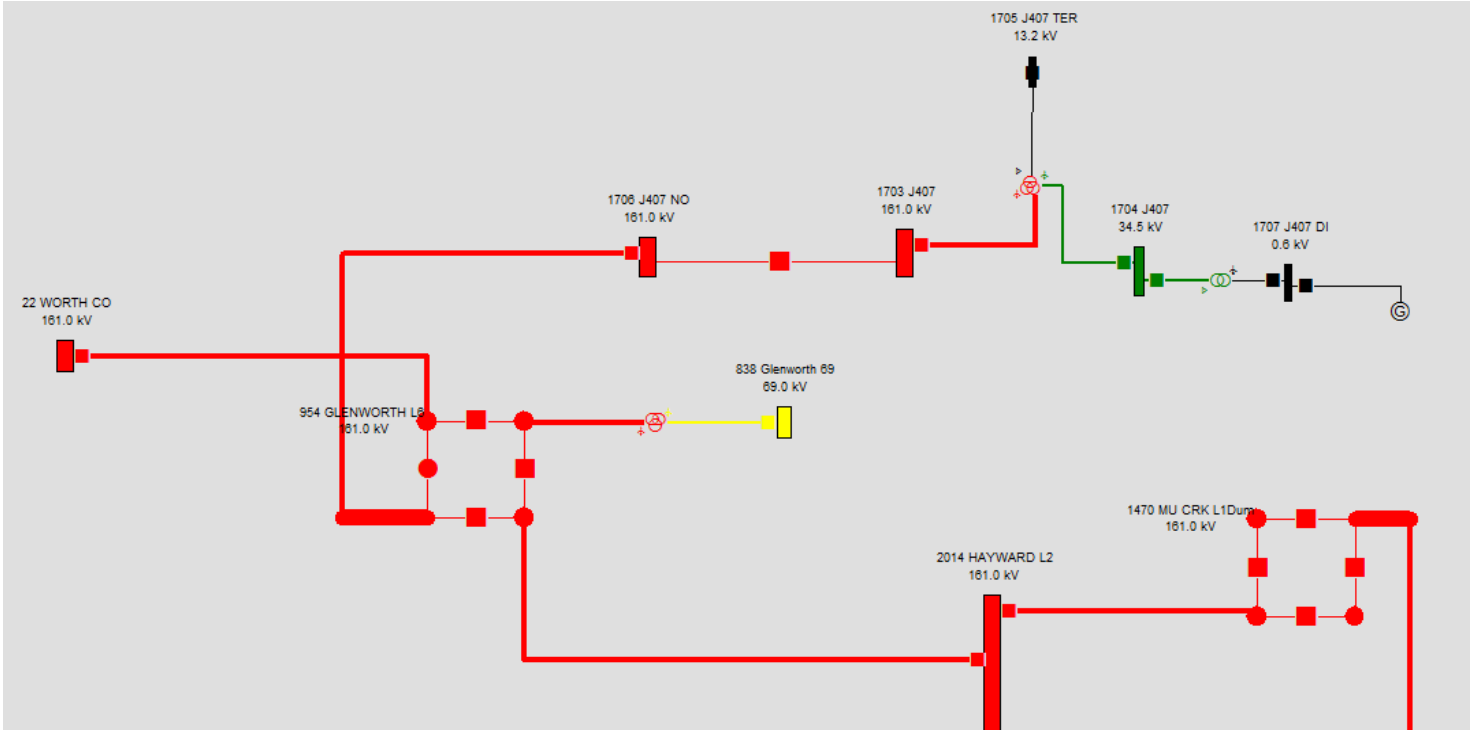
	161kV Bus			69kV Bus		
	Three Phase	**Double Line to Ground**	**Single Line to Ground**	**Three Phase**	**Double line to Ground**	**Single Line to Ground**
Existing System – Max fault Current	13392.3 A	12471.3 A	11256.9 A	11790.7 A	12785.5 A	12827.3 A
J407 in Service – Max fault current	14536.0 A	13780.3 A	12517.9 A	12012.6 A	13099.0 A	13086.2 A

Table 2: Hayward fault analysis

	Glenworth 161kV Bus			Freeborn 161kV Bus		
	Three Phase	**Double Line to Ground**	**Single Line to Ground**	**Three Phase**	**Double Line to Ground**	**Single Line to Ground**
Existing System – Max fault Current	11910.9 A	11027.4 A	9394.8 A	9625.9 A	8963.6 A	7984.6 A
J407 in Service – Max fault current	12547.4 A	11498.8 A	9896.4 A	5818.7 A	9276.5 A	8198.4 A

	Adams 161kV Bus			Murphy Creek 161kV Bus		
	Three Phase	**Double Line to Ground**	**Single Line to Ground**	**Three Phase**	**Double Line to Ground**	**Single Line to Ground**
Existing System – Max fault Current	16774.2 A	16550.3 A	16399.1 A	11229.6 A	10480.6 A	9272.3 A
J407 in Service – Max fault current	16985.1 A	16698.4 A	16496.4 A	11496.1 A	10659.3 A	9403.3 A

Table 3: Fault analysis of adjacent buses to Hayward Substation at 161kV



Study 2: J407 connected at Glenworth

Future and present fault values were compared with breaker ratings (table 4) on several busses at Glenworth. A tabular summary of fault duties at these busses is included below in Table 5.

Substations other than Glenworth substation did not experience fault current increases above typical equipment ratings. A tabular summary of fault duties at the adjacent 69kV substations is included below in Table 6.

Substation	Voltage (kV)	Breaker Number	Continuous	Interrupting (KA)
Glenworth	161	5710	3000	40
Glenworth	161	5730	3000	40
Glenworth	161	5740	3000	40
Glenworth	161	5800	3000	40

Table 4: Breaker Ratings

Fault Study Results

Maximum fault current assumes all generation on. Other options can be considered but were not included in this study.

	161kV Bus			69kV Bus		
	Three Phase	**Double Line to Ground**	**Single Line to Ground**	**Three Phase**	**Double line to Ground**	**Single Line to Ground**
Existing System – Max fault Current	11910.9 A	11027.4 A	9394.1 A	10739.8 A	10262.5 A	10333.1 A
J407 in Service – Max fault current	13053.4 A	12114.7 A	10750.0 A	10948.1 A	11100.6 A	10602.5 A

Table 5: Glenworth fault analysis

	Worth Co 161kV Bus			Hayward 161kV Bus		
	Three Phase	**Double Line to Ground**	**Single Line to Ground**	**Three Phase**	**Double Line to Ground**	**Single Line to Ground**
Existing System – Max fault Current	12153.5 A	11127.4 A	9319.9 A	13392.3 A	12669.8 A	11256.9 A
J407 in Service – Max fault current	12560.8 A	11408.9 A	9599.6 A	14193.4 A	13329.0 A	11956.8 A

Table 6: Fault analysis of adjacent buses to Glenworth Substation at 161kV

Conclusion

This study shows that all of the Hayward or Glenworth circuit breakers have acceptable interrupting ratings. The added generation results in fault currents that are well below the breaker interrupting ratings. It should be noted that this study only accounts for active interrupting devices. This report does not include passive device ratings such as switches.

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J411 Short Circuit Study Performed by MEC

The scope of this facilities study included a review of the available fault current at the proposed 345 kV interconnection substation for J411 and nearby substations both with and without the Interconnection Customer interconnected. The fault currents were used to identify if any existing circuit breakers become overdutied because of the proposed Interconnection Customer. The study reviewed single-line-to-ground (SLG) fault current levels and three phase (3PH) fault current levels. The study did not include potential facility upgrades required because of the DPP system impact studies or Optional Studies. Depending on the nature of the facility upgrades, an additional review may be necessary. The results of the analysis are summarized in the following table.

Table 1. Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J411

			SLG Fault Current Comparison				3 Phase Fault Current Comparison		
Bus Name	Base kV	Owner	Base SLG w/o new wind farm	SLG with new wind farm	SLG Difference w/ wind farm vs Base		Base 3PH w/o new wind farm	3PH with with new wind farm	3PH Difference w/ wind farm vs Base
J411 Collector	34.5	MEC	3,982	25,445	21,463		13,582	23,967	10,385
J411 POI	345	MEC	5,522	7,704	2,182		8,376	9,576	1,200
RAUN 3	345	MEC	27,014	27,370	355		24,841	25,379	538
LEHIGH 3	345	MEC	9,340	9,634	294		12,058	12,342	285
S3451 3	345	OPPD	19,758	19,769	11		21,720	21,751	31
HOSKINS3	345	NPPD	9,171	9,178	7		10,004	10,026	22
SIOUXCY3	345	WAPA	12,358	12,392	34		14,215	14,319	104
HIGHLND 3	345	MEC	9,725	9,740	15		11,833	11,882	49
RAUN 5	161	MEC	32,459	32,589	130		26,503	26,701	198
WEBSTER3	345	MEC	9,420	9,550	130		11,591	11,761	170
GRIMES 3	345	MEC	17,079	17,105	27		19,631	19,686	55
LGR415 9	34.5	MEC	18,648	18,666	18		18,829	18,853	24
LGR425 9	34.5	MEC	18,689	18,706	18		18,931	18,955	24
S3454 3	345	OPPD	17,420	17,424	3		21,964	21,977	14
S3459 3	345	OPPD	18,353	18,358	5		22,057	22,075	18
S1251 5	161	OPPD	30,391	30,401	10		30,618	30,643	25
SHELCRK3	345	NPPD	8,816	8,818	2		9,554	9,560	7
HOSKINS4	230	NPPD	11,095	11,102	7		10,859	10,875	16
HOSKINS7	115	NPPD	18,792	18,799	6		17,729	17,743	14
SPLT RK3	345	Xcel	8,106	8,110	5		9,220	9,235	15
SIOUXCY4	230	WAPA	18,953	18,988	35		18,900	18,984	84
OBRIEN 3	345	MEC	10,528	10,544	16		12,443	12,489	46
SHD415 9	34.5	MEC	17,858	17,860	2		17,917	17,922	5
SHD425 9	34.5	MEC	17,858	17,860	2		17,917	17,922	5
SHD435 9	34.5	MEC	17,820	17,823	3		17,825	17,830	5
LIBERTY5	161	MEC	27,677	27,771	94		24,558	24,727	169
INTCHG 5	161	MEC	11,611	11,626	15		14,511	14,565	54
NEAL N 5	161	MEC	30,672	30,783	111		25,132	25,308	177
TEKAMAH5	161	OPPD	7,216	7,217	1		9,453	9,458	5
NEAL 4 5	161	MEC	22,634	22,688	54		18,525	18,617	92
KOSSUTH 3	345	MEC	8,085	8,109	24		11,178	11,237	59
WEBSTER5	161	MEC	16,730	16,821	91		17,480	17,569	89
FALLOW 3	345	MEC	8,214	8,216	2		9,353	9,359	6
BOONVIL3	345	MEC	14,333	14,343	10		16,381	16,406	26
SYCAMOR3	345	MEC	18,010	18,030	20		19,334	19,379	45
GRIMES 5	161	MEC	22,077	22,090	13		23,366	23,392	26

The results of the short circuit analysis showed the three phase fault current at the interconnection substation 345 kV bus to be 8,376 Amps without the Interconnection Customer included and 9,576 Amps with the Interconnection Customer included (based upon the assumed modeling information for the tie-line, generator step-up transformers, wind turbines, grounding transformers, and other collector system assumptions). In specifying equipment or completing equipment settings such as voltage control systems, the Interconnection Customer should be aware that fault currents are subject to change and may increase or decrease at the interconnection point because of additions and/or retirements of the transmission system and/or area generation or system contingencies.

As shown in the table, the changes in fault current at buses around the point of interconnection are relatively small. Based on the Transmission Owner's short circuit criteria, no Transmission Owner short circuit constraints appear for the Interconnection Customer's project. The applicable bus results in the table were shared with other potentially impacted transmission owners if the modeled change in fault current was greater than 100 Amps. A protective relay coordination review will be required if the Interconnection Customer's project proceeds, and the Interconnection Customer will need to provide relay settings to the Transmission Owner. In addition, continued communication and coordination will be required for the parties to meet NERC Standard PRC-001 and PRC-005.

Evaluation of Fault Data and Interrupting Ratings for the Interconnection of Project J416

5/2/16

Discussion and Assumptions

Project J416 is a 200 MW, wind-powered generating facility with proposed interconnection to the future ITC Midwest-owned portion of the future Emery to Blackhawk 345 kV line. The data reflects proposed system additions for the MISO Multi Value Projects 3 and 4. Fault values presented below reflect system conditions absent the interconnection of Project J416. Fault values were calculated using Computer Aided Protection Engineering (Cape) by Electrocon International. Three phase fault calculations were simulated at Killdeer 345 kV substation.

The diagram below shows a one-line diagram of the future Killdeer to Blackhawk 345 kV line.

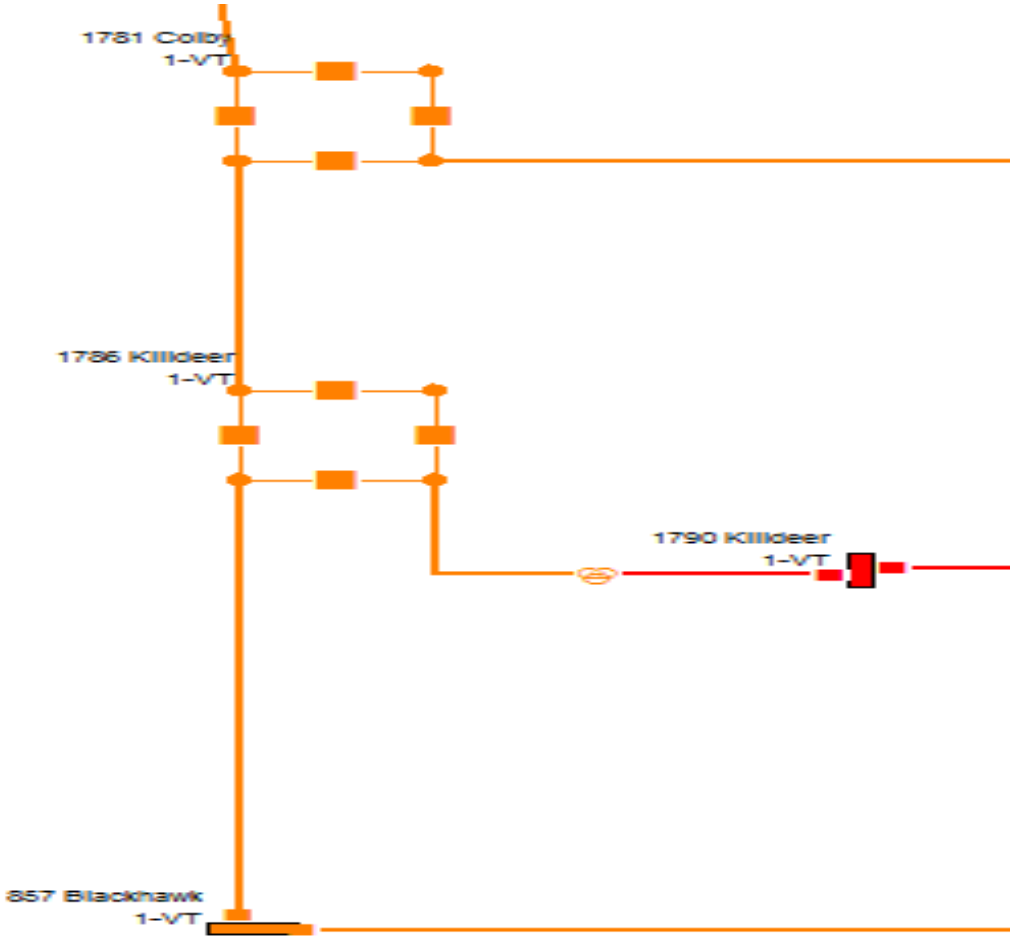

Diagram 1

The table below provides indication of expected fault current values upon completion of the Multi Value Projects 3 and 4.

	Three Phase	**Single Line to Ground**	**X/R Three Phase**	**Positive Sequence Thevenin (p.u.)**		**Zero Sequence Thevenin (p.u.)**	
				R1	**X1**	**R0**	**X0**
Killdeer 345 kV bus	10,721A	11,257A	30.46	.00114	.01557	.00204	.0200

Table 1

Conclusion

Explicit modeling of project J416 was not warranted for the evaluation. The interrupting ratings of 345 kV circuit breakers at the Killdeer substation are 50 kA. If an approximation of 4 times the rated current capacity of the generating facility at 345 kV were utilized, the fault current contribution of project J416 would be approximately 1340A. It can be safely assumed that upgrades to Killdeer 345 kV will not be required due to the fault current contribution of project J416.

J426 Short Circuit Study

Introduction

A short circuit analysis was performed by Siemens PTI to assess impact of the J426 wind generating facility (Vestas OptiSpeed wind turbines utilizing DFIG) on the adequacy of existing circuit breakers and related equipment in the Study Project area.

Short Circuit Model

A CAPE short circuit database including positive, negative and zero sequence parameters of the Xcel system and its neighboring systems was provided by the MISO. This starting short circuit model is listed below:

- Short Circuit Model: "NSP_1_5_2016.GDB"

The J426 short circuit study model was developed as follows:

- Applied MRES provided response file to update model in the Marshall area.
- Added J391, J400 generating facilities with online status.
- Added the J426 generating facility with its sequence parameters at Chanarambie 34.5 kV substation via a 34.5 kV interconnection radial line (6 miles). The associated 34.5-0.69 kV GSU transformer (Z=9.2% at 105 MVA, X/R is 10.4, D-YG) was also added.
- J426 was represented using the conventional generator model, and impedances of the machine were set as follows:
    - Zero sequence impedance (Z_0): j0.1669 pu
    - Negative sequence impedance (Z_2): j0.1669 pu
    - Positive sequence impedance (Z_1): j0.1669 pu

Short Circuit Analysis

Short circuit analysis was performed on the study case (with the J426 project) and benchmark case (without the J426 project). Classical short circuit solution option was used in the calculation. The following fault simulation options were used in the short circuit analysis:

- Prefault voltage was set to "1.00 per unit with multiplier of 1"
- Current limited generator set to "Enforce machine current limits"
- All loads, shunts and transformer magnetizing branches were ignored.

Buses within 8-bus distance from the POI of J426 project were considered as the Study Project area. Three-phase (3PH) and Single Line to Ground (SLG) faults were simulated in the Study Project area. The results of short circuit currents with J426 (study case) and without J426 (benchmark case) are listed in below Table.

With addition of the J426 generating facility, the maximum increase in the 3PH short circuit current is 28.35% (5083.4 amps), and the maximum increase in the SLG short circuit current is 22.50% (5035.4 amps), which are both observed at the Chanarambie 34.5 kV substation bus.

Summary of Short Circuit Analysis

The change in fault current at buses in the Study Project area are shown in the below Table. Based on the Transmission Owner's short circuit criteria, interconnection of the J426 generation project does not cause any Transmission Owner short circuit constraints.

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J426

Substation	Faulted Bus			Benchmark Case without J426 Project		Study Case with J426 Project		Amps Change with J426 vs Benchmark		% Change with J426 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
CHANARAMBIE (NSPM)	120132	CHB_IB_TR04	34.5	22375.1	17928.4	27410.5	23011.8	5035.4	5083.4	22.50%	28.35%
CHANARAMBIE (NSPM)	120131	CHB_IB_TR03	34.5	22375.1	17928.4	27410.5	23011.8	5035.4	5083.4	22.50%	28.35%
CHANARAMBIE (NSPM)	120127	CHB_FDR_CAP3	34.5	22375.1	17928.4	27410.5	23011.8	5035.4	5083.4	22.50%	28.35%
CHANARAMBIE (NSPM)	120126	CHB_FDR341	34.5	22375.1	17928.4	27410.5	23011.8	5035.4	5083.4	22.50%	28.35%
CHANARAMBIE (NSPM)	120125	CHB_FDR332	34.5	22375.1	17928.4	27410.5	23011.8	5035.4	5083.4	22.50%	28.35%
CHANARAMBIE (NSPM)	120124	CHB_FDR331	34.5	22375.1	17928.4	27410.5	23011.8	5035.4	5083.4	22.50%	28.35%
CHANARAMBIE (NSPM)	120111	CHB_34_5KV_4	34.5	22375.1	17928.4	27410.5	23011.8	5035.4	5083.4	22.50%	28.35%
CHANARAMBIE (NSPM)	120110	CHB_34_5KV_3	34.5	22375.1	17928.4	27410.5	23011.8	5035.4	5083.4	22.50%	28.35%
CHANARAMBIE (NSPM)	120114	CHB_CAP3	34.5	21479.4	17349.1	26075.2	22064.0	4595.8	4714.9	21.40%	27.18%
CHANARAMBIE (NSPM)	120107	CHB_IB_TR04	115	9577.4	8087.6	10829.7	9476.9	1252.3	1389.3	13.08%	17.18%
CHANARAMBIE (NSPM)	120106	CHB_IB_TR03	115	9577.4	8087.6	10829.7	9476.9	1252.3	1389.3	13.08%	17.18%
CHANARAMBIE (NSPM)	120105	CHB_IB_TR02	115	9577.4	8087.6	10829.7	9476.9	1252.3	1389.3	13.08%	17.18%
CHANARAMBIE (NSPM)	120104	CHB_IB_PIP	115	9577.4	8087.6	10829.7	9476.9	1252.3	1389.3	13.08%	17.18%
CHANARAMBIE (NSPM)	120103	CHB_IB_LAY	115	9577.4	8087.6	10829.7	9476.9	1252.3	1389.3	13.08%	17.18%
CHANARAMBIE (NSPM)	120102	CHB_IB_FTN	115	9577.4	8087.6	10829.7	9476.9	1252.3	1389.3	13.08%	17.18%
CHANARAMBIE (NSPM)	120101	CHB_115KV_2	115	9577.4	8087.6	10829.7	9476.9	1252.3	1389.3	13.08%	17.18%
CHANARAMBIE (NSPM)	120100	CHB_115KV_1	115	9577.4	8087.6	10829.7	9476.9	1252.3	1389.3	13.08%	17.18%
CHANARAMBIE (NSPM)	120130	CHB_IB_TR02	34.5	22992.3	17831.6	25063.2	19728.8	2070.9	1897.2	9.01%	10.64%
CHANARAMBIE (NSPM)	120129	CHB_IB_TR01	34.5	22992.3	17831.6	25063.2	19728.8	2070.9	1897.2	9.01%	10.64%
CHANARAMBIE (NSPM)	120123	CHB_FDR323	34.5	22992.3	17831.6	25063.2	19728.8	2070.9	1897.2	9.01%	10.64%
CHANARAMBIE (NSPM)	120122	CHB_FDR322	34.5	22992.3	17831.6	25063.2	19728.8	2070.9	1897.2	9.01%	10.64%
CHANARAMBIE (NSPM)	120121	CHB_FDR321	34.5	22992.3	17831.6	25063.2	19728.8	2070.9	1897.2	9.01%	10.64%
CHANARAMBIE (NSPM)	120120	CHB_FDR313	34.5	22992.3	17831.6	25063.2	19728.8	2070.9	1897.2	9.01%	10.64%
CHANARAMBIE (NSPM)	120119	CHB_FDR312	34.5	22992.3	17831.6	25063.2	19728.8	2070.9	1897.2	9.01%	10.64%
CHANARAMBIE (NSPM)	120117	CHB_FDR311	34.5	22992.3	17831.6	25063.2	19728.8	2070.9	1897.2	9.01%	10.64%
CHANARAMBIE (NSPM)	120109	CHB_34_5KV_2	34.5	22992.3	17831.6	25063.2	19728.8	2070.9	1897.2	9.01%	10.64%
CHANARAMBIE (NSPM)	120108	CHB_34_5KV_1	34.5	22992.3	17831.6	25063.2	19728.8	2070.9	1897.2	9.01%	10.64%
CHANARAMBIE (NSPM)	120113	CHB_CAP2	34.5	22047.3	17258.2	23942.0	19027.6	1894.7	1769.4	8.59%	10.25%
CHANARAMBIE (NSPM)	120112	CHB_CAP1	34.5	22047.3	17258.2	23942.0	19027.6	1894.7	1769.4	8.59%	10.25%
CHANARAMBIE (NSPM)	120116	CHB_ENXCO_II	34.5	21748.8	16985.6	23600.3	18702.9	1851.5	1717.3	8.51%	10.11%
CHANARAMBIE (NSPM)	120115	CHB_ENXCO_I	34.5	21748.8	16985.6	23600.3	18702.9	1851.5	1717.3	8.51%	10.11%
CHANARAMBIE (NSPM)	120137	CHB_TR03_TER	13.8	0.0	17065.1	0.0	18771.7	0.0	1706.6	0.00%	10.00%
CHANARAMBIE (NSPM)	120133	CHB_MORAINE	34.5	21318.4	16697.8	23094.8	18355.4	1776.4	1657.6	8.33%	9.93%
CHANARAMBIE (NSPM)	120138	CHB_TR04_TER	13.8	0.0	15335.1	0.0	16694.2	0.0	1359.1	0.00%	8.86%
ELLSBOROUGH (GRE)	133700	ELBT_115KV	115	5278.3	7146.7	5421.2	7556.5	142.9	409.8	2.71%	5.73%
ELLSBOROUGH (GRE)	133701	ELB_115KV	115	5272.7	7141.4	5415.3	7550.5	142.6	409.1	2.70%	5.73%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J426

Substation	Faulted Bus			Benchmark Case without J426 Project		Study Case with J426 Project		Amps Change with J426 vs Benchmark		% Change with J426 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
PIPESTONE (NSPM)	189603	PIP_IB_SPK	115	6108.7	7420.9	6275.4	7802.0	166.7	381.1	2.73%	5.14%
PIPESTONE (NSPM)	189602	PIP_IB_CHB	115	6108.7	7420.9	6275.4	7802.0	166.7	381.1	2.73%	5.14%
PIPESTONE (NSPM)	189601	PIP_IB_BRI	115	6108.7	7420.9	6275.4	7802.0	166.7	381.1	2.73%	5.14%
PIPESTONE (NSPM)	189600	PIP_115KV_1	115	6108.7	7420.9	6275.4	7802.0	166.7	381.1	2.73%	5.14%
FENTON (NSPM)	137608	FTN_IB_TR05	115	9778.3	9952.6	10078.2	10428.4	299.9	475.8	3.07%	4.78%
FENTON (NSPM)	137606	FTN_IB_NOB2	115	9778.3	9952.6	10078.2	10428.4	299.9	475.8	3.07%	4.78%
FENTON (NSPM)	137605	FTN_IB_NOB1	115	9778.3	9952.6	10078.2	10428.4	299.9	475.8	3.07%	4.78%
FENTON (NSPM)	137604	FTN_IB_CHB	115	9778.3	9952.6	10078.2	10428.4	299.9	475.8	3.07%	4.78%
FENTON (NSPM)	137603	FTN_115_TR02	115	9778.3	9952.6	10078.2	10428.4	299.9	475.8	3.07%	4.78%
FENTON (NSPM)	137602	FTN_115_TR01	115	9778.3	9952.6	10078.2	10428.4	299.9	475.8	3.07%	4.78%
FENTON (NSPM)	137601	FTN_115KV_2	115	9778.3	9952.6	10078.2	10428.4	299.9	475.8	3.07%	4.78%
FENTON (NSPM)	137600	FTN_115KV_1	115	9778.3	9952.6	10078.2	10428.4	299.9	475.8	3.07%	4.78%
CHANARAMBIE (NSPM)	120135	CHB_TR01_TER	13.8	0.0	18555.5	0.0	19309.2	0.0	753.7	0.00%	4.06%
CHANARAMBIE (NSPM)	120136	CHB_TR02_TER	13.8	0.0	18549.1	0.0	19302.2	0.0	753.1	0.00%	4.06%
CHANARAMBIE (NSPM)	120128	CHB_GOLF	34.5	2034.4	3299.4	2069.3	3432.6	34.9	133.2	1.72%	4.04%
CHANARAMBIE (NSPM)	120118	CHB_FDR311_E	34.5	3808.0	5306.5	3862.0	5457.3	54.0	150.8	1.42%	2.84%
CHANARAMBIE (NSPM)	120134	CHB_VIK_II	34.5	3245.0	5122.6	3284.3	5263.6	39.3	141.0	1.21%	2.75%
LAKE YANKTON (NSPM)	162315	LAY_IB_SWM	115	10541.7	10807.1	10726.5	11102.0	184.8	294.9	1.75%	2.73%
LAKE YANKTON (NSPM)	162314	LAY_IB_LYC2	115	10541.7	10807.1	10726.5	11102.0	184.8	294.9	1.75%	2.73%
LAKE YANKTON (NSPM)	162313	LAY_IB_LYC1	115	10541.7	10807.1	10726.5	11102.0	184.8	294.9	1.75%	2.73%
LAKE YANKTON (NSPM)	162312	LAY_IB_CHB	115	10541.7	10807.1	10726.5	11102.0	184.8	294.9	1.75%	2.73%
LAKE YANKTON (NSPM)	162311	LAY_IB_CAP4	115	10541.7	10807.1	10726.5	11102.0	184.8	294.9	1.75%	2.73%
LAKE YANKTON (NSPM)	162310	LAY_IB_CAP3	115	10541.7	10807.1	10726.5	11102.0	184.8	294.9	1.75%	2.73%
LAKE YANKTON (NSPM)	162309	LAY_IB_CAP2	115	10541.7	10807.1	10726.5	11102.0	184.8	294.9	1.75%	2.73%
LAKE YANKTON (NSPM)	162308	LAY_IB_CAP1	115	10541.7	10807.1	10726.5	11102.0	184.8	294.9	1.75%	2.73%
LAKE YANKTON (NSPM)	162307	LAY_IB_BRI	115	10541.7	10807.1	10726.5	11102.0	184.8	294.9	1.75%	2.73%
LAKE YANKTON (NSPM)	162306	LAY_CAP	115	10541.7	10807.1	10726.5	11102.0	184.8	294.9	1.75%	2.73%
LAKE YANKTON (NSPM)	162301	LAY_115KV_2	115	10541.7	10807.1	10726.5	11102.0	184.8	294.9	1.75%	2.73%
LAKE YANKTON (NSPM)	162300	LAY_115KV_1	115	10541.7	10807.1	10726.5	11102.0	184.8	294.9	1.75%	2.73%
LAKE YANKTON (NSPM)	162305	LAY_C4_115KV	115	10099.8	10343.5	10269.0	10613.1	169.2	269.6	1.68%	2.61%
LAKE YANKTON (NSPM)	162304	LAY_C3_115KV	115	10099.8	10343.5	10269.0	10613.1	169.2	269.6	1.68%	2.61%
LAKE YANKTON (NSPM)	162303	LAY_C2_115KV	115	10099.8	10343.5	10269.0	10613.1	169.2	269.6	1.68%	2.61%
LAKE YANKTON (NSPM)	162302	LAY_C1_115KV	115	10099.8	10343.5	10269.0	10613.1	169.2	269.6	1.68%	2.61%
PIPESTONE (NSPM)	189608	PIP_IB_WPI	69	6012.7	6029.1	6096.1	6157.6	83.4	128.5	1.39%	2.13%
PIPESTONE (NSPM)	189607	PIP_IB_TR06	69	6012.7	6029.1	6096.1	6157.6	83.4	128.5	1.39%	2.13%
PIPESTONE (NSPM)	189606	PIP_IB_TR05	69	6012.7	6029.1	6096.1	6157.6	83.4	128.5	1.39%	2.13%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J426

Substation	Faulted Bus			Benchmark Case without J426 Project		Study Case with J426 Project		Amps Change with J426 vs Benchmark		% Change with J426 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
PIPESTONE (NSPM)	189605	PIP_IB_FTN	69	6012.7	6029.1	6096.1	6157.6	83.4	128.5	1.39%	2.13%
PIPESTONE (NSPM)	189604	PIP_69KV_1	69	6012.7	6029.1	6096.1	6157.6	83.4	128.5	1.39%	2.13%
FENTON (NSPM)	137623	FTN_IB_TR1	34.5	16843.4	14677.0	17099.4	14972.0	256.0	295.0	1.52%	2.01%
FENTON (NSPM)	137617	FTN_FDR312	34.5	16843.4	14677.0	17099.4	14972.0	256.0	295.0	1.52%	2.01%
FENTON (NSPM)	137615	FTN_FDR311	34.5	16843.4	14677.0	17099.4	14972.0	256.0	295.0	1.52%	2.01%
FENTON (NSPM)	137613	FTN_34_5KV_1	34.5	16843.4	14677.0	17099.4	14972.0	256.0	295.0	1.52%	2.01%
BUFFALO RIDGE (NSPM)	114403	BRI_115KV_4	115	9976.9	9136.4	10112.0	9306.3	135.1	169.9	1.35%	1.86%
BUFFALO RIDGE (NSPM)	114402	BRI_115KV_3	115	9976.9	9136.4	10112.0	9306.3	135.1	169.9	1.35%	1.86%
BUFFALO RIDGE (NSPM)	114401	BRI_115KV_2	115	9976.9	9136.4	10112.0	9306.3	135.1	169.9	1.35%	1.86%
BUFFALO RIDGE (NSPM)	114400	BRI_115KV_1	115	9976.9	9136.4	10112.0	9306.3	135.1	169.9	1.35%	1.86%
FENTON (NSPM)	137624	FTN_IB_TR2	34.5	14848.5	12448.8	15045.6	12658.8	197.1	210.0	1.33%	1.69%
FENTON (NSPM)	137621	FTN_FDR322	34.5	14848.5	12448.8	15045.6	12658.8	197.1	210.0	1.33%	1.69%
FENTON (NSPM)	137619	FTN_FDR321	34.5	14848.5	12448.8	15045.6	12658.8	197.1	210.0	1.33%	1.69%
FENTON (NSPM)	137614	FTN_34_5KV_2	34.5	14848.5	12448.8	15045.6	12658.8	197.1	210.0	1.33%	1.69%
NOBLES COUNTY (NSPM)	182014	NOB_IB_TR10	115	22131.7	20314.7	22386.8	20638.5	255.1	323.8	1.15%	1.59%
NOBLES COUNTY (NSPM)	182013	NOB_IB_TR09	115	22131.7	20314.7	22386.8	20638.5	255.1	323.8	1.15%	1.59%
NOBLES COUNTY (NSPM)	182012	NOB_IB_TR02	115	22131.7	20314.7	22386.8	20638.5	255.1	323.8	1.15%	1.59%
NOBLES COUNTY (NSPM)	182011	NOB_IB_TR01	115	22131.7	20314.7	22386.8	20638.5	255.1	323.8	1.15%	1.59%
NOBLES COUNTY (NSPM)	182010	NOB_IB_FTN2	115	22131.7	20314.7	22386.8	20638.5	255.1	323.8	1.15%	1.59%
NOBLES COUNTY (NSPM)	182009	NOB_IB_FTN1	115	22131.7	20314.7	22386.8	20638.5	255.1	323.8	1.15%	1.59%
NOBLES COUNTY (NSPM)	182007	NOB_IB_C1	115	22131.7	20314.7	22386.8	20638.5	255.1	323.8	1.15%	1.59%
NOBLES COUNTY (NSPM)	182005	NOB_115KV_2	115	22131.7	20314.7	22386.8	20638.5	255.1	323.8	1.15%	1.59%
NOBLES COUNTY (NSPM)	182004	NOB_115KV_1	115	22131.7	20314.7	22386.8	20638.5	255.1	323.8	1.15%	1.59%
NOBLES COUNTY (NSPM)	182008	NOB_IB_CAP	115	19674.7	18225.0	19875.3	18484.5	200.6	259.5	1.02%	1.42%
NOBLES COUNTY (NSPM)	182006	NOB_115KV_C1	115	19674.7	18225.0	19875.3	18484.5	200.6	259.5	1.02%	1.42%
FENTON (NSPM)	137612	FTN_IB_TSS	69	5702.9	5609.9	5753.6	5685.3	50.7	75.4	0.89%	1.34%
FENTON (NSPM)	137611	FTN_IB_TR05	69	5702.9	5609.9	5753.6	5685.3	50.7	75.4	0.89%	1.34%
FENTON (NSPM)	137610	FTN_IB_PIP	69	5702.9	5609.9	5753.6	5685.3	50.7	75.4	0.89%	1.34%
FENTON (NSPM)	137609	FTN_69KV	69	5702.9	5609.9	5753.6	5685.3	50.7	75.4	0.89%	1.34%
WEST RIDGE (NSPM)	223800	WRDT_69KV	69	3386.9	4523.9	3408.3	4584.6	21.4	60.7	0.63%	1.34%
WEST RIDGE (NSPM)	223801	WRD_69KV	69	3370.4	4494.4	3391.5	4554.2	21.1	59.8	0.63%	1.33%
CHANDLER (NOB)	120200	CHNT_69KV	69	4558.6	5079.2	4590.9	5141.7	32.3	62.5	0.71%	1.23%
CHANDLER (NOB)	120201	CHN_69KV	69	4345.3	4913.3	4374.5	4971.6	29.2	58.3	0.67%	1.19%
ROCK RIVER (NSPM)	197000	ROCT_69KV	69	3029.4	4311.9	3045.0	4362.9	15.6	51.0	0.51%	1.18%
BUFFALO RIDGE (NSPM)	114450	BRI_IB_TR02	34.5	27106.8	20505.0	27391.0	20747.3	284.2	242.3	1.05%	1.18%
BUFFALO RIDGE (NSPM)	114449	BRI_IB_TR01	34.5	27106.8	20505.0	27391.0	20747.3	284.2	242.3	1.05%	1.18%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J426

Substation	Faulted Bus			Benchmark Case without J426 Project		Study Case with J426 Project		Amps Change with J426 vs Benchmark		% Change with J426 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
BUFFALO RIDGE (NSPM)	114448	BRI_FDR323	34.5	27106.8	20505.0	27391.0	20747.3	284.2	242.3	1.05%	1.18%
BUFFALO RIDGE (NSPM)	114447	BRI_FDR322	34.5	27106.8	20505.0	27391.0	20747.3	284.2	242.3	1.05%	1.18%
BUFFALO RIDGE (NSPM)	114446	BRI_FDR321	34.5	27106.8	20505.0	27391.0	20747.3	284.2	242.3	1.05%	1.18%
BUFFALO RIDGE (NSPM)	114445	BRI_FDR313	34.5	27106.8	20505.0	27391.0	20747.3	284.2	242.3	1.05%	1.18%
BUFFALO RIDGE (NSPM)	114444	BRI_FDR312	34.5	27106.8	20505.0	27391.0	20747.3	284.2	242.3	1.05%	1.18%
BUFFALO RIDGE (NSPM)	114443	BRI_FDR311	34.5	27106.8	20505.0	27391.0	20747.3	284.2	242.3	1.05%	1.18%
BUFFALO RIDGE (NSPM)	114436	BRI_34_5KV_2	34.5	27106.8	20505.0	27391.0	20747.3	284.2	242.3	1.05%	1.18%
BUFFALO RIDGE (NSPM)	114435	BRI_34_5KV_1	34.5	27106.8	20505.0	27391.0	20747.3	284.2	242.3	1.05%	1.18%
NOBLES COUNTY (NSPM)	182003	NOB_IB_SPK	345	9027.0	9484.0	9094.1	9595.6	67.1	111.6	0.74%	1.18%
NOBLES COUNTY (NSPM)	182002	NOB_IB_LAJ	345	9027.0	9484.0	9094.1	9595.6	67.1	111.6	0.74%	1.18%
NOBLES COUNTY (NSPM)	182001	NOB_345KV_2	345	9027.0	9484.0	9094.1	9595.6	67.1	111.6	0.74%	1.18%
NOBLES COUNTY (NSPM)	182000	NOB_345KV_1	345	9027.0	9484.0	9094.1	9595.6	67.1	111.6	0.74%	1.18%
BUFFALO RIDGE (NSPM)	114431	BRI_323_C1	34.5	26278.1	20232.7	26544.7	20468.4	266.6	235.7	1.01%	1.16%
BUFFALO RIDGE (NSPM)	114417	BRI_321_C1	34.5	25207.5	19862.5	25452.3	20089.5	244.8	227.0	0.97%	1.14%
BUFFALO RIDGE (NSPM)	114427	BRI_322_C1	34.5	25125.3	19837.2	25368.4	20063.6	243.1	226.4	0.97%	1.14%
LAKE YANKTON (NSPM)	162319	LAY_IB_TR01	34.5	14238.1	15550.5	14333.6	15725.8	95.5	175.3	0.67%	1.13%
LAKE YANKTON (NSPM)	162318	LAY_FDR311	34.5	14238.1	15550.5	14333.6	15725.8	95.5	175.3	0.67%	1.13%
LAKE YANKTON (NSPM)	162317	LAY_34_5KV	34.5	14238.1	15550.5	14333.6	15725.8	95.5	175.3	0.67%	1.13%
LYON COUNTY (NSPM)	168316	LYC_IB_TR09	115	18249.4	16988.9	18389.7	17172.1	140.3	183.2	0.77%	1.08%
LYON COUNTY (NSPM)	168315	LYC_IB_MSH	115	18249.4	16988.9	18389.7	17172.1	140.3	183.2	0.77%	1.08%
LYON COUNTY (NSPM)	168314	LYC_IB_LAY2	115	18249.4	16988.9	18389.7	17172.1	140.3	183.2	0.77%	1.08%
LYON COUNTY (NSPM)	168313	LYC_IB_LAY1	115	18249.4	16988.9	18389.7	17172.1	140.3	183.2	0.77%	1.08%
LYON COUNTY (NSPM)	168311	LYC_IB_CAP2	115	18249.4	16988.9	18389.7	17172.1	140.3	183.2	0.77%	1.08%
LYON COUNTY (NSPM)	168310	LYC_IB_CAP1	115	18249.4	16988.9	18389.7	17172.1	140.3	183.2	0.77%	1.08%
LYON COUNTY (NSPM)	168307	LYC_CAP	115	18249.4	16988.9	18389.7	17172.1	140.3	183.2	0.77%	1.08%
LYON COUNTY (NSPM)	168306	LYC_115KV_2	115	18249.4	16988.9	18389.7	17172.1	140.3	183.2	0.77%	1.08%
LYON COUNTY (NSPM)	168305	LYC_115KV_1	115	18249.4	16988.9	18389.7	17172.1	140.3	183.2	0.77%	1.08%
VALLEY VIEW (NSPM)	217600	VVWT_69KV	69	3179.7	4299.0	3195.3	4345.0	15.6	46.0	0.49%	1.07%
VALLEY VIEW (NSPM)	217601	VVW_69KV	69	3174.7	4295.0	3190.3	4340.9	15.6	45.9	0.49%	1.07%
ROCK RIVER (NSPM)	197001	ROC_69KV	69	2772.8	4027.3	2766.0	4069.2	-6.8	41.9	-0.25%	1.04%
LYON COUNTY (NSPM)	168309	LYC_CAP2	115	16967.3	15902.9	17088.2	16062.5	120.9	159.6	0.71%	1.00%
LYON COUNTY (NSPM)	168308	LYC_CAP1	115	16967.3	15902.9	17088.2	16062.5	120.9	159.6	0.71%	1.00%
UILK (NSPM_UILK WIND	216600	UWI_69KV	69	2210.9	3005.2	2222.7	3035.0	11.8	29.8	0.53%	0.99%
WEST PIPESTONE (NSPM	223700	WPI_69KV_B1	69	2205.1	2999.2	2216.8	3028.8	11.7	29.6	0.53%	0.99%
SOUTHWEST MARSHALL	205507	SWM_IB_TR01	115	7656.4	10566.0	7690.5	10666.6	34.1	100.6	0.45%	0.95%
SOUTHWEST MARSHALL	205506	SWM_IB_SEA	115	7656.4	10566.0	7690.5	10666.6	34.1	100.6	0.45%	0.95%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J426

Substation	Faulted Bus			Benchmark Case without J426 Project		Study Case with J426 Project		Amps Change with J426 vs Benchmark		% Change with J426 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
SOUTHWEST MARSHALL	205505	SWM_IB_SAR	115	7656.4	10566.0	7690.5	10666.6	34.1	100.6	0.45%	0.95%
SOUTHWEST MARSHALL	205504	SWM_IB_LAY	115	7656.4	10566.0	7690.5	10666.6	34.1	100.6	0.45%	0.95%
SOUTHWEST MARSHALL	205501	SWM_115KV_2	115	7656.4	10566.0	7690.5	10666.6	34.1	100.6	0.45%	0.95%
SOUTHWEST MARSHALL	205500	SWM_115KV_1	115	7656.4	10566.0	7690.5	10666.6	34.1	100.6	0.45%	0.95%
FENTON (NSPM)	137618	FTN_FDR312_E	34.5	4822.3	7212.0	4844.3	7280.0	22.0	68.0	0.46%	0.94%
FENTON (NSPM)	137616	FTN_FDR311_E	34.5	4822.3	7212.0	4844.3	7280.0	22.0	68.0	0.46%	0.94%
SOUTHWEST MARSHALL	205503	SWM_115KV_C2	115	7577.1	10415.0	7610.4	10512.6	33.3	97.6	0.44%	0.94%
SOUTHWEST MARSHALL	205502	SWM_115KV_C1	115	7577.1	10415.0	7610.4	10512.6	33.3	97.6	0.44%	0.94%
MARSHALL SW STATION	170603	MSH_IB_SEA	115	9733.7	12433.0	9778.7	12545.6	45.0	112.6	0.46%	0.91%
MARSHALL SW STATION	170602	MSH_IB_NSV	115	9733.7	12433.0	9778.7	12545.6	45.0	112.6	0.46%	0.91%
MARSHALL SW STATION	170601	MSH_IB_LYC	115	9733.7	12433.0	9778.7	12545.6	45.0	112.6	0.46%	0.91%
MARSHALL SW STATION	170600	MSH_115KV	115	9733.7	12433.0	9778.7	12545.6	45.0	112.6	0.46%	0.91%
FENTON (NSPM)	137626	FTN_TR02_TER	13.8	0.0	17187.2	0.0	17340.5	0.0	153.3	0.00%	0.89%
FENTON (NSPM)	137622	FTN_FDR322_E	34.5	4646.5	6646.3	4666.9	6703.9	20.4	57.6	0.44%	0.87%
FENTON (NSPM)	137620	FTN_FDR321_E	34.5	4646.5	6646.3	4666.9	6703.9	20.4	57.6	0.44%	0.87%
SOUTHEAST (MARSHALL)	205200	SEA_115KV	115	8163.8	10916.2	8197.8	11010.1	34.0	93.9	0.42%	0.86%
NORTH SEVENTH STREET	183200	NSV_115KV_1	115	8858.5	11750.6	8894.7	11849.1	36.2	98.5	0.41%	0.84%
ERIE ROAD (MARSHALL)	135600	ERD_115KV	115	8521.9	11382.4	8555.7	11475.3	33.8	92.9	0.40%	0.82%
SARATOGA (MARSHALL)	199400	SAR_115KV	115	7616.6	10428.1	7645.8	10513.1	29.2	85.0	0.38%	0.82%
YANKEE (NSPM)	229507	YNK_IB_TR02	115	11551.0	11926.8	11611.1	12021.8	60.1	95.0	0.52%	0.80%
YANKEE (NSPM)	229506	YNK_IB_TR01	115	11551.0	11926.8	11611.1	12021.8	60.1	95.0	0.52%	0.80%
YANKEE (NSPM)	229504	YNK_IB_BRI	115	11551.0	11926.8	11611.1	12021.8	60.1	95.0	0.52%	0.80%
YANKEE (NSPM)	229502	YNK_IB_BOK1	115	11551.0	11926.8	11611.1	12021.8	60.1	95.0	0.52%	0.80%
YANKEE (NSPM)	229501	YNK_115KV_2	115	11551.0	11926.8	11611.1	12021.8	60.1	95.0	0.52%	0.80%
YANKEE (NSPM)	229500	YNK_115KV_1	115	11551.0	11926.8	11611.1	12021.8	60.1	95.0	0.52%	0.80%
WOODSTOCK (PARSON E)	229200	WSKT_69KV	69	2033.0	3194.3	2040.4	3219.3	7.4	25.0	0.36%	0.78%
WOODSTOCK (PARSON E)	229201	WSK_69KV_1	69	2029.9	3190.4	2037.3	3215.3	7.4	24.9	0.36%	0.78%
SOUTH RIDGE (NSPM)	204803	SRD_C196	69	3073.3	3731.2	3085.1	3759.2	11.8	28.0	0.38%	0.75%
NORTH SEVENTH STREET	58071	J391_TAP	115	8057.2	10463.6	8086.2	10539.2	29.0	75.6	0.36%	0.72%
LAKE YANKTON (NSPM)	162322	LAY_TR01_TER	13.8	0.0	25636.6	0.0	25821.7	0.0	185.1	0.00%	0.72%
FENTON (NSPM)	137625	FTN_TR01_TER	13.8	0.0	13958.2	0.0	14057.1	0.0	98.9	0.00%	0.71%
LAKE WILSON (NOB)	162200	LKW_69KV	69	2867.4	3582.9	2877.4	3608.0	10.0	25.1	0.35%	0.70%
BROOKINGS COUNTY (NS	113206	BOK_IB_WHI1	345	9854.7	10222.6	9894.6	10287.0	39.9	64.4	0.40%	0.63%
BROOKINGS COUNTY (NS	113205	BOK_IB_TR10	345	9854.7	10222.6	9894.6	10287.0	39.9	64.4	0.40%	0.63%
BROOKINGS COUNTY (NS	113204	BOK_IB_TR09	345	9854.7	10222.6	9894.6	10287.0	39.9	64.4	0.40%	0.63%
BROOKINGS COUNTY (NS	113201	BOK_345KV_2	345	9854.7	10222.6	9894.6	10287.0	39.9	64.4	0.40%	0.63%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J426

Substation	Faulted Bus			Benchmark Case without J426 Project		Study Case with J426 Project		Amps Change with J426 vs Benchmark		% Change with J426 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
BROOKINGS COUNTY (NS	113200	BOK_345KV_1	345	9854.7	10222.6	9894.6	10287.0	39.9	64.4	0.40%	0.63%
WHITE (WAPA)	225606	WHI_IB_WTT	345	9865.1	10239.6	9904.9	10304.0	39.8	64.4	0.40%	0.63%
WHITE (WAPA)	225605	WHI_IB_TR01	345	9865.1	10239.6	9904.9	10304.0	39.8	64.4	0.40%	0.63%
WHITE (WAPA)	225604	WHI_IB_SPK	345	9865.1	10239.6	9904.9	10304.0	39.8	64.4	0.40%	0.63%
WHITE (WAPA)	225603	WHI_IB_BOK2	345	9865.1	10239.6	9904.9	10304.0	39.8	64.4	0.40%	0.63%
WHITE (WAPA)	225602	WHI_IB_BOK1	345	9865.1	10239.6	9904.9	10304.0	39.8	64.4	0.40%	0.63%
WHITE (WAPA)	225601	WHI_345KV_2	345	9865.1	10239.6	9904.9	10304.0	39.8	64.4	0.40%	0.63%
WHITE (WAPA)	225600	WHI_345KV_1	345	9865.1	10239.6	9904.9	10304.0	39.8	64.4	0.40%	0.63%
SPLIT ROCK (NSPM)	206104	SPK_IB_WHI	345	12320.9	12989.0	12370.0	13070.1	49.1	81.1	0.40%	0.62%
SPLIT ROCK (NSPM)	206103	SPK_IB_SOC	345	12320.9	12989.0	12370.0	13070.1	49.1	81.1	0.40%	0.62%
SPLIT ROCK (NSPM)	206102	SPK_IB_NOB	345	12320.9	12989.0	12370.0	13070.1	49.1	81.1	0.40%	0.62%
SPLIT ROCK (NSPM)	206101	SPK_345KV_2	345	12320.9	12989.0	12370.0	13070.1	49.1	81.1	0.40%	0.62%
SPLIT ROCK (NSPM)	206100	SPK_345KV_1	345	12320.9	12989.0	12370.0	13070.1	49.1	81.1	0.40%	0.62%
BROOKINGS COUNTY (NS	113212	BOK_IB_YNK2	115	20966.5	19006.2	21063.4	19124.6	96.9	118.4	0.46%	0.62%
BROOKINGS COUNTY (NS	113211	BOK_IB_YNK1	115	20966.5	19006.2	21063.4	19124.6	96.9	118.4	0.46%	0.62%
BROOKINGS COUNTY (NS	113210	BOK_IB_TR10	115	20966.5	19006.2	21063.4	19124.6	96.9	118.4	0.46%	0.62%
BROOKINGS COUNTY (NS	113209	BOK_115KV_2	115	20966.5	19006.2	21063.4	19124.6	96.9	118.4	0.46%	0.62%
BROOKINGS COUNTY (NS	113208	BOK_115KV_1	115	20966.5	19006.2	21063.4	19124.6	96.9	118.4	0.46%	0.62%
BUFFALO RIDGE (NSPM)	114453	BRI_TR02_TER	13.8	0.0	28187.7	0.0	28362.8	0.0	175.1	0.00%	0.62%
BUFFALO RIDGE (NSPM)	114452	BRI_TR01_TER	13.8	0.0	28101.0	0.0	28275.0	0.0	174.0	0.00%	0.62%
LYON COUNTY (NSPM)	168304	LYC_IB_TR09	345	9183.2	10432.2	9216.0	10495.5	32.8	63.3	0.36%	0.61%
LYON COUNTY (NSPM)	168303	LYC_IB_CMT2	345	9183.2	10432.2	9216.0	10495.5	32.8	63.3	0.36%	0.61%
LYON COUNTY (NSPM)	168302	LYC_IB_BOK1	345	9183.2	10432.2	9216.0	10495.5	32.8	63.3	0.36%	0.61%
LYON COUNTY (NSPM)	168301	LYC_345KV_2	345	9183.2	10432.2	9216.0	10495.5	32.8	63.3	0.36%	0.61%
LYON COUNTY (NSPM)	168300	LYC_345KV_1	345	9183.2	10432.2	9216.0	10495.5	32.8	63.3	0.36%	0.61%
HADLEY (NSPM)	146800	HAD_69KV	69	2461.1	3261.2	2467.7	3280.4	6.6	19.2	0.27%	0.59%
SOUTH RIDGE (NSPM)	204801	SRD_69KV	69	1451.4	2305.5	1455.2	2318.2	3.8	12.7	0.26%	0.55%
SOUTH RIDGE (NSPM)	204800	SRDT_69KV	69	1453.2	2308.1	1457.0	2320.7	3.8	12.6	0.26%	0.55%
BUFFALO RIDGE (NSPM)	114419	BRI_321_C2	34.5	7754.4	9932.2	7774.9	9986.4	20.5	54.2	0.26%	0.55%
RUTHTON (NSPM)	198506	RTH_INTSUB	34.5	8732.2	10926.6	8756.1	10986.2	23.9	59.6	0.27%	0.55%
RUTHTON (NSPM)	198531	RTH_RISER7	34.5	8480.4	10718.7	8502.7	10775.7	22.3	57.0	0.26%	0.53%
SOUTH RIDGE (NSPM)	204802	SRD_C195	69	1369.8	2164.9	1373.2	2176.0	3.4	11.1	0.25%	0.51%
SLAYTON WEST (NSPM)	203600	SLWT_69KV	69	2056.6	2899.0	2060.4	2912.1	3.8	13.1	0.18%	0.45%
BUFFALO RIDGE (NSPM)	114409	BRI_311_C2	34.5	6509.3	8388.7	6523.3	8426.6	14.0	37.9	0.22%	0.45%
SLAYTON WEST (NSPM)	203601	SLW_69KV	69	2050.5	2892.6	2054.3	2905.6	3.8	13.0	0.19%	0.45%
SLAYTON (NOBLES)	203500	SLT_69KV	69	2026.7	2870.2	2030.4	2882.9	3.7	12.7	0.18%	0.44%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J426

Substation	Faulted Bus			Benchmark Case without J426 Project		Study Case with J426 Project		Amps Change with J426 vs Benchmark		% Change with J426 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
SPLIT ROCK (NSPM)	206127	SPK_IB_WSF	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206126	SPK_IB_TR11	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206125	SPK_IB_TR10	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206124	SPK_IB_TR07	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206123	SPK_IB_TR06	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206122	SPK_IB_PIR	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206121	SPK_IB_PIP	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206120	SPK_IB_LAW2	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206119	SPK_IB_LAW1	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206118	SPK_IB_FLS	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206117	SPK_IB_CHC	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206116	SPK_IB_CAP2	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206115	SPK_IB_CAP1	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206114	SPK_IB_CAP	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206113	SPK_IB_ANS2	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206112	SPK_IB_ANS1	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206109	SPK_CAP	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206108	SPK_115KV_2	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
SPLIT ROCK (NSPM)	206107	SPK_115KV_1	115	42041.7	36961.3	42181.9	37121.1	140.2	159.8	0.33%	0.43%
NOBLES COUNTY (NSPM)	182034	NOB_IB_TR02	34.5	22856.8	19238.8	22933.0	19320.8	76.2	82.0	0.33%	0.43%
NOBLES COUNTY (NSPM)	182031	NOB_FDR323	34.5	22856.8	19238.8	22933.0	19320.8	76.2	82.0	0.33%	0.43%
NOBLES COUNTY (NSPM)	182030	NOB_FDR322_M	34.5	22856.8	19238.8	22933.0	19320.8	76.2	82.0	0.33%	0.43%
NOBLES COUNTY (NSPM)	182028	NOB_FDR322	34.5	22856.8	19238.8	22933.0	19320.8	76.2	82.0	0.33%	0.43%
NOBLES COUNTY (NSPM)	182027	NOB_FDR321_M	34.5	22856.8	19238.8	22933.0	19320.8	76.2	82.0	0.33%	0.43%
NOBLES COUNTY (NSPM)	182025	NOB_FDR321	34.5	22856.8	19238.8	22933.0	19320.8	76.2	82.0	0.33%	0.43%
NOBLES COUNTY (NSPM)	182016	NOB_34_5KV_2	34.5	22856.8	19238.8	22933.0	19320.8	76.2	82.0	0.33%	0.43%
NOBLES COUNTY (NSPM)	182033	NOB_IB_TR01	34.5	22525.5	19178.0	22599.5	19259.4	74.0	81.4	0.33%	0.42%
NOBLES COUNTY (NSPM)	182023	NOB_FDR313	34.5	22525.5	19178.0	22599.5	19259.4	74.0	81.4	0.33%	0.42%
NOBLES COUNTY (NSPM)	182022	NOB_FDR312_M	34.5	22525.5	19178.0	22599.5	19259.4	74.0	81.4	0.33%	0.42%
NOBLES COUNTY (NSPM)	182020	NOB_FDR312	34.5	22525.5	19178.0	22599.5	19259.4	74.0	81.4	0.33%	0.42%
NOBLES COUNTY (NSPM)	182019	NOB_FDR311_M	34.5	22525.5	19178.0	22599.5	19259.4	74.0	81.4	0.33%	0.42%
NOBLES COUNTY (NSPM)	182017	NOB_FDR311	34.5	22525.5	19178.0	22599.5	19259.4	74.0	81.4	0.33%	0.42%
NOBLES COUNTY (NSPM)	182015	NOB_34_5KV_1	34.5	22525.5	19178.0	22599.5	19259.4	74.0	81.4	0.33%	0.42%
BUFFALO RIDGE (NSPM)	114428	BRI_322_C2	34.5	5700.3	7840.4	5710.7	7873.3	10.4	32.9	0.18%	0.42%
BUFFALO RIDGE (NSPM)	114432	BRI_323_C2	34.5	5514.4	7641.5	5524.0	7672.6	9.6	31.1	0.17%	0.41%
ANGUS ANSON (NSPM)	102503	ANS_IB_TR41	115	38627.6	35267.8	38744.0	35411.1	116.4	143.3	0.30%	0.41%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J426

Substation	Faulted Bus			Benchmark Case without J426 Project		Study Case with J426 Project		Amps Change with J426 vs Benchmark		% Change with J426 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
ANGUS ANSON (NSPM)	102502	ANS_IB_GSU4	115	38627.6	35267.8	38744.0	35411.1	116.4	143.3	0.30%	0.41%
ANGUS ANSON (NSPM)	102501	ANS_115KV_2	115	38627.6	35267.8	38744.0	35411.1	116.4	143.3	0.30%	0.41%
LAKEFIELD JCT (IPW)	162507	LAJ_IB_TR02	345	11722.0	14195.9	11747.5	14252.7	25.5	56.8	0.22%	0.40%
LAKEFIELD JCT (IPW)	162506	LAJ_IB_TR01	345	11722.0	14195.9	11747.5	14252.7	25.5	56.8	0.22%	0.40%
LAKEFIELD JCT (IPW)	162505	LAJ_IB_RAU	345	11722.0	14195.9	11747.5	14252.7	25.5	56.8	0.22%	0.40%
LAKEFIELD JCT (IPW)	162504	LAJ_IB_NOB	345	11722.0	14195.9	11747.5	14252.7	25.5	56.8	0.22%	0.40%
LAKEFIELD JCT (IPW)	162503	LAJ_IB_LFD	345	11722.0	14195.9	11747.5	14252.7	25.5	56.8	0.22%	0.40%
LAKEFIELD JCT (IPW)	162502	LAJ_IB_HNW	345	11722.0	14195.9	11747.5	14252.7	25.5	56.8	0.22%	0.40%
LAKEFIELD JCT (IPW)	162501	LAJ_345KV_2	345	11722.0	14195.9	11747.5	14252.7	25.5	56.8	0.22%	0.40%
LAKEFIELD JCT (IPW)	162500	LAJ_345KV_1	345	11722.0	14195.9	11747.5	14252.7	25.5	56.8	0.22%	0.40%
ANGUS ANSON (NSPM)	102500	ANS_115KV_1	115	37060.7	34189.2	37165.8	34321.2	105.1	132.0	0.28%	0.39%
SPLIT ROCK (NSPM)	206111	SPK_CAP2	115	35835.6	32076.8	35936.8	32196.7	101.2	119.9	0.28%	0.37%
SPLIT ROCK (NSPM)	206110	SPK_CAP1	115	35835.6	32076.8	35936.8	32196.7	101.2	119.9	0.28%	0.37%
HAZEL CREEK (NSPM)	148702	HZC_IB_LYC	345	6662.6	7544.0	6676.6	7571.0	14.0	27.0	0.21%	0.36%
HAZEL CREEK (NSPM)	148700	HZC_345KV_1	345	6662.6	7544.0	6676.6	7571.0	14.0	27.0	0.21%	0.36%
LYON COUNTY (NSPM)	168323	LYC_TR09_TER	34.5	0.0	15945.9	0.0	15997.1	0.0	51.2	0.00%	0.32%
LYON COUNTY (NSPM)	168322	LYC_IB_RB9	34.5	0.0	15945.9	0.0	15997.1	0.0	51.2	0.00%	0.32%
CEDAR MOUNTAIN (GRE)	119105	CMT_IB_TR01	345	8642.7	10933.2	8656.9	10967.6	14.2	34.4	0.16%	0.31%
CEDAR MOUNTAIN (GRE)	119104	CMT_IB_LYC2	345	8642.7	10933.2	8656.9	10967.6	14.2	34.4	0.16%	0.31%
CEDAR MOUNTAIN (GRE)	119103	CMT_IB_HNA2	345	8642.7	10933.2	8656.9	10967.6	14.2	34.4	0.16%	0.31%
CEDAR MOUNTAIN (GRE)	119102	CMT_IB_HNA1	345	8642.7	10933.2	8656.9	10967.6	14.2	34.4	0.16%	0.31%
CEDAR MOUNTAIN (GRE)	119101	CMT_345KV_2	345	8642.7	10933.2	8656.9	10967.6	14.2	34.4	0.16%	0.31%
CEDAR MOUNTAIN (GRE)	119100	CMT_345KV_1	345	8642.7	10933.2	8656.9	10967.6	14.2	34.4	0.16%	0.31%
LAWRENCE (NSPM)	163104	LAW_115KV_5	115	29062.9	29490.4	29120.8	29579.4	57.9	89.0	0.20%	0.30%
LAWRENCE (NSPM)	163103	LAW_115KV_4	115	29062.9	29490.4	29120.8	29579.4	57.9	89.0	0.20%	0.30%
LAWRENCE (NSPM)	163102	LAW_115KV_3	115	29062.9	29490.4	29120.8	29579.4	57.9	89.0	0.20%	0.30%
LAWRENCE (NSPM)	163101	LAW_115KV_2	115	29062.9	29490.4	29120.8	29579.4	57.9	89.0	0.20%	0.30%
LAWRENCE (NSPM)	163100	LAW_115KV_1	115	29062.9	29490.4	29120.8	29579.4	57.9	89.0	0.20%	0.30%
YANKEE (NSPM)	229520	YNK_FDR323	34.5	18008.2	15782.9	18049.3	15830.0	41.1	47.1	0.23%	0.30%
YANKEE (NSPM)	229518	YNK_FDR322	34.5	18008.2	15782.9	18049.3	15830.0	41.1	47.1	0.23%	0.30%
YANKEE (NSPM)	229516	YNK_FDR321	34.5	18008.2	15782.9	18049.3	15830.0	41.1	47.1	0.23%	0.30%
YANKEE (NSPM)	229509	YNK_34_5KV_2	34.5	18008.2	15782.9	18049.3	15830.0	41.1	47.1	0.23%	0.30%
YANKEE (NSPM)	229514	YNK_FDR313	34.5	18786.1	15769.5	18831.1	15816.5	45.0	47.0	0.24%	0.30%
YANKEE (NSPM)	229512	YNK_FDR312	34.5	18786.1	15769.5	18831.1	15816.5	45.0	47.0	0.24%	0.30%
YANKEE (NSPM)	229510	YNK_FDR311	34.5	18786.1	15769.5	18831.1	15816.5	45.0	47.0	0.24%	0.30%
YANKEE (NSPM)	229508	YNK_34_5KV_1	34.5	18786.1	15769.5	18831.1	15816.5	45.0	47.0	0.24%	0.30%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J426

Substation	Faulted Bus			Benchmark Case without J426 Project		Study Case with J426 Project		Amps Change with J426 vs Benchmark		% Change with J426 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
PIPESTONE (NSPM)	189617	PIP_TR06_TER	13.8	0.0	4006.9	0.0	4018.7	0.0	11.8	0.00%	0.29%
PIPESTONE (NSPM)	189621	PIP_TR05_TER	2.4	0.0	22935.5	0.0	23001.3	0.0	65.8	0.00%	0.29%
LAKE YANKTON (NSPM)	162316	LAY_69KV_2	69	2391.3	2227.3	2395.8	2233.6	4.5	6.3	0.19%	0.28%
LYON COUNTY (NSPM)	168321	LYC_IB_TSS	69	8934.1	8603.1	8951.1	8627.4	17.0	24.3	0.19%	0.28%
LYON COUNTY (NSPM)	168320	LYC_IB_TR01	69	8934.1	8603.1	8951.1	8627.4	17.0	24.3	0.19%	0.28%
LYON COUNTY (NSPM)	168319	LYC_IB_MNV	69	8934.1	8603.1	8951.1	8627.4	17.0	24.3	0.19%	0.28%
LYON COUNTY (NSPM)	168318	LYC_IB_MLY	69	8934.1	8603.1	8951.1	8627.4	17.0	24.3	0.19%	0.28%
LYON COUNTY (NSPM)	168317	LYC_69KV_1	69	8934.1	8603.1	8951.1	8627.4	17.0	24.3	0.19%	0.28%
PIPESTONE (NSPM)	189615	PIP_FDR62	13.8	5247.9	4992.0	5261.2	5006.0	13.3	14.0	0.25%	0.28%
PIPESTONE (NSPM)	189613	PIP_FDR61	13.8	5247.9	4992.0	5261.2	5006.0	13.3	14.0	0.25%	0.28%
PIPESTONE (NSPM)	189612	PIP_13_8KV	13.8	5247.9	4992.0	5261.2	5006.0	13.3	14.0	0.25%	0.28%
PIPESTONE (NSPM)	189620	PIP_IB_TR02	4.16	13911.6	12716.0	13939.8	12751.2	28.2	35.2	0.20%	0.28%
PIPESTONE (NSPM)	189619	PIP_FDR03	4.16	13911.6	12716.0	13939.8	12751.2	28.2	35.2	0.20%	0.28%
PIPESTONE (NSPM)	189618	PIP_FDR01	4.16	13911.6	12716.0	13939.8	12751.2	28.2	35.2	0.20%	0.28%
CURRIE (NOB)	126800	CUR_69KV_1	69	1736.4	2580.7	1738.1	2587.8	1.7	7.1	0.10%	0.28%
NOBLES COUNTY (NSPM)	182035	NOB_TR09_TER	34.5	0.0	12805.8	0.0	12841.0	0.0	35.2	0.00%	0.27%
NOBLES COUNTY (NSPM)	182036	NOB_TR10_TER	34.5	0.0	12791.7	0.0	12826.8	0.0	35.1	0.00%	0.27%
TEPPEOTA (NSPM)	212600	TPO_69KV	69	1732.6	2579.3	1734.3	2586.1	1.7	6.8	0.10%	0.26%
GREEN VALLEY (OTP)	146100	GVY_69KV	69	7899.5	8118.4	7912.3	8139.5	12.8	21.1	0.16%	0.26%
BUFFALO RIDGE (NSPM)	114410	BRI_311_C3	34.5	3434.9	4985.8	3439.6	4998.2	4.7	12.4	0.14%	0.25%
BUFFALO RIDGE (NSPM)	114429	BRI_322_C3	34.5	3216.8	4894.6	3220.9	4906.6	4.1	12.0	0.13%	0.25%
BUFFALO RIDGE (NSPM)	114420	BRI_321_C3	34.5	3133.5	4881.8	3137.5	4893.7	4.0	11.9	0.13%	0.24%
BUFFALO RIDGE (NSPM)	114433	BRI_323_C3	34.5	3195.1	4870.9	3199.2	4882.7	4.1	11.8	0.13%	0.24%
SIOUX FALLS (WAPA)	202902	SFW_NO_115KV	115	27834.6	26346.8	27881.4	26409.1	46.8	62.3	0.17%	0.24%
SIOUX FALLS (WAPA)	202901	SFW_115KV	115	27834.6	26346.8	27881.4	26409.1	46.8	62.3	0.17%	0.24%
PIPESTONE (NSPM)	189616	PIP_FDR62_E	13.8	2433.8	3200.1	2436.7	3207.5	2.9	7.4	0.12%	0.23%
BUFFALO RIDGE (NSPM)	114411	BRI_312_C2	34.5	3397.4	5037.1	3401.6	5048.5	4.2	11.4	0.12%	0.23%
CHANDLER (NOB)	120202	CHN_12_5KV	12.5	5113.3	4810.5	5121.3	4821.1	8.0	10.6	0.16%	0.22%
PIPESTONE (NSPM)	189614	PIP_FDR61_E	13.8	2310.7	3056.7	2313.3	3063.4	2.6	6.7	0.11%	0.22%
LAKE SARAH (NOBLES)	162100	LSAT_69KV	69	1841.9	2712.8	1843.3	2718.5	1.4	5.7	0.08%	0.21%
FENTON (NSPM)	137627	FTN_TR05_TER	13.8	0.0	4055.8	0.0	4063.8	0.0	8.0	0.00%	0.20%
BUFFALO RIDGE (NSPM)	114434	BRI_323_C4	34.5	2622.2	4083.8	2625.0	4091.8	2.8	8.0	0.11%	0.20%
BUFFALO RIDGE (NSPM)	114430	BRI_322_C4	34.5	2626.3	4083.8	2629.1	4091.8	2.8	8.0	0.11%	0.20%
PIPESTONE (NSPM)	189611	PIP_IB_TR03	23	1739.6	1609.4	1742.0	1612.5	2.4	3.1	0.14%	0.19%
PIPESTONE (NSPM)	189609	PIP_FDR90	23	1739.6	1609.4	1742.0	1612.5	2.4	3.1	0.14%	0.19%
TRACY SW STA (NSPM)	214404	TSS_IB_LYC	69	2158.8	3049.8	2160.3	3055.4	1.5	5.6	0.07%	0.18%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J426

Substation	Faulted Bus			Benchmark Case without J426 Project		Study Case with J426 Project		Amps Change with J426 vs Benchmark		% Change with J426 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
TRACY SW STA (NSPM)	214403	TSS_IB_FTN	69	2158.8	3049.8	2160.3	3055.4	1.5	5.6	0.07%	0.18%
TRACY SW STA (NSPM)	214402	TSS_IB_CAP	69	2158.8	3049.8	2160.3	3055.4	1.5	5.6	0.07%	0.18%
TRACY SW STA (NSPM)	214400	TSS_69KV	69	2158.8	3049.8	2160.3	3055.4	1.5	5.6	0.07%	0.18%
WALNUT GROVE (REDWOO	220100	WLGV_69KV	69	2359.0	3328.6	2360.7	3334.7	1.7	6.1	0.07%	0.18%
BUFFALO RIDGE (NSPM)	114421	BRI_321_C4	34.5	2394.7	3849.8	2397.0	3856.8	2.3	7.0	0.10%	0.18%
BUFFALO RIDGE (NSPM)	114412	BRI_312_C3	34.5	2757.5	4176.6	2760.3	4184.1	2.8	7.5	0.10%	0.18%
ELLSBOROUGH (GRE)	133703	ELB_FDR01	12.5	3178.0	3170.6	3183.6	3176.1	5.6	5.5	0.18%	0.17%
ROCK RIVER (NSPM)	197007	ROC_FDR91	23	2036.5	1847.7	2039.1	1850.9	2.6	3.2	0.13%	0.17%
ROCK RIVER (NSPM)	197005	ROC_FDR90	23	2036.5	1847.7	2039.1	1850.9	2.6	3.2	0.13%	0.17%
ROCK RIVER (NSPM)	197004	ROC_23KV	23	2036.5	1847.7	2039.1	1850.9	2.6	3.2	0.13%	0.17%
ELLSBOROUGH (GRE)	133702	ELB_12_5KV	12.5	3192.0	3184.4	3197.7	3189.9	5.7	5.5	0.18%	0.17%
NOBLES COUNTY (NSPM)	182024	NOB_FDR313_E	34.5	7271.8	9110.3	7277.6	9126.0	5.8	15.7	0.08%	0.17%
NOBLES COUNTY (NSPM)	182032	NOB_FDR323_E	34.5	8118.0	9121.2	8125.8	9136.9	7.8	15.7	0.10%	0.17%
VALLEY VIEW (NSPM)	217602	VVW_34_5KV	34.5	1476.3	1337.9	1478.2	1340.2	1.9	2.3	0.13%	0.17%
SIOUX FALLS (WAPA)	202900	SFW_230KV	230	12448.0	12578.6	12461.9	12599.9	13.9	21.3	0.11%	0.17%
SPLIT ROCK (NSPM)	206105	SPK_230KV	230	12160.8	12229.5	12174.5	12250.1	13.7	20.6	0.11%	0.17%
UILK (NSPM_UILK WIND	216601	UWI_13_8KV	13.8	2356.8	2245.1	2359.5	2248.7	2.7	3.6	0.11%	0.16%
BUFFALO RIDGE (NSPM)	114422	BRI_321_C5	34.5	2117.6	3445.5	2119.4	3451.0	1.8	5.5	0.09%	0.16%
FALLS (NSPM)	136603	FLS_IB_TR02	115	10578.9	14726.7	10586.4	14749.9	7.5	23.2	0.07%	0.16%
FALLS (NSPM)	136602	FLS_IB_SPK	115	10578.9	14726.7	10586.4	14749.9	7.5	23.2	0.07%	0.16%
FALLS (NSPM)	136601	FLS_115KV_2	115	10578.9	14726.7	10586.4	14749.9	7.5	23.2	0.07%	0.16%
FALLS (NSPM)	136600	FLS_115KV_1	115	10578.9	14726.7	10586.4	14749.9	7.5	23.2	0.07%	0.16%
WEST SIOUX FALLS (NS	224204	WSF_IB_SPK	115	11051.7	14678.0	11059.8	14700.4	8.1	22.4	0.07%	0.15%
WEST SIOUX FALLS (NS	224203	WSF_115KV_6	115	11051.7	14678.0	11059.8	14700.4	8.1	22.4	0.07%	0.15%
WEST SIOUX FALLS (NS	224202	WSF_115KV_4	115	11051.7	14678.0	11059.8	14700.4	8.1	22.4	0.07%	0.15%
WEST SIOUX FALLS (NS	224201	WSF_115KV_2	115	11051.7	14678.0	11059.8	14700.4	8.1	22.4	0.07%	0.15%
WEST SIOUX FALLS (NS	224200	WSF_115KV_1	115	11051.7	14678.0	11059.8	14700.4	8.1	22.4	0.07%	0.15%
WOODSTOCK (PARSON E)	229202	WSK_GEN01	34.5	3308.4	2739.1	3312.4	2743.2	4.0	4.1	0.12%	0.15%
PIPESTONE (NSPM)	189610	PIP_FDR90_E	23	1017.2	1162.1	1018.0	1163.8	0.8	1.7	0.08%	0.15%
ROCK RIVER (NSPM)	197006	ROC_FDR90_5M	23	1644.0	1516.6	1645.7	1518.7	1.7	2.1	0.10%	0.14%
CHERRY CREEK (NSPM)	120608	CHC_IB_CAP1	115	10025.1	13622.8	10031.4	13641.2	6.3	18.4	0.06%	0.14%
CHERRY CREEK (NSPM)	120607	CHC_IB_C1	115	10025.1	13622.8	10031.4	13641.2	6.3	18.4	0.06%	0.14%
CHERRY CREEK (NSPM)	120605	CHC_115KV_6	115	10025.1	13622.8	10031.4	13641.2	6.3	18.4	0.06%	0.14%
CHERRY CREEK (NSPM)	120604	CHC_115KV_5	115	10025.1	13622.8	10031.4	13641.2	6.3	18.4	0.06%	0.14%
CHERRY CREEK (NSPM)	120603	CHC_115KV_4	115	10025.1	13622.8	10031.4	13641.2	6.3	18.4	0.06%	0.14%
CHERRY CREEK (NSPM)	120602	CHC_115KV_3	115	10025.1	13622.8	10031.4	13641.2	6.3	18.4	0.06%	0.14%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J426

Substation	Faulted Bus			Benchmark Case without J426 Project		Study Case with J426 Project		Amps Change with J426 vs Benchmark		% Change with J426 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
CHERRY CREEK (NSPM)	120601	CHC_115KV_2	115	10025.1	13622.8	10031.4	13641.2	6.3	18.4	0.06%	0.14%
CHERRY CREEK (NSPM)	120600	CHC_115KV_1	115	10025.1	13622.8	10031.4	13641.2	6.3	18.4	0.06%	0.14%
BUFFALO RIDGE (NSPM)	114423	BRI_321_C6	34.5	1865.8	3069.5	1867.1	3073.6	1.3	4.1	0.07%	0.13%
CHERRY CREEK (NSPM)	120606	CHC_115KV_C1	115	9893.5	13379.3	9899.6	13397.1	6.1	17.8	0.06%	0.13%
BUFFALO RIDGE (NSPM)	114413	BRI_312_C4	34.5	2098.7	3250.8	2100.3	3255.1	1.6	4.3	0.08%	0.13%
NOBLES COUNTY (NSPM)	182037	NOB_TR01_TER	13.8	0.0	16748.9	0.0	16770.5	0.0	21.6	0.00%	0.13%
NOBLES COUNTY (NSPM)	182038	NOB_TR02_TER	13.8	0.0	16665.7	0.0	16687.1	0.0	21.4	0.00%	0.13%
ROCK RIVER (NSPM)	197002	ROC91_3_35M	23	1275.5	1401.9	1276.5	1403.7	1.0	1.8	0.08%	0.13%
MINNEHAHA (NSPM)	176103	MHA_IB_TR02	115	9422.7	13053.9	9428.1	13070.6	5.4	16.7	0.06%	0.13%
MINNEHAHA (NSPM)	176102	MHA_IB_TR01	115	9422.7	13053.9	9428.1	13070.6	5.4	16.7	0.06%	0.13%
MINNEHAHA (NSPM)	176101	MHA_115KV_2	115	9422.7	13053.9	9428.1	13070.6	5.4	16.7	0.06%	0.13%
MINNEHAHA (NSPM)	176100	MHA_115KV_1	115	9422.7	13053.9	9428.1	13070.6	5.4	16.7	0.06%	0.13%
LAKE SARAH (NOBLES)	162101	LSA_69KV	69	1216.3	1877.5	1217.2	1879.9	0.9	2.4	0.07%	0.13%
LYON COUNTY (NSPM)	6051	J400_COL	34.5	8939.6	8713.2	8946.7	8724.3	7.1	11.1	0.08%	0.13%
ROCK RIVER (NSPM)	197003	ROC91_3_82M	23	1202.7	1344.9	1203.6	1346.6	0.9	1.7	0.07%	0.13%
SOUTH RIDGE (NSPM)	204806	SRD_FDR211_E	23.9	1762.3	1347.8	1764.2	1349.5	1.9	1.7	0.11%	0.13%
SOUTH RIDGE (NSPM)	204805	SRD_FDR211	23.9	1762.3	1347.8	1764.2	1349.5	1.9	1.7	0.11%	0.13%
SOUTH RIDGE (NSPM)	204804	SRD_23KV	23.9	1762.3	1347.8	1764.2	1349.5	1.9	1.7	0.11%	0.13%
BUFFALO RIDGE (NSPM)	114404	BRI311_DELTA	34.5	1877.2	2897.2	1878.7	2900.8	1.5	3.6	0.08%	0.12%
BUFFALO RIDGE (NSPM)	114424	BRI_321_C7	34.5	1678.6	2784.5	1679.7	2787.9	1.1	3.4	0.07%	0.12%
YANKEE (NSPM)	229522	YNK_TR01_TER	13.8	0.0	16922.9	0.0	16941.9	0.0	19.0	0.00%	0.11%
BUFFALO RIDGE (NSPM)	114425	BRI_321_C8	34.5	1549.7	2585.6	1550.7	2588.4	1.0	2.8	0.06%	0.11%
BUFFALO RIDGE (NSPM)	114405	BRI311_ECHO	34.5	1645.6	2563.8	1646.7	2566.5	1.1	2.7	0.07%	0.11%
NOBLES COUNTY (NSPM)	182018	NOB_FDR311_E	34.5	5739.2	6952.0	5743.1	6959.2	3.9	7.2	0.07%	0.10%
LINCOLN COUNTY (NSPM	164903	LCO_IB_T7	115	7847.5	10622.6	7851.1	10633.5	3.6	10.9	0.05%	0.10%
LINCOLN COUNTY (NSPM	164902	LCO_IB_LAW	115	7847.5	10622.6	7851.1	10633.5	3.6	10.9	0.05%	0.10%
LINCOLN COUNTY (NSPM	164901	LCO_115KV_2	115	7847.5	10622.6	7851.1	10633.5	3.6	10.9	0.05%	0.10%
LINCOLN COUNTY (NSPM	164900	LCO_115KV_1	115	7847.5	10622.6	7851.1	10633.5	3.6	10.9	0.05%	0.10%
LOUISE (NSPM)	166500	LOU_115KV_1	115	7233.3	10202.2	7236.4	10212.2	3.1	10.0	0.04%	0.10%
SLAYTON WEST (NSPM)	203605	SLW_FDR62	13.8	4928.5	4318.3	4934.2	4322.5	5.7	4.2	0.12%	0.10%
SLAYTON WEST (NSPM)	203603	SLW_FDR61	13.8	4928.5	4318.3	4934.2	4322.5	5.7	4.2	0.12%	0.10%
SLAYTON WEST (NSPM)	203602	SLW_13_8KV_1	13.8	4928.5	4318.3	4934.2	4322.5	5.7	4.2	0.12%	0.10%
BUFFALO RIDGE (NSPM)	114426	BRI_321_C9	34.5	1427.6	2394.9	1428.4	2397.2	0.8	2.3	0.06%	0.10%
BUFFALO RIDGE (NSPM)	114442	BRI_CHARLIE2	34.5	1492.7	2414.7	1493.6	2417.0	0.9	2.3	0.06%	0.10%
BUFFALO RIDGE (NSPM)	114441	BRI_CHARLIE1	34.5	1495.2	2414.7	1496.1	2417.0	0.9	2.3	0.06%	0.10%
SOUTHWEST MARSHALL	205509	SWM_13_8KV_2	13.8	0.0	11265.0	0.0	11275.6	0.0	10.6	0.00%	0.09%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J426

Substation	Faulted Bus			Benchmark Case without J426 Project		Study Case with J426 Project		Amps Change with J426 vs Benchmark		% Change with J426 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
SOUTHWEST MARSHALL	205508	SWM_13_8KV_1	13.8	12285.5	11233.2	12292.9	11243.7	7.4	10.5	0.06%	0.09%
SPLIT ROCK (NSPM)	206106	SPK_161KV	161	8344.8	7965.2	8350.2	7972.6	5.4	7.4	0.06%	0.09%
MILROY (REDWOOD)	175801	MLY_69KV_2	69	3035.8	4413.9	3036.7	4417.9	0.9	4.0	0.03%	0.09%
MILROY (REDWOOD)	175800	MLY_69KV_1	69	3035.8	4413.9	3036.7	4417.9	0.9	4.0	0.03%	0.09%
YANKEE (NSPM)	229523	YNK_TR02_TER	13.8	0.0	14231.5	0.0	14244.3	0.0	12.8	0.00%	0.09%
SIOUX CITY (WAPA)	202700	SOC_345KV	345	12165.9	13965.9	12172.1	13978.3	6.2	12.4	0.05%	0.09%
BUFFALO RIDGE (NSPM)	114414	BRI_312_C5	34.5	1565.9	2481.5	1566.8	2483.7	0.9	2.2	0.06%	0.09%
NOBLES COUNTY (NSPM)	182029	NOB_FDR322_E	34.5	4238.2	5611.9	4240.5	5616.6	2.3	4.7	0.05%	0.08%
BUFFALO RIDGE (NSPM)	114415	BRI_312_C6	34.5	1438.7	2304.0	1439.5	2305.9	0.8	1.9	0.06%	0.08%
BUFFALO RIDGE (NSPM)	114418	BRI_321_C10	34.5	1306.5	2203.9	1307.2	2205.7	0.7	1.8	0.05%	0.08%
NOBLES COUNTY (NSPM)	182026	NOB_FDR321_E	34.5	4414.8	5422.3	4417.4	5426.7	2.6	4.4	0.06%	0.08%
BUFFALO RIDGE (NSPM)	114455	BRI_CHA_480V	0.48	98988.7	152620.5	99043.4	152742.8	54.7	122.3	0.06%	0.08%
BUFFALO RIDGE (NSPM)	114416	BRI_312_SHI	34.5	1403.5	2254.1	1404.2	2255.9	0.7	1.8	0.05%	0.08%
BUFFALO RIDGE (NSPM)	114408	BRI321_TAP	34.5	1221.2	2067.8	1221.8	2069.4	0.6	1.6	0.05%	0.08%
NOBLES COUNTY (NSPM)	182021	NOB_FDR312_E	34.5	3067.7	3870.4	3068.8	3873.3	1.1	2.9	0.04%	0.07%
SOUTH RIDGE (NSPM)	204807	SRD_TR01_TER	2.4	0.0	7862.2	0.0	7868.0	0.0	5.8	0.00%	0.07%
BUFFALO RIDGE (NSPM)	114406	BRI312_FOXTR	34.5	1280.1	2077.3	1280.7	2078.7	0.6	1.4	0.05%	0.07%
BUFFALO RIDGE (NSPM)	114438	BRI_ALPHZULU	34.5	1072.1	1827.8	1072.6	1829.0	0.5	1.2	0.05%	0.07%
BUFFALO RIDGE (NSPM)	114437	BRI_ALPHA	34.5	1072.1	1827.8	1072.6	1829.0	0.5	1.2	0.05%	0.07%
YELLOW MEDICINE (NSP	229700	YLM_69KV	69	2912.3	4269.5	2912.9	4272.3	0.6	2.8	0.02%	0.07%
LAWRENCE (NSPM)	163110	LAW_IB_TR08	69	11869.2	11388.6	11874.1	11395.7	4.9	7.1	0.04%	0.06%
LAWRENCE (NSPM)	163108	LAW_IB_CLFP	69	11869.2	11388.6	11874.1	11395.7	4.9	7.1	0.04%	0.06%
LAWRENCE (NSPM)	163107	LAW_IB_CLFE	69	11869.2	11388.6	11874.1	11395.7	4.9	7.1	0.04%	0.06%
LAWRENCE (NSPM)	163106	LAW_69KV_2	69	11869.2	11388.6	11874.1	11395.7	4.9	7.1	0.04%	0.06%
HADLEY (NSPM)	146807	HAD_FDR22	12.5	1684.0	1559.1	1684.7	1560.0	0.7	0.9	0.04%	0.06%
HADLEY (NSPM)	146806	HAD_FDR21	12.5	1684.0	1559.1	1684.7	1560.0	0.7	0.9	0.04%	0.06%
HADLEY (NSPM)	146805	HAD_12_5KV	12.5	1684.0	1559.1	1684.7	1560.0	0.7	0.9	0.04%	0.06%
WOOD LAKE TAP (NSPM)	228900	WDLT_69KV	69	2888.7	4232.7	2889.2	4235.1	0.5	2.4	0.02%	0.06%
THOLEN (NSPM)	212800	THN_34_5KV	34.5	1100.6	1813.2	1101.0	1814.2	0.4	1.0	0.04%	0.06%
MINNESOTA VALLEY (NS	176525	MNV_IB_TR12	69	10287.2	9517.0	10290.9	9521.9	3.7	4.9	0.04%	0.05%
MINNESOTA VALLEY (NS	176524	MNV_IB_TR11	69	10287.2	9517.0	10290.9	9521.9	3.7	4.9	0.04%	0.05%
MINNESOTA VALLEY (NS	176523	MNV_IB_TR02	69	10287.2	9517.0	10290.9	9521.9	3.7	4.9	0.04%	0.05%
MINNESOTA VALLEY (NS	176522	MNV_69KV_474	69	10287.2	9517.0	10290.9	9521.9	3.7	4.9	0.04%	0.05%
MINNESOTA VALLEY (NS	176521	MNV_69KV_473	69	10287.2	9517.0	10290.9	9521.9	3.7	4.9	0.04%	0.05%
MINNESOTA VALLEY (NS	176520	MNV_69KV_472	69	10287.2	9517.0	10290.9	9521.9	3.7	4.9	0.04%	0.05%
MINNESOTA VALLEY (NS	176519	MNV_69KV_470	69	10287.2	9517.0	10290.9	9521.9	3.7	4.9	0.04%	0.05%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J426

Substation	Faulted Bus			Benchmark Case without J426 Project		Study Case with J426 Project		Amps Change with J426 vs Benchmark		% Change with J426 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
MINNESOTA VALLEY (NS	176518	MNV_69KV_2	69	10287.2	9517.0	10290.9	9521.9	3.7	4.9	0.04%	0.05%
MINNESOTA VALLEY (NS	176517	MNV_69KV_1	69	10287.2	9517.0	10290.9	9521.9	3.7	4.9	0.04%	0.05%
LAKE YANKTON (NSPM)	162321	LAY_FDR61	13.8	3692.8	3258.3	3695.6	3259.9	2.8	1.6	0.08%	0.05%
LAKE YANKTON (NSPM)	162320	LAY_13_8KV	13.8	3692.8	3258.3	3695.6	3259.9	2.8	1.6	0.08%	0.05%
LAWRENCE (NSPM)	163109	LAW_IB_TR07	69	9776.5	9109.5	9780.7	9113.8	4.2	4.3	0.04%	0.05%
LAWRENCE (NSPM)	163105	LAW_69KV_1	69	9776.5	9109.5	9780.7	9113.8	4.2	4.3	0.04%	0.05%
WEST SIOUX FALLS (NS	224206	WSF_IB_TR05	69	8263.9	8736.7	8266.9	8740.7	3.0	4.0	0.04%	0.05%
WEST SIOUX FALLS (NS	224205	WSF_69KV	69	8263.9	8736.7	8266.9	8740.7	3.0	4.0	0.04%	0.05%
BUFFALO RIDGE (NSPM)	114407	BRI312_GOLF	34.5	956.6	1595.5	957.0	1596.2	0.4	0.7	0.04%	0.04%
ANGUS ANSON (NSPM)	102504	ANS_GEN04	18	7.9	88277.4	7.9	88315.4	0.0	38.0	0.00%	0.04%
SPLIT ROCK (NSPM)	206129	SPK_TR07_TER	13.8	0.0	34136.8	0.0	34151.2	0.0	14.4	0.00%	0.04%
SHAOKATAN II (NSPM)	201618	SKT_INTSUB	34.5	866.2	1455.6	866.5	1456.2	0.3	0.6	0.03%	0.04%
BUFFALO RIDGE (NSPM)	114451	BRI_ZULU_1	34.5	866.2	1455.6	866.5	1456.2	0.3	0.6	0.03%	0.04%
SHERIDAN (GRE)	202200	SHDT_69KV	69	2126.3	3427.1	2126.4	3428.5	0.1	1.4	0.00%	0.04%
SOUTHEAST (MARSHALL)	205201	SEA_13_8KV_4	13.8	7181.9	6996.7	7183.2	6999.5	1.3	2.8	0.02%	0.04%
ROCK COUNTY (NSPM)	196405	RCY_IB_SPK	161	4320.4	5160.2	4321.6	5162.2	1.2	2.0	0.03%	0.04%
ROCK COUNTY (NSPM)	196404	RCY_IB_MWD	161	4320.4	5160.2	4321.6	5162.2	1.2	2.0	0.03%	0.04%
ROCK COUNTY (NSPM)	196403	RCY_IB_MAG	161	4320.4	5160.2	4321.6	5162.2	1.2	2.0	0.03%	0.04%
ROCK COUNTY (NSPM)	196402	RCY_IB_FUT	161	4320.4	5160.2	4321.6	5162.2	1.2	2.0	0.03%	0.04%
ROCK COUNTY (NSPM)	196401	RCY_161KV_2	161	4320.4	5160.2	4321.6	5162.2	1.2	2.0	0.03%	0.04%
ROCK COUNTY (NSPM)	196400	RCY_161KV_1	161	4320.4	5160.2	4321.6	5162.2	1.2	2.0	0.03%	0.04%
WABASSO (GRE)	219202	WBS_SHD_RWO	69	2003.1	3275.9	2003.2	3276.9	0.1	1.0	0.00%	0.03%
PRAIRIE ROSE (ENEL)	191200	PIR_115KV	115	3896.2	3143.0	3897.4	3143.9	1.2	0.9	0.03%	0.03%
LAKE YANKTON (NSPM)	162323	LAY_TR02_TER	13.8	0.0	2627.4	0.0	2628.1	0.0	0.7	0.00%	0.03%
SPLIT ROCK (NSPM)	206130	SPK_TR10_TER	13.8	0.0	27901.7	0.0	27909.1	0.0	7.4	0.00%	0.03%
SPLIT ROCK (NSPM)	206131	SPK_TR11_TER	13.8	0.0	27916.2	0.0	27923.6	0.0	7.4	0.00%	0.03%
PRAIRIE ROSE (ENEL)	191204	PIR_TR02_TER	13.8	0.0	14815.1	0.0	14818.3	0.0	3.2	0.00%	0.02%
PRAIRIE ROSE (ENEL)	191203	PIR_TR01_TER	13.8	0.0	14815.1	0.0	14818.3	0.0	3.2	0.00%	0.02%
LYON COUNTY (NSPM)	168325	LYC_TR01_TER	13.8	0.0	6489.3	0.0	6490.7	0.0	1.4	0.00%	0.02%
SARATOGA (MARSHALL)	199402	SAR_GEN01	13.8	14715.6	14194.5	14717.0	14197.3	1.4	2.8	0.01%	0.02%
SARATOGA (MARSHALL)	199401	SAR_FDR21	13.8	14715.6	14194.5	14717.0	14197.3	1.4	2.8	0.01%	0.02%
ANGUS ANSON (NSPM)	102508	ANS_STAUX	13.8	0.9	84570.9	0.9	84586.8	0.0	15.9	0.00%	0.02%
ANGUS ANSON (NSPM)	102507	ANS_GEN02	13.8	0.9	84570.9	0.9	84586.8	0.0	15.9	0.00%	0.02%
ANGUS ANSON (NSPM)	102505	ANS_13_8KV_2	13.8	0.9	84570.9	0.9	84586.8	0.0	15.9	0.00%	0.02%
WEST SIOUX FALLS (NS	224208	WSF_13_8KV_8	13.8	15097.3	13863.0	15099.4	13865.6	2.1	2.6	0.01%	0.02%
WEST SIOUX FALLS (NS	224207	WSF_13_8KV_7	13.8	15125.0	13887.6	15127.1	13890.2	2.1	2.6	0.01%	0.02%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J426

Substation	Faulted Bus			Benchmark Case without J426 Project		Study Case with J426 Project		Amps Change with J426 vs Benchmark		% Change with J426 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
ANGUS ANSON (NSPM)	102506	ANS_13_8KV_3	13.8	0.9	84470.5	0.9	84486.3	0.0	15.8	0.00%	0.02%
GRANT (NSPM)	145300	GRTT_115KV	115	2762.9	3861.5	2763.3	3862.2	0.4	0.7	0.01%	0.02%
PRAIRIE ROSE (ENEL)	191202	PIR_GEN02	34.5	9783.9	7657.1	9786.0	7658.3	2.1	1.2	0.02%	0.02%
PRAIRIE ROSE (ENEL)	191201	PIR_GEN01	34.5	9783.9	7657.1	9786.0	7658.3	2.1	1.2	0.02%	0.02%
GRANT (NSPM)	145301	GRT_115KV	115	2762.9	3861.5	2763.3	3862.1	0.4	0.6	0.01%	0.02%
SPLIT ROCK (NSPM)	206128	SPK_TR06_TER	36.2	0.0	7143.8	0.0	7144.9	0.0	1.1	0.00%	0.02%
WABASSO (GRE)	219201	WBS_69KV	69	1970.9	3292.1	1971.1	3292.6	0.2	0.5	0.01%	0.02%
FALLS (NSPM)	136606	FLS_13_8KV_3	13.8	9910.6	9640.5	9911.5	9641.8	0.9	1.3	0.01%	0.01%
FALLS (NSPM)	136605	FLS_13_8KV_2	13.8	9910.6	9640.5	9911.5	9641.8	0.9	1.3	0.01%	0.01%
FALLS (NSPM)	136604	FLS_13_8KV_1	13.8	9910.6	9640.5	9911.5	9641.8	0.9	1.3	0.01%	0.01%
LAWRENCE (NSPM)	163117	LAW_FDR322	34.5	7596.5	7416.6	7597.8	7417.5	1.3	0.9	0.02%	0.01%
LAWRENCE (NSPM)	163115	LAW_FDR321	34.5	7596.5	7416.6	7597.8	7417.5	1.3	0.9	0.02%	0.01%
LAWRENCE (NSPM)	163114	LAW_FDR312	34.5	7596.5	7416.6	7597.8	7417.5	1.3	0.9	0.02%	0.01%
LAWRENCE (NSPM)	163113	LAW_FDR311	34.5	7596.5	7416.6	7597.8	7417.5	1.3	0.9	0.02%	0.01%
LAWRENCE (NSPM)	163112	LAW_34_5KV_2	34.5	7596.5	7416.6	7597.8	7417.5	1.3	0.9	0.02%	0.01%
LAWRENCE (NSPM)	163111	LAW_34_5KV_1	34.5	7596.5	7416.6	7597.8	7417.5	1.3	0.9	0.02%	0.01%
LOUISE (NSPM)	166501	LOU_13_8KV_1	13.8	9384.1	9161.5	9384.9	9162.6	0.8	1.1	0.01%	0.01%
WATERBURY (GRE)	221304	WRB_IB_SMM	69	2089.2	3511.7	2089.4	3512.1	0.2	0.4	0.01%	0.01%
WATERBURY (GRE)	221303	WRB_IB_LYC	69	2089.2	3511.7	2089.4	3512.1	0.2	0.4	0.01%	0.01%
WATERBURY (GRE)	221302	WRB_IB_JHN	69	2089.2	3511.7	2089.4	3512.1	0.2	0.4	0.01%	0.01%
WATERBURY (GRE)	221301	WRB_IB_DOT	69	2089.2	3511.7	2089.4	3512.1	0.2	0.4	0.01%	0.01%
WATERBURY (GRE)	221300	WRB_69KV_1	69	2089.2	3511.7	2089.4	3512.1	0.2	0.4	0.01%	0.01%
ANGUS ANSON (NSPM)	102517	ANS_FDR48	4.16	399.9	26014.6	399.9	26017.5	0.0	2.9	0.00%	0.01%
ANGUS ANSON (NSPM)	102516	ANS_FDR47	4.16	399.9	26014.6	399.9	26017.5	0.0	2.9	0.00%	0.01%
ANGUS ANSON (NSPM)	102515	ANS_FDR46	4.16	399.9	26014.6	399.9	26017.5	0.0	2.9	0.00%	0.01%
ANGUS ANSON (NSPM)	102514	ANS_FDR45	4.16	399.9	26014.6	399.9	26017.5	0.0	2.9	0.00%	0.01%
ANGUS ANSON (NSPM)	102513	ANS_FDR43	4.16	399.9	26014.6	399.9	26017.5	0.0	2.9	0.00%	0.01%
ANGUS ANSON (NSPM)	102512	ANS_FDR42	4.16	399.9	26014.6	399.9	26017.5	0.0	2.9	0.00%	0.01%
ANGUS ANSON (NSPM)	102511	ANS_4_16_PAF	4.16	399.9	26014.6	399.9	26017.5	0.0	2.9	0.00%	0.01%
ANGUS ANSON (NSPM)	102510	ANS_4_16_41	4.16	399.9	26014.6	399.9	26017.5	0.0	2.9	0.00%	0.01%
LAWRENCE (NSPM)	163119	LAW_TR08_TER	13.8	0.0	8532.0	0.0	8532.9	0.0	0.9	0.00%	0.01%
CHERRY CREEK (NSPM)	120623	CHC_FDR64	13.8	8446.1	7860.7	8446.7	7861.5	0.6	0.8	0.01%	0.01%
CHERRY CREEK (NSPM)	120621	CHC_FDR63	13.8	8446.1	7860.7	8446.7	7861.5	0.6	0.8	0.01%	0.01%
CHERRY CREEK (NSPM)	120619	CHC_FDR62	13.8	8446.1	7860.7	8446.7	7861.5	0.6	0.8	0.01%	0.01%
CHERRY CREEK (NSPM)	120617	CHC_FDR61	13.8	8446.1	7860.7	8446.7	7861.5	0.6	0.8	0.01%	0.01%
CHERRY CREEK (NSPM)	120616	CHC_13_8KV	13.8	8446.1	7860.7	8446.7	7861.5	0.6	0.8	0.01%	0.01%

Single-Line-to-Ground (SLG) and Three Phase (3PH) Fault Currents with and without J426

Substation	Faulted Bus			Benchmark Case without J426 Project		Study Case with J426 Project		Amps Change with J426 vs Benchmark		% Change with J426 vs Benchmark	
	#	Name	kV	SLG Fault SC Amps	3PH Fault SC Amps	SLG Fault SC Amps	3PH Fault SC Amps	SLG	3PH	SLG	3PH
BALATON (NSPM)	105700	BLN_13_8KV	13.8	1565.3	2085.9	1565.8	2086.1	0.5	0.2	0.03%	0.01%
WEST SIOUX FALLS (NS	224226	WSF_TR05_TER	13.8	0.0	6488.7	0.0	6489.3	0.0	0.6	0.00%	0.01%
MINNEHAHA (NSPM)	176115	MHA_FDR73	13.8	7327.2	6832.1	7327.7	6832.7	0.5	0.6	0.01%	0.01%
MINNEHAHA (NSPM)	176114	MHA_FDR72	13.8	7327.2	6832.1	7327.7	6832.7	0.5	0.6	0.01%	0.01%
MINNEHAHA (NSPM)	176112	MHA_FDR71	13.8	7327.2	6832.1	7327.7	6832.7	0.5	0.6	0.01%	0.01%
MINNEHAHA (NSPM)	176105	MHA_13_8KV_2	13.8	7327.2	6832.1	7327.7	6832.7	0.5	0.6	0.01%	0.01%
MINNEHAHA (NSPM)	176110	MHA_FDR63	13.8	7376.3	6877.0	7376.8	6877.6	0.5	0.6	0.01%	0.01%
MINNEHAHA (NSPM)	176108	MHA_FDR62	13.8	7376.3	6877.0	7376.8	6877.6	0.5	0.6	0.01%	0.01%
MINNEHAHA (NSPM)	176106	MHA_FDR61	13.8	7376.3	6877.0	7376.8	6877.6	0.5	0.6	0.01%	0.01%
MINNEHAHA (NSPM)	176104	MHA_13_8KV_1	13.8	7376.3	6877.0	7376.8	6877.6	0.5	0.6	0.01%	0.01%
GREEN VALLEY (OTP)	146102	GVY_12_5KV	12.5	1503.0	1486.4	1503.1	1486.5	0.1	0.1	0.01%	0.01%
MITCHELL (NW PUBLIC)	176900	MIT_115KV	115	2870.9	4482.4	2870.9	4482.7	0.0	0.3	0.00%	0.01%
LAWRENCE (NSPM)	163118	LAW_TR07_TER	13.8	0.0	5115.4	0.0	5115.7	0.0	0.3	0.00%	0.01%
YELLOW MEDICINE (NSP	229701	YLM_23KV	23	2921.8	2752.2	2922.2	2752.2	0.4	0.0	0.01%	0.00%
MILROY (REDWOOD)	175803	MLY_12_5KV_2	12.5	574.1	569.8	574.1	569.8	0.0	0.0	0.00%	0.00%
MILROY (REDWOOD)	175802	MLY_12_5KV_1	12.5	574.1	569.8	574.1	569.8	0.0	0.0	0.00%	0.00%
GREEN VALLEY (OTP)	146101	GVY_41_6KV	41.6	546.3	378.0	546.3	378.0	0.0	0.0	0.00%	0.00%
CHERRY CREEK (NSPM)	120614	CHC_FDR321	34.5	7211.3	6794.3	7212.4	6782.0	1.1	-12.3	0.02%	-0.18%
CHERRY CREEK (NSPM)	120613	CHC_FDR312	34.5	7211.3	6794.3	7212.4	6782.0	1.1	-12.3	0.02%	-0.18%
CHERRY CREEK (NSPM)	120611	CHC_FDR311	34.5	7211.3	6794.3	7212.4	6782.0	1.1	-12.3	0.02%	-0.18%
CHERRY CREEK (NSPM)	120610	CHC_34_5KV	34.5	7211.3	6794.3	7212.4	6782.0	1.1	-12.3	0.02%	-0.18%
CHANARAMBIE (NSPM)	5674	J426_COL	34.5	-	-	15250.9	16135.8				

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Appendix

J

2018 Cost Allocation Results

J.1 Distribution Factor (DF) and MW Contribution Results for Cost Allocation

Table J-1: Distribution Factor and MW Contribution on Constraints for Thermal NU Cost Allocation in 2018

Table J-2: Distribution Factor and MW Contribution on Constraints for Voltage Support NU Cost Allocation in 2018

Table J-1: Distribution Factor and MW Contribution on Constraints for Thermal NU Cost Allocation in 2018

Monitored Element	Contingency	Cont Type	Summary GIP With Impact	Comments	J299 5+31.5 10+63	G736 200 40	J385 0 100	J391 0 50	J400 0 62.5	J405 0 40	J407 200 40	J411 300 60	J416 200 40	J426 100 20	J299 ST 5 10	J299 CT 31.5 63	G736 200 40	J385 0 100	J391 0 50	J400 0 62.5	J405 0 40	J407 200 40	J411 300 60	J416 200 40	J426 100 20
613210 OWATANA1 69.0 630116 PRAT T 8 69.0 1	P42:161:ITCM:COLBY5-NIW 5 9650:IA-MVP NIW 5 161 - COLBY5 161 1 LIME CK5 161 - COLBY5 161 1	P4-2	J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	9.36	0.00	0.00	0.00	-0.00391	-0.00546	-0.00359	-0.00518	-0.00322	-0.00325	-0.00301	0.04678	0.00018	0.00323	-0.00172
613210 OWATANA1 69.0 630116 PRAT T 8 69.0 1	P42:161:ITCM:COLBY5-NIW 5 9530:IA-MVP NIW 5 161 - COLBY5 161 1 COLBY3 345 - COLBY5 161 1	P4-2	J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	9.32	0.00	0.00	0.00	-0.00394	-0.00550	-0.00361	-0.00522	-0.00324	-0.00327	-0.00303	0.04662	0.00022	0.00332	-0.00174
613210 OWATANA1 69.0 630116 PRAT T 8 69.0 1	631036 NIW 5 161 631202 COLBY5 161 1 NIW 5 161 - COLBY5 161 1	P1	J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	9.31	0.00	0.00	0.00	-0.00397	-0.00552	-0.00363	-0.00524	-0.00326	-0.00329	-0.00304	0.04655	0.00020	0.00369	-0.00176
616002 GRE-JOHNJCT7 115 620216 ORTONVL7 115 1	P23:230.0:UMZB:# 599 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - GRANITF4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P2-3	G736, G736,	2018 SH	0.00	43.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00116	-0.00121	0.21667	-0.00087	-0.00098	-0.00138	0.00568	-0.00076	-0.00005	-0.00058	-0.00066
616002 GRE-JOHNJCT7 115 620216 ORTONVL7 115 1	P23:230.0:UMZB:# 604 #: FB IN SD. BF 482 BIGSTON4 230 - BLAIR 4 230 1 BLAIR 8 69.0 - BLAIR 4 230 1 BLAIR 8 69.0 - NBCS111G 12.5 1	P2-3	G736, G736,	2018 SH	0.00	43.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00108	-0.00113	0.21694	-0.00075	-0.00076	-0.00122	0.00548	-0.00072	-0.00011	-0.00056	-0.00066
616002 GRE-JOHNJCT7 115 620216 ORTONVL7 115 1	620314 BIGSTON4 230 652503 BLAIR 4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P1	G736, G736,	2018 SH	0.00	43.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00108	-0.00113	0.21694	-0.00075	-0.00076	-0.00122	0.00548	-0.00072	-0.00011	-0.00056	-0.00066
616002 GRE-JOHNJCT7 115 620216 ORTONVL7 115 1	P23:230.0:UMZB:# 601 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - WATERTN4 230 1 BLAIR 4 230 - GRANITF4 230 1	P2-3	G736, G736,	2018 SH	0.00	43.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00116	-0.00121	0.21667	-0.00087	-0.00098	-0.00138	0.00568	-0.00076	-0.00005	-0.00058	-0.00066
616002 GRE-JOHNJCT7 115 652555 MORRIS 7 115 1	P23:230.0:UMZB:# 599 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - GRANITF4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P2-3	G736, G736,	2018 SH	0.00	43.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00116	-0.00121	0.21667	-0.00087	-0.00098	-0.00138	0.00568	-0.00076	-0.00005	-0.00058	-0.00066
616002 GRE-JOHNJCT7 115 652555 MORRIS 7 115 1	P23:230.0:UMZB:# 604 #: FB IN SD. BF 482 BIGSTON4 230 - BLAIR 4 230 1 BLAIR 8 69.0 - BLAIR 4 230 1 BLAIR 8 69.0 - NBCS111G 12.5 1	P2-3	G736, G736,	2018 SH	0.00	43.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00108	-0.00113	0.21694	-0.00075	-0.00076	-0.00122	0.00548	-0.00072	-0.00011	-0.00056	-0.00066
616002 GRE-JOHNJCT7 115 652555 MORRIS 7 115 1	620314 BIGSTON4 230 652503 BLAIR 4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P1	G736, G736,	2018 SH	0.00	43.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00108	-0.00113	0.21694	-0.00075	-0.00076	-0.00122	0.00548	-0.00072	-0.00011	-0.00056	-0.00066
616002 GRE-JOHNJCT7 115 652555 MORRIS 7 115 1	P23:230.0:UMZB:# 601 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - WATERTN4 230 1 BLAIR 4 230 - GRANITF4 230 1	P2-3	G736, G736,	2018 SH	0.00	43.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00116	-0.00121	0.21667	-0.00087	-0.00098	-0.00138	0.00568	-0.00076	-0.00005	-0.00058	-0.00066
620211 CANBY 7 115 652551 GRANITF7 115 1	P23:230.0:UMZB:# 599 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - GRANITF4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P2-3	G736,	2018 SH	0.00	37.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00388	-0.00411	0.18820	0.00231	-0.01733	-0.01386	0.01139	-0.00184	-0.00237	-0.00159	-0.00858
620211 CANBY 7 115 652551 GRANITF7 115 1	620314 BIGSTON4 230 652503 BLAIR 4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P1	G736,	2018 SH	0.00	37.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00368	-0.00388	0.18893	0.00264	-0.01674	-0.01343	0.01085	-0.00172	-0.00252	-0.00153	-0.00856
620211 CANBY 7 115 652551 GRANITF7 115 1	P23:230.0:UMZB:# 604 #: FB IN SD. BF 482 BIGSTON4 230 - BLAIR 4 230 1 BLAIR 8 69.0 - BLAIR 4 230 1 BLAIR 8 69.0 - NBCS111G 12.5 1	P2-3	G736,	2018 SH	0.00	37.79	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00368	-0.00388	0.18893	0.00264	-0.01674	-0.01343	0.01085	-0.00172	-0.00252	-0.00153	-0.00856
620211 CANBY 7 115 652551 GRANITF7 115 1	P23:230.0:UMZB:# 601 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - WATERTN4 230 1 BLAIR 4 230 - GRANITF4 230 1	P2-3	G736,	2018 SH	0.00	37.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00388	-0.00411	0.18820	0.00231	-0.01733	-0.01386	0.01139	-0.00184	-0.00237	-0.00159	-0.00858
620212 BURR 7 115 620213 MARIETT7 115 1	P23:230.0:UMZB:# 599 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - GRANITF4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P2-3	G736,	2018 SH	0.00	22.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00217	-0.00230	0.11341	0.00122	-0.00951	-0.00763	0.00649	-0.00104	-0.00129	-0.00090	-0.00472
620212 BURR 7 115 620213 MARIETT7 115 1	620314 BIGSTON4 230 652503 BLAIR 4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P1	G736,	2018 SH	0.00	22.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00206	-0.00217	0.11382	0.00140	-0.00917	-0.00739	0.00619	-0.00098	-0.00138	-0.00086	-0.00471
620212 BURR 7 115 620213 MARIETT7 115 1	P23:230.0:UMZB:# 604 #: FB IN SD. BF 482 BIGSTON4 230 - BLAIR 4 230 1 BLAIR 8 69.0 - BLAIR 4 230 1 BLAIR 8 69.0 - NBCS111G 12.5 1	P2-3	G736,	2018 SH	0.00	22.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00206	-0.00217	0.11382	0.00140	-0.00917	-0.00739	0.00619	-0.00098	-0.00138	-0.00086	-0.00471
620212 BURR 7 115 620213 MARIETT7 115 1	P23:230.0:UMZB:# 601 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - WATERTN4 230 1 BLAIR 4 230 - GRANITF4 230 1	P2-3	G736,	2018 SH	0.00	22.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00217	-0.00230	0.11341	0.00122	-0.00951	-0.00763	0.00649	-0.00104	-0.00129	-0.00090	-0.00472
620213 MARIETT7 115 620214 BIGSTON7 115 1	P23:230.0:UMZB:# 599 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - GRANITF4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P2-3	G736,	2018 SH	0.00	22.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00217	-0.00230	0.11341	0.00122	-0.00951	-0.00763	0.00649	-0.00104	-0.00129	-0.00090	-0.00472

Table J-1: Distribution Factor and MW Contribution on Constraints for Thermal NU Cost Allocation in 2018

Monitored Element	Contingency	Cont Type	Summary GIP With Impact	Comments	J299	G736	J385	J391	J400	J405	J407	J411	J416	J426	J299 ST	J299 CT	G736	J385	J391	J400	J405	J407	J411	J416	J426
					5+31.5	200	0	0	0	0	200	300	200	100	5	31.5	200	0	0	0	0	200	300	200	100
					10+63	40	100	50	62.5	40	40	60	40	20	10	63	40	100	50	62.5	40	40	60	40	20
620213 MARIETT7 115 620214 BIGSTON7 115 1	620314 BIGSTON4 230 652503 BLAIR 4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P1	G736,	2018 SH	0.00	22.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00206	-0.00217	0.11382	0.00140	-0.00917	-0.00739	0.00619	-0.00098	-0.00138	-0.00086	-0.00471
620213 MARIETT7 115 620214 BIGSTON7 115 1	P23:230.0:UMZB:# 604 #: FB IN SD. BF 482 BIGSTON4 230 - BLAIR 4 230 1 BLAIR 8 69.0 - BLAIR 4 230 1 BLAIR 8 69.0 - NBCS111G 12.5 1	P2-3	G736,	2018 SH	0.00	22.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00206	-0.00217	0.11382	0.00140	-0.00917	-0.00739	0.00619	-0.00098	-0.00138	-0.00086	-0.00471
620213 MARIETT7 115 620214 BIGSTON7 115 1	P23:230.0:UMZB:# 601 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - WATERTN4 230 1 BLAIR 4 230 - GRANITF4 230 1	P2-3	G736,	2018 SH	0.00	22.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00217	-0.00230	0.11341	0.00122	-0.00951	-0.00763	0.00649	-0.00104	-0.00129	-0.00090	-0.00472
620214 BIGSTON7 115 620215 HIWY12 7 115 1	P23:230.0:UMZB:# 599 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - GRANITF4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P2-3	G736, G736,	2018 SH	0.00	58.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00287	-0.00302	0.29145	0.00022	-0.00881	-0.00761	0.01057	-0.00156	-0.00113	-0.00127	-0.00453
620314 BIGSTON4 230 620214 BIGSTON7 115 620316 BIGSTON9 13.8 1	P23:230.0:UMZB:# 599 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - GRANITF4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P2-3	G736, G736,	2018 SH	0.00	80.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00504	-0.00532	0.40486	0.00144	-0.01832	-0.01524	0.01706	-0.00260	-0.00242	-0.00217	-0.00924
620314 BIGSTON4 230 620214 BIGSTON7 115 620316 BIGSTON9 13.8 1	620314 BIGSTON4 230 652503 BLAIR 4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P1	G736, G736,	2018 SH	0.00	81.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00476	-0.00501	0.40587	0.00190	-0.01751	-0.01465	0.01633	-0.00244	-0.00264	-0.00208	-0.00922
620314 BIGSTON4 230 620214 BIGSTON7 115 620316 BIGSTON9 13.8 1	P23:230.0:UMZB:# 604 #: FB IN SD. BF 482 BIGSTON4 230 - BLAIR 4 230 1 BLAIR 8 69.0 - BLAIR 4 230 1 BLAIR 8 69.0 - NBCS111G 12.5 1	P2-3	G736, G736,	2018 SH	0.00	81.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00476	-0.00501	0.40587	0.00190	-0.01751	-0.01465	0.01633	-0.00244	-0.00264	-0.00208	-0.00922
620314 BIGSTON4 230 620214 BIGSTON7 115 620316 BIGSTON9 13.8 1	P23:230.0:UMZB:# 601 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - WATERTN4 230 1 BLAIR 4 230 - GRANITF4 230 1	P2-3	G736, G736,	2018 SH	0.00	80.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00504	-0.00532	0.40486	0.00144	-0.01832	-0.01524	0.01706	-0.00260	-0.00242	-0.00217	-0.00924
620314 BIGSTON4 230 620325 BROWNSV4 230 1	P23:230.0:UMZB:# 604 #: FB IN SD. BF 482 BIGSTON4 230 - BLAIR 4 230 1 BLAIR 8 69.0 - BLAIR 4 230 1 BLAIR 8 69.0 - NBCS111G 12.5 1	P2-3	G736, G736,	2018 SH	0.00	118.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00476	0.00501	0.59413	-0.00190	0.01751	0.01465	-0.01633	0.00244	0.00264	0.00208	0.00922
620314 BIGSTON4 230 620325 BROWNSV4 230 1	620314 BIGSTON4 230 652503 BLAIR 4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P1	G736, G736,	2018 SH	0.00	118.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00476	0.00501	0.59413	-0.00190	0.01751	0.01465	-0.01633	0.00244	0.00264	0.00208	0.00922
620314 BIGSTON4 230 620325 BROWNSV4 230 1	P23:230.0:UMZB:# 599 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - GRANITF4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P2-3	G736, G736,	2018 SH	0.00	119.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00504	0.00532	0.59514	-0.00144	0.01832	0.01524	-0.01706	0.00260	0.00242	0.00217	0.00924
620314 BIGSTON4 230 620325 BROWNSV4 230 1	P23:230.0:UMZB:# 601 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - WATERTN4 230 1 BLAIR 4 230 - GRANITF4 230 1	P2-3	G736, G736,	2018 SH	0.00	119.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00504	0.00532	0.59514	-0.00144	0.01832	0.01524	-0.01706	0.00260	0.00242	0.00217	0.00924
629990 ELLENDALE5 69.0 630131 STELCTR8 69.0 1	P42:161:ITCM:COLBY5-NIW 5 9650:IA-MVP NIW 5 161 - COLBY5 161 1 LIME CK5 161 - COLBY5 161 1	P4-2	J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	9.36	0.00	0.00	0.00	-0.00391	-0.00546	-0.00359	-0.00518	-0.00322	-0.00325	-0.00301	0.04678	0.00018	0.00323	-0.00172
629990 ELLENDALE5 69.0 630131 STELCTR8 69.0 1	P42:161:ITCM:COLBY5-NIW 5 9530:IA-MVP NIW 5 161 - COLBY5 161 1 COLBY3 345 - COLBY5 161 1	P4-2	J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	9.32	0.00	0.00	0.00	-0.00394	-0.00550	-0.00361	-0.00522	-0.00324	-0.00327	-0.00303	0.04662	0.00022	0.00332	-0.00174
629990 ELLENDALE5 69.0 630131 STELCTR8 69.0 1	631036 NIW 5 161 631202 COLBY5 161 1 NIW 5 161 - COLBY5 161 1	P1	J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	9.31	0.00	0.00	0.00	-0.00397	-0.00552	-0.00363	-0.00524	-0.00326	-0.00329	-0.00304	0.04655	0.00020	0.00369	-0.00176
630116 PRAT T 8 69.0 630131 STELCTR8 69.0 1	P42:161:ITCM:COLBY5-NIW 5 9650:IA-MVP NIW 5 161 - COLBY5 161 1 LIME CK5 161 - COLBY5 161 1	P4-2	J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	9.36	0.00	0.00	0.00	-0.00391	-0.00546	-0.00359	-0.00518	-0.00322	-0.00325	-0.00301	0.04678	0.00018	0.00323	-0.00172
630116 PRAT T 8 69.0 630131 STELCTR8 69.0 1	P42:161:ITCM:COLBY5-NIW 5 9530:IA-MVP NIW 5 161 - COLBY5 161 1 COLBY3 345 - COLBY5 161 1	P4-2	J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	9.32	0.00	0.00	0.00	-0.00394	-0.00550	-0.00361	-0.00522	-0.00324	-0.00327	-0.00303	0.04662	0.00022	0.00332	-0.00174
630116 PRAT T 8 69.0 630131 STELCTR8 69.0 1	631036 NIW 5 161 631202 COLBY5 161 1 NIW 5 161 - COLBY5 161 1	P1	J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	9.31	0.00	0.00	0.00	-0.00397	-0.00552	-0.00363	-0.00524	-0.00326	-0.00329	-0.00304	0.04655	0.00020	0.00369	-0.00176
631036 NIW 5 161 631202 COLBY5 161 1	P22:161:ITCM:HAYWD#25 L2:MN HAYWD#25 161 - HAYWD#15 161 1 HAYWD#25 161 - GLENWRTH5 161 1 MURPHY CR 5 161 - HAYWD#25 161 1 HAYWD#28 69.0 - HAYWD#25 161 1	P2-2	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	152.54	0.00	0.00	0.00	0.01263	0.01416	0.00813	0.00904	0.00903	0.00908	0.00647	0.76268	-0.00154	-0.05023	0.00911
631036 NIW 5 161 631202 COLBY5 161 1	P13:161-69:ITCM:HAYWD#25 T2:MN HAYWD#25 161 - HAYWD#15 161 1 HAYWD#25 161 - GLENWRTH5 161 1 MURPHY CR 5 161 - HAYWD#25 161 1 HAYWD#28 69.0 - HAYWD#25 161 1	P1	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	152.54	0.00	0.00	0.00	0.01263	0.01416	0.00813	0.00904	0.00903	0.00908	0.00647	0.76268	-0.00154	-0.05023	0.00911

Table J-1: Distribution Factor and MW Contribution on Constraints for Thermal NU Cost Allocation in 2018

Monitored Element	Contingency	Cont Type	Summary GIP With Impact	Comments	J299 5+31.5 10+63	G736 200 40	J385 0 100	J391 0 50	J400 0 62.5	J405 0 40	J407 200 40	J411 300 60	J416 200 40	J426 100 20	J299 ST 5 10	J299 CT 31.5 63	G736 200 40	J385 0 100	J391 0 50	J400 0 62.5	J405 0 40	J407 200 40	J411 300 60	J416 200 40	J426 100 20
631036 NIW 5 161 631202 COLBY5 161 1	ITCM-B110-NW HAYWD#28 69.0 - HAYWD#25 161 1 HAYWD#25 161 - GLENWRTH5 161 1 MURPHY CR 5 161 - HAYWD#25 161 1	P1	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	152.54	0.00	0.00	0.00	0.01263	0.01416	0.00813	0.00904	0.00903	0.00908	0.00647	0.76268	-0.00154	-0.05023	0.00911
631036 NIW 5 161 631202 COLBY5 161 1	ITCM-C218-NW HAYWD#15 161 - FREEBORN5 161 1 HAYWD#18 69.0 - HAYWD#15 161 1 HAYWD#25 161 - HAYWD#15 161 1 ADAMS_S5 161 - HAYWD#15 161 1 HAYWD#25 161 - GLENWRTH5 161 1 MURPHY CR 5 161 - HAYWD#25 161 1 HAYWD#28 69.0 - HAYWD#25 161 1	P4	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	157.41	0.00	0.00	0.00	0.01191	0.01359	0.00759	0.00838	0.00842	0.00847	0.00602	0.78703	-0.00138	-0.04511	0.00843
631036 NIW 5 161 631202 COLBY5 161 1	631044 HAYWD#25 161 631174 GLENWRTH5 161 1 HAYWD#25 161 - GLENWRTH5 161 1	P1	J407, J407, J407-Outlet2	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	150.40	0.00	0.00	0.00	0.01175	0.01303	0.00806	0.00979	0.00868	0.00873	0.00637	0.75198	-0.00241	-0.05218	0.00826
631036 NIW 5 161 631202 COLBY5 161 1	631139 HAZLTON3 345 631144 MITCHLCO3 345 1 HAZLTON3 345 - MITCHLCO3 345 1	P1	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	76.23	0.00	0.00	0.00	0.04998	0.05315	0.03950	0.04861	0.04092	0.04112	0.03290	0.38113	-0.00099	-0.14660	0.03755
631036 NIW 5 161 631202 COLBY5 161 1	ITCM-C939-LN HAZLTON3 345 - MITCHLCO3 345 1 SALEM 3 345 - ROCK CK3 345 1	P6	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	75.87	0.00	0.00	0.00	0.04891	0.05207	0.03852	0.04769	0.03990	0.04010	0.03197	0.37935	-0.00208	-0.14942	0.03651
631036 NIW 5 161 631202 COLBY5 161 1	P24:161:ITCM:LIME CK5 043:IA-NW LIME CK5 161 - EMERY 5 161 2 LIME CK5 161 - BARTON5 161 1 LIME CK5 161 - COLBY5 161 1 LIME CK5 161 - CLKREACT5 161 1 LMCK W 8 69.0 - LIME CK5 161 1 LMCK E 8 69.0 - LIME CK5 161 1	P2-4	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	70.30	0.00	0.00	0.00	0.03802	0.04104	0.02876	0.03636	0.02996	0.03012	0.02345	0.35148	-0.00614	-0.16807	0.02742
631036 NIW 5 161 631202 COLBY5 161 1	P55:345:ITCM:MITCHLCO3 N9-N10:IA MITCHLCO3 345 - G172_G1 34.5 1 MITCHLCO3 345 - G172_G2 34.5 1 ADAMS 3 345 - MITCHLCO3 345 1 HAZLTON3 345 - MITCHLCO3 345 1	P5-5	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	76.34	0.00	0.00	0.00	0.05052	0.05369	0.04004	0.04915	0.04146	0.04166	0.03344	0.38168	-0.00045	-0.14606	0.03809
631036 NIW 5 161 631202 COLBY5 161 1	P23:345:ITCM:HAZLTON3 9985:IA-NE HAZLTON3 345 - HCKRYCK3 345 1 HAZLTON3 345 - MITCHLCO3 345 1	P2-3	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	75.20	0.00	0.00	0.00	0.04783	0.05097	0.03764	0.04685	0.03895	0.03915	0.03118	0.37598	-0.00292	-0.15689	0.03552
631036 NIW 5 161 631202 COLBY5 161 1	P22:161:ITCM:LIME CK5 L1:IA-NW LMCK W 8 69.0 - LIME CK5 161 1 LIME CK5 161 - COLBY5 161 1 LIME CK5 161 - CLKREACT5 161 1	P2-2	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	70.35	0.00	0.00	0.00	0.03499	0.03789	0.02573	0.03118	0.02721	0.02735	0.02108	0.35177	-0.00366	-0.14892	0.02571
631036 NIW 5 161 631202 COLBY5 161 1	P13:161-69:ITCM:LIME CK5 T1:IA-NW LMCK W 8 69.0 - LIME CK5 161 1 LIME CK5 161 - COLBY5 161 1 LIME CK5 161 - CLKREACT5 161 1 CRYSTLK5 161 - CLKREACT5 161 1 G735_WF5 34.5 - CRYSTLKII5 161 1 CRYSTLK5 161 - CRYSTLKII5 161 1 G595_WF9 34.5 - CRYSTLK5 161 1	P1	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	70.35	0.00	0.00	0.00	0.03499	0.03789	0.02573	0.03118	0.02721	0.02735	0.02108	0.35177	-0.00366	-0.14892	0.02571
631036 NIW 5 161 631202 COLBY5 161 1	631155 CRYSTLK5 161 631220 CLKREACT5 161 1 CRYSTLK5 161 - CLKREACT5 161 1	P1	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	73.36	0.00	0.00	0.00	0.03479	0.03772	0.02540	0.03027	0.02697	0.02711	0.02090	0.36678	-0.00284	-0.13574	0.02576
631036 NIW 5 161 631202 COLBY5 161 1	631047 LIME CK5 161 631220 CLKREACT5 161 1 LIME CK5 161 - CLKREACT5 161 1	P1	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	73.36	0.00	0.00	0.00	0.03479	0.03772	0.02540	0.03027	0.02697	0.02711	0.02090	0.36678	-0.00284	-0.13574	0.02576
631036 NIW 5 161 631202 COLBY5 161 1	P23:345:GRE:PVS 19JB3 ADAMS 3 345 - GRE-PL VLLY3 345 1 ADAMS 3 345 - ADAMS 5 161 - ADAMS1 9 13.8 9 GRE-PL VLLY3 345 - GRE-PL VLLY5 161 - GRE-PL VLL1T13.8 1	P2-3	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	77.17	0.00	0.00	0.00	0.04931	0.05255	0.03869	0.04726	0.04020	0.04039	0.03229	0.38587	-0.00044	-0.14380	0.03718
631036 NIW 5 161 631202 COLBY5 161 1	P23:345:GRE:PVS 19JB2 GRE-PL VLLY3 345 - GRE-PL VLLY5 161 - GRE-PL VLL2T13.8 2 ADAMS 3 345 - GRE-PL VLLY3 345 1 ADAMS 3 345 - ADAMS 5 161 - ADAMS1 9 13.8 9	P2-3	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	77.19	0.00	0.00	0.00	0.04929	0.05254	0.03867	0.04724	0.04018	0.04037	0.03227	0.38594	-0.00044	-0.14377	0.03717
631036 NIW 5 161 631202 COLBY5 161 1	P22:345:XEL:ADAMS 3 N1:MN ADAMS 3 345 - GRE-PL VLLY3 345 1 ADAMS 5 161 - ADAMS_N5 161 1 ADAMS 5 161 - ADAMS_S5 161 1 ADAMS 3 345 - ADAMS 5 161 - ADAMS1 9 13.8 9 REMOVE SWSHUNT FROM BUS 601002	P2-2	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	76.89	0.00	0.00	0.00	0.04961	0.05281	0.03905	0.04778	0.04053	0.04073	0.03260	0.38447	-0.00044	-0.14437	0.03741
631036 NIW 5 161 631202 COLBY5 161 1	B2.ADM-PVS AS ADAMS 3 345 - ADAMS 5 161 - ADAMS1 9 13.8 9 ADAMS 3 345 - GRE-PL VLLY3 345 1	P1	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	76.89	0.00	0.00	0.00	0.04960	0.05281	0.03905	0.04777	0.04053	0.04072	0.03260	0.38447	-0.00044	-0.14436	0.03741

Table J-1: Distribution Factor and MW Contribution on Constraints for Thermal NU Cost Allocation in 2018

Monitored Element	Contingency	Cont Type	Summary GIP With Impact	Comments	J299	G736	J385	J391	J400	J405	J407	J411	J416	J426	J299 ST	J299 CT	G736	J385	J391	J400	J405	J407	J411	J416	J426
					5+31.5	200	0	0	0	0	200	300	200	100	5	31.5	200	0	0	0	0	200	300	200	100
					10+63	40	100	50	62.5	40	40	60	40	20	10	63	40	100	50	62.5	40	40	60	40	20
631036 NIW 5 161 631202 COLBY5 161 1	P12:345:XEL-ITC:AMD-PVS-MTC AS ADAMS 3 345 - GRE-PL VLLY3 345 1 ADAMS 3 345 - MITCHLCO3 345 1 ADAMS 3 345 - ADAMS 5 161 - ADAMS1 9 13.8 9	P1	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	76.89	0.00	0.00	0.00	0.04960	0.05281	0.03905	0.04777	0.04053	0.04072	0.03260	0.38447	-0.00044	-0.14436	0.03741
631036 NIW 5 161 631202 COLBY5 161 1	GENS: EMERYST1 + G735_WF5 REMOVE UNIT 1 FROM BUS EMERYST1 18.0 REMOVE UNIT 1 FROM BUS G735_WF5 34.5	P3	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	73.36	0.00	0.00	0.00	0.03479	0.03772	0.02540	0.03027	0.02697	0.02711	0.02090	0.36678	-0.00284	-0.13574	0.02576
631036 NIW 5 161 631202 COLBY5 161 1	GENS: ARNOLD1G + G735_WF5 REMOVE UNIT 1 FROM BUS ARNOLD1G 22.0 REMOVE UNIT 1 FROM BUS G735_WF5 34.5	P3	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	73.36	0.00	0.00	0.00	0.03479	0.03772	0.02540	0.03027	0.02697	0.02711	0.02090	0.36678	-0.00284	-0.13574	0.02576
631036 NIW 5 161 631202 COLBY5 161 1	GENS: OTTUMW1G + G735_WF5 REMOVE UNIT 1 FROM BUS OTTUMW1G 24.0 REMOVE UNIT 1 FROM BUS G735_WF5 34.5	P3	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	73.36	0.00	0.00	0.00	0.03479	0.03772	0.02540	0.03027	0.02697	0.02711	0.02090	0.36678	-0.00284	-0.13574	0.02576
631036 NIW 5 161 631202 COLBY5 161 1	GENS: LOUIS31G + G735_WF5 REMOVE UNIT 1 FROM BUS LOUIS31G 24.0 REMOVE UNIT 1 FROM BUS G735_WF5 34.5	P3	J407, J407,	2018 SH	0.00	0.00	0.00	0.00	0.00	0.00	73.36	0.00	0.00	0.00	0.03479	0.03772	0.02540	0.03027	0.02697	0.02711	0.02090	0.36678	-0.00284	-0.13574	0.02576
603002 WILMART7 115 603003 SWAN LK7 115 1	601050 HELENA 3 345 601072 SHEAS LK3 345 1 HELENA 3 345 - SHEAS LK3 345 1	P1	J299-Outlet1	2018 SPK	7.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08342	0.10663	-0.02366	-0.01867	-0.02257	-0.02265	-0.01239	0.00788	0.01358	0.00422	0.00213
603002 WILMART7 115 603003 SWAN LK7 115 1	P23:345:XEL:8S72 HNA HELENA 3 345 - GRE-CHUBLAK3 345 1 HELENA 3 345 - SHEAS LK3 345 1	P2-3	J299-Outlet1	2018 SPK	7.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08280	0.10605	-0.02508	-0.01867	-0.02473	-0.02490	-0.01334	0.00833	0.01309	0.00455	0.00060
603002 WILMART7 115 603003 SWAN LK7 115 1	P23:345:XEL:8S82 SSL SHEAS LK3 345 - SHEAS LK 7 115 - SHEAS LK9 34.5 9 SHEAS LK 7 115 - SHEAS LK8 69.0 5 WILMART3 345 - SHEAS LK3 345 1 HELENA 3 345 - SHEAS LK3 345 1	P2-3	J299-Outlet1	2018 SPK	7.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08325	0.10704	-0.02365	-0.01864	-0.02257	-0.02265	-0.01239	0.00789	0.01355	0.00423	0.00211
603002 WILMART7 115 603003 SWAN LK7 115 1	P23:345:XEL:8S81 SSL SHEAS LK3 345 - SHEAS LK 7 115 - SHEAS LK9 34.5 9 WILMART3 345 - SHEAS LK3 345 1 HELENA 3 345 - SHEAS LK3 345 1	P2-3	J299-Outlet1	2018 SPK	7.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08325	0.10704	-0.02365	-0.01864	-0.02257	-0.02265	-0.01239	0.00789	0.01355	0.00423	0.00211
616002 GRE-JOHNJCT7 115 620216 ORTONVL7 115 1	P23:230.0:UMZB:# 599 #: FB IN SD. NON-BUS-TIE BLAIR 4 230 - GRANITF4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P2-3	G736,	2018 SPK	0.00	8.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00098	-0.00103	0.21685	-0.00069	-0.00080	-0.00120	0.00586	-0.00058	0.00013	-0.00040	-0.00048
616002 GRE-JOHNJCT7 115 620216 ORTONVL7 115 1	620314 BIGSTON4 230 652503 BLAIR 4 230 1 BIGSTON4 230 - BLAIR 4 230 1	P1	G736,	2018 SPK	0.00	8.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00091	-0.00095	0.21712	-0.00057	-0.00059	-0.00104	0.00566	-0.00054	0.00007	-0.00038	-0.00048
616002 GRE-JOHNJCT7 115 620216 ORTONVL7 115 1	P23:230.0:UMZB:# 604 #: FB IN SD. BF 482 BIGSTON4 230 - BLAIR 4 230 1 BLAIR 8 69.0 - BLAIR 4 230 1 BLAIR 8 69.0 - NBCS111G 12.5 1	P2-3	G736,	2018 SPK	0.00	8.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.00091	-0.00095	0.21712	-0.00057	-0.00059	-0.00104	0.00566	-0.00054	0.00007	-0.00038	-0.00048
631079 BNE JCT5 161 636020 FT.DODG5 161 1	P61:345-161:MEC-ITCM:GRIMES-LEHIGH + STORY CO-FERN GRIMES 3 345 - LEHIGH 3 345 1 STRY_CO5 161 - FERNALD5 161 1	P6-1	J411,	2018 SH LPC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.33	0.00	0.00	0.02064	0.02036	0.01576	0.01298	0.01798	0.01800	0.01363	0.01669	0.04775	0.01354	0.02068
631079 BNE JCT5 161 636020 FT.DODG5 161 1	P23:345:MEC:GRIMES 904 FALLOW 3 345 - GRIMES 3 345 1 GRIMES 3 345 - LEHIGH 3 345 1 REMOVE SWSHUNT FROM BUS 636010	P2-3	J411,	2018 SH LPC	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.50	0.00	0.00	0.02207	0.02173	0.01738	0.01352	0.01968	0.01969	0.01559	0.01571	0.05166	0.01108	0.02278

Table J-2: Distribution Factor and MW Contribution on Constraints for Voltage Support NU Cost Allocation in 2018

Monitored Element	Location	Contingency	Type	Mitigation	Comments	J299	G736	J385	J391	J400	J405	J407	J411	J416	J426		J299 ST	J299 CT	G736	J385	J391	J400	J405	J407	J411	J416	J426
						5+31.5	200	0	0	0	0	200	300	200	100		5	31.5	200	0	0	0	0	200	300	200	100
						10+63	40	100	50	62.5	40	40	60	40	20		10	63	40	100	50	62.5	40	40	60	40	20
None																											

J.2 Cost Allocation Details

Table J-3: Network Upgrades Cost Allocation in 2018

Table J-3: Network Upgrades Cost Allocation in 2018

Monitored Element	English Name	Cost	J299	G736	J385	J391	J400	J405	J407	J411	J416	J426
613210 OWATANA1 69.0 630116 PRAT T 8 69.0 1	West Owatonna-Pratt Tap 69 kV	$3,000,000	$0	$0	$0	$0	$0	$0	$3,000,000	$0	$0	$0
616002 GRE-JOHNJCT7 115 620216 ORTONVL7 115 1	Johnson Jct-Ortonville 115 kV	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
616002 GRE-JOHNJCT7 115 652555 MORRIS 7 115 1	Johnson Jct-Morris 115 kV	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
620211 CANBY 7 115 652551 GRANITF7 115 1	Canby-Granite Falls 115 kV	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
620212 BURR 7 115 620213 MARIETT7 115 1	Burr-Marietta 115 kV	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
620213 MARIETT7 115 620214 BIGSTON7 115 1	Bigstone-Marietta 115 kV	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
620214 BIGSTON7 115 620215 HIWY12 7 115 1	Bigstone-Highway12 115 kV	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
620314 BIGSTON4 230 620214 BIGSTON7 115 620316 BIGSTON9 13.8 1	Bigstone 230-115-13.8 kV xfmr	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
620314 BIGSTON4 230 620325 BROWNSV4 230 1	Bigstone-Brownsville 230 kV	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
629990 ELLENDALE5 69.0 630131 STELCTR8 69.0 1	Ellendale-Steel Center 69kV	$1,400,000	$0	$0	$0	$0	$0	$0	$1,400,000	$0	$0	$0
630116 PRAT T 8 69.0 630131 STELCTR8 69.0 1	Pratt Tap-Steel Center 69 kV	$4,900,000	$0	$0	$0	$0	$0	$0	$4,900,000	$0	$0	$0
631036 NIW 5 161 631202 COLBY5 161 1	NIW-Colby 161 kV	$8,250,000	$0	$0	$0	$0	$0	$0	$8,250,000	$0	$0	$0
603002 WILMART7 115 603003 SWAN LK7 115 1	Wilmarth-Swan Lake 115 kV	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
631079 BNE JCT5 161 636020 FT.DODG5 161 1	Boone Jct-Fort Dodge 161 kV	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Cost Per Project for Actual NRIS Elections for each Project		**$17,550,000**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$17,550,000**	**$0**	**$0**	**$0**

Appendix
K

2025 Cost Allocation Results

K.1 Distribution Factor (DF) and MW Contribution Results for Cost Allocation in 2025

Table K-1: Distribution Factor and MW Contribution on Constraints for Thermal NU Cost Allocation in 2025

Table K-2: Distribution Factor and MW Contribution on Constraints for Voltage Support NU Cost Allocation in 2025

Table K-1: Distribution Factor and MW Contribution on Constraints for Thermal NU Cost Allocation in 2025

Monitored Element	Contingency	Cont Type	Summary GIP With Impact	Comments	J299 5+31.5 10+63	G736 200 40	J385 0 100	J391 0 50	J400 0 62.5	J405 0 40	J407 200 40	J411 300 60	J416 200 40	J426 100 20	J299 ST 5 10	J299 CT 31.5 63	G736 200 40	J385 0 100	J391 0 50	J400 0 62.5	J405 0 40	J407 200 40	J411 300 60	J416 200 40	J426 100 20
631036 NIW 5 161 631202 COLBY5 161 1	P22:161:ITCM:HAYWD#25 L2:MN HAYWD#25 161 - HAYWD#15 161 1 HAYWD#25 161 - GLENWRTH5 161 1 MURPHY CR 5 161 - HAYWD#25 161 1 HAYWD#28 69.0 - HAYWD#25 161 1	P2-2	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	156.31	0.00	0.00	0.00	0.00453	0.00594	0.00287	0.00609	0.00317	0.00323	0.00204	0.78155	-0.00527	-0.02700	0.00162
631036 NIW 5 161 631202 COLBY5 161 1	ITCM-B110-NW HAYWD#28 69.0 - HAYWD#25 161 1 HAYWD#25 161 - GLENWRTH5 161 1 MURPHY CR 5 161 - HAYWD#25 161 1	P1	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	156.31	0.00	0.00	0.00	0.00453	0.00594	0.00287	0.00609	0.00317	0.00323	0.00204	0.78155	-0.00527	-0.02700	0.00162
631036 NIW 5 161 631202 COLBY5 161 1	J407-Outlet2 GLENWRTH5 161 - HAYWD#25 161 1	P1	J407, J407, J407-Outlet2	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	154.24	0.00	0.00	0.00	0.00393	0.00511	0.00277	0.00691	0.00299	0.00305	0.00197	0.77118	-0.00630	-0.02869	0.00099
631036 NIW 5 161 631202 COLBY5 161 1	ITCM-C218-NW HAYWD#15 161 - FREEBORN5 161 1 HAYWD#18 69.0 - HAYWD#15 161 1 HAYWD#25 161 - HAYWD#15 161 1 ADAMS_S5 161 - HAYWD#15 161 1 HAYWD#25 161 - GLENWRTH5 161 1 MURPHY CR 5 161 - HAYWD#25 161 1 HAYWD#28 69.0 - HAYWD#25 161 1	P4	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	160.91	0.00	0.00	0.00	0.00435	0.00585	0.00274	0.00589	0.00301	0.00307	0.00195	0.80453	-0.00502	-0.02429	0.00141
631036 NIW 5 161 631202 COLBY5 161 1	631139 HAZLTON3 345 631144 MITCHLCO3 345 1 HAZLTON3 345 - MITCHLCO3 345 1	P1	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	80.43	0.00	0.00	0.00	0.02580	0.02875	0.02205	0.03797	0.02295	0.02318	0.01862	0.40215	-0.01177	-0.08144	0.01538
631036 NIW 5 161 631202 COLBY5 161 1	ITCM-C939-LN HAZLTON3 345 - MITCHLCO3 345 1 SALEM 3 345 - ROCK CK3 345 1	P3	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	80.35	0.00	0.00	0.00	0.02549	0.02845	0.02177	0.03768	0.02267	0.02290	0.01836	0.40176	-0.01202	-0.08196	0.01510
631036 NIW 5 161 631202 COLBY5 161 1	P23:345:ITCM:HAZLTON3 9985:IA-NE HAZLTON3 345 - HCKRYCK3 345 1 HAZLTON3 345 - MITCHLCO3 345 1	P2-3	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	79.76	0.00	0.00	0.00	0.02388	0.02682	0.02043	0.03688	0.02125	0.02148	0.01713	0.39878	-0.01394	-0.08830	0.01347
631036 NIW 5 161 631202 COLBY5 161 1	P55:345:ITCM:MITCHLCO3 N9-N10:IA MITCHLCO3 345 - G172_G1 34.5 1 MITCHLCO3 345 - G172_G2 34.5 1 ADAMS 3 345 - MITCHLCO3 345 1 HAZLTON3 345 - MITCHLCO3 345 1	P5-5	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	80.51	0.00	0.00	0.00	0.02621	0.02917	0.02247	0.03838	0.02337	0.02360	0.01904	0.40257	-0.01135	-0.08103	0.01580
631036 NIW 5 161 631202 COLBY5 161 1	P23:345:GRE:PVS 19JB3 ADAMS 3 345 - GRE-PL VLLY3 345 1 ADAMS 3 345 - ADAMS 5 161 - ADAMS1 9 13.8 9 GRE-PL VLLY3 345 - GRE-PL VLLY5 161 - GRE-PL VLL1T13.8 1	P2-3	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	81.71	0.00	0.00	0.00	0.02461	0.02767	0.02073	0.03553	0.02161	0.02183	0.01749	0.40853	-0.01108	-0.07879	0.01467
631036 NIW 5 161 631202 COLBY5 161 1	B2.ADM-PVS AS ADAMS 3 345 - ADAMS 5 161 - ADAMS1 9 13.8 9 ADAMS 3 345 - GRE-PL VLLY3 345 1	P1	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	81.40	0.00	0.00	0.00	0.02490	0.02792	0.02107	0.03610	0.02196	0.02218	0.01780	0.40700	-0.01112	-0.07920	0.01489
631036 NIW 5 161 631202 COLBY5 161 1	P22:345:XEL:ADAMS 3 N1:MN ADAMS 3 345 - GRE-PL VLLY3 345 1 ADAMS 5 161 - ADAMS_N5 161 1 ADAMS 5 161 - ADAMS_S5 161 1 ADAMS 3 345 - ADAMS 5 161 - ADAMS1 9 13.8 9 REMOVE SWSHUNT FROM BUS 601002	P2-2	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	81.40	0.00	0.00	0.00	0.02490	0.02792	0.02107	0.03610	0.02196	0.02218	0.01780	0.40700	-0.01112	-0.07920	0.01489
631036 NIW 5 161 631202 COLBY5 161 1	P23:345:XEL-ITC:8S2 ADM AS ADAMS 3 345 - GRE-PL VLLY3 345 1 ADAMS 3 345 - MITCHLCO3 345 1 ADAMS 3 345 - ADAMS 5 161 - ADAMS1 9 13.8 9	P2-3	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	81.40	0.00	0.00	0.00	0.02490	0.02792	0.02107	0.03610	0.02196	0.02218	0.01780	0.40700	-0.01112	-0.07920	0.01489
631036 NIW 5 161 631202 COLBY5 161 1	P24:161:ITCM:LIME CK5 043:IA-NW LIME CK5 161 - EMERY 5 161 2 LIME CK5 161 - BARTON5 161 1 LIME CK5 161 - COLBY5 161 1 LIME CK5 161 - CLKREACT5 161 1 LMCK W 8 69.0 - LIME CK5 161 1 LMCK E 8 69.0 - LIME CK5 161 1	P2-4	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	76.03	0.00	0.00	0.00	0.01439	0.01728	0.01225	0.02804	0.01269	0.01290	0.00983	0.38017	-0.01916	-0.09366	0.00516
631036 NIW 5 161 631202 COLBY5 161 1	601002 ADAMS 3 345 631144 MITCHLCO3 345 1 ADAMS 3 345 - MITCHLCO3 345 1	P1	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	80.51	0.00	0.00	0.00	0.02621	0.02917	0.02247	0.03838	0.02337	0.02360	0.01904	0.40257	-0.01135	-0.08103	0.01580
631036 NIW 5 161 631202 COLBY5 161 1	P23:161:SMP:MURPHY CR 5-HAYWD#25 BKR66QB1 MURPHY CR 5 161 - HAYWD#25 161 1 MURPHY CR 8 69.0 - MURPHY CR 5 161 1	P2-3	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	92.87	0.00	0.00	0.00	0.01585	0.01931	0.01099	0.01771	0.01193	0.01206	0.00880	0.46436	-0.00845	-0.06540	0.00885
631036 NIW 5 161 631202 COLBY5 161 1	P23:161:SMP:MURPHY CR 5-HAYWAD#25 BKR66QB2 MURPHY CR 5 161 - HAYWD#25 161 1 AUSTIN 5 161 - MURPHY CR 5 161 1 AUSTIN NE8 69.0 - AUSTIN 5 161 1	P2-3	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	92.87	0.00	0.00	0.00	0.01585	0.01931	0.01099	0.01771	0.01193	0.01206	0.00880	0.46436	-0.00845	-0.06540	0.00885
631036 NIW 5 161 631202 COLBY5 161 1	613042 MURPHY CR 5 161 631044 HAYWD#25 161 1 MURPHY CR 5 161 - HAYWD#25 161 1	P1	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	92.87	0.00	0.00	0.00	0.01585	0.01931	0.01099	0.01771	0.01193	0.01206	0.00880	0.46436	-0.00845	-0.06540	0.00885

Table K-1: Distribution Factor and MW Contribution on Constraints for Thermal NU Cost Allocation in 2025

Monitored Element	Contingency	Cont Type	Summary GIP With Impact	Comments	J299	G736	J385	J391	J400	J405	J407	J411	J416	J426	J299 ST	J299 CT	G736	J385	J391	J400	J405	J407	J411	J416	J426
					5+31.5	200	0	0	0	0	200	300	200	100	5	31.5	200	0	0	0	0	200	300	200	100
					10+63	40	100	50	62.5	40	40	60	40	20	10	63	40	100	50	62.5	40	40	60	40	20
631036 NIW 5 161 631202 COLBY5 161 1	P23:161:SMP:MURPHY CR 5-AUSTIN 5 BKR66QB3 AUSTIN 5 161 - MURPHY CR 5 161 1 AUSTIN NE8 69.0 - AUSTIN 5 161 1 MURPHY CR 8 69.0 - MURPHY CR 5 161 1	P2-3	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	92.87	0.00	0.00	0.00	0.01585	0.01931	0.01099	0.01771	0.01193	0.01206	0.00880	0.46436	-0.00845	-0.06540	0.00885
631036 NIW 5 161 631202 COLBY5 161 1	ITCM-C310-NW LMCK W 8 69.0 - LIME CK5 161 1 LIME CK5 161 - COLBY5 161 1 LIME CK5 161 - CLKREACT5 161 1	P4	J407, J407,	2025 SH	0.00	0.00	0.00	0.00	0.00	0.00	75.62	0.00	0.00	0.00	0.01343	0.01623	0.01106	0.02421	0.01154	0.01172	0.00886	0.37812	-0.01608	-0.08324	0.00524
631100 LIBERTY5 161 631159 HCKRYCK5 161 1	631139 HAZLTON3 345 631191 HCKRYCK3 345 1 HAZLTON3 345 - HCKRYCK3 345 1	P1	J407, J416,	2025 SH LPC	0.00	0.00	0.00	0.00	0.00	0.00	8.16	0.00	11.14	0.00	0.02566	0.02599	0.02196	0.02259	0.02302	0.02308	0.01955	0.04080	0.01773	0.05569	0.02294

Table K-2: Distribution Factor and MW Contribution on Constraints for Voltage Support NU Cost Allocation in 2025

Monitored Element	Location	Contingency	Type	Mitigation	Comments	J299	G736	J385	J391	J400	J405	J407	J411	J416	J426	J299 ST	J299 CT	G736	J385	J391	J400	J405	J407	J411	J416	J426
						5+31.5	200	0	0	0	0	200	300	200	100	5	31.5	200	0	0	0	0	200	300	200	100
						10+63	40	100	50	62.5	40	40	60	40	20	10	63	40	100	50	62.5	40	40	60	40	20
None																										

K.2 Cost Allocation Details

Table K-3: Network Upgrades Cost Allocation in 2025

Table K-3: Network Upgrades Cost Allocation in 2025

Monitored Element	English Name	Cost	J299	G736	J385	J391	J400	J405	J407	J411	J416	J426
631036 NIW 5 161 631202 COLBY5 161 1	NIW-Colby 161 kV	$8,250,000	$0	$0	$0	$0	$0	$0	$8,250,000	$0	$0	$0
631100 LIBERTY5 161 631159 HCKRYCK5 161 1	Liberty-Hickory Creek 161 kV	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Cost Per Project for Actual NRIS Elections for each Project		**$8,250,000**	**$0**	**$0**	**$0**	**$0**	**$0**	**$0**	**$8,250,000**	**$0**	**$0**	**$0**

Appendix L

Results for 2018 Scenario

L.1 Results Summary for 2018 Scenario

L.1.1 Total Network Upgrades for all Projects in 2018 Scenario

The total cost of network upgrades in the interconnection plan required for each generation project is listed in Table L-1 for 2018 scenario.

Table L-1: Total Cost of Network Upgrades for Generation Projects in 2018 Scenario

Project Num	ERIS Network Upgrades ($)			NRIS Network Upgrades ($)	Interconnection Facilities ($)		Shared Network Upgrade	Total Cost ($)
	Steady-State & Voltage Stability	Transient Stability	Short-circuit	Deliverability	TO Network Upgrades	TO - Owned Direct assigned		
G736	$0	$0	$0	$0	$1,854,806	$351,391	$0	$2,206,197
J299	$0	$0	$0	$0	$0	$0	$0	$0
J385	$0	$0	$0	$0	$2,238,000	$260,000	$0	$2,498,000
J391	$0	$0	$0	$0	$17,000	$459,000	$0	$476,000
J400	$0	$0	$0	$0	$1,010,000	$261,000	$0	$1,271,000
J405	$0	$0	$0	$0	$0	$614,540	$0	$614,540
J407	$17,550,000	$0	$0	$0	$477,461	$387,904	$0	$18,415,365
J411	$0	$0	$0	$0	$9,162,000	$860,000	$0	$10,022,000
J416	$0	$0	$0	$0	$10,119,531	$15,393,953	$0	$25,513,484
J426	$0	$0	$0	$0	$3,413,000	$1,816,000	$0	$5,229,000
Total ($)	**$17,550,000**	**$0**	**$0**	**$0**	**$28,291,798**	**$20,403,788**	**$0**	**$66,245,586**

L.1.2 Per Project Summary for 2018 Scenario

This Section provides estimated cost of Network Upgrades on a per project basis for the 2018 scenario. The shared cost of Network Upgrades for all generation projects are listed below:

G736 Summary

Network Upgrade	Cost	G736
Not Required	$0	$0
Total Cost Per Project for Actual NRIS Elections for each Project		**$0**

J299 Summary

Network Upgrade	Total Cost	J299
Not Required	$0	$0
Total Cost Per Project for Actual NRIS Elections for each Project		**$0**

J385 Summary

Network Upgrade	Total Cost	J385
Not Required	$0	$0
Total Cost Per Project for Actual NRIS Elections for each Project		**$0**

J391 Summary

Network Upgrade	Total Cost	J391
Not Required	$0	$0
Total Cost Per Project for Actual NRIS Elections for each Project		**$0**

J400 Summary

Network Upgrade	Cost	J400
Not Required	$0	$0
Total Cost Per Project for Actual NRIS Elections for each Project		**$0**

J405 Summary

Network Upgrade	Cost	J405
Not Required	$0	$0
Total Cost Per Project for Actual NRIS Elections for each Project		**$0**

J407 Summary

Network Upgrade	Cost	J407
613210 OWATANA1 69.0 630116 PRAT T 8 69.0 1	$3,000,000	$3,000,000

Network Upgrade	Cost	J407
629990 ELLENDALE5 69.0 630131 STELCTR8 69.0 1	$1,400,000	$1,400,000
630116 PRAT T 8 69.0 630131 STELCTR8 69.0 1	$4,900,000	$4,900,000
631036 NIW 5 161 631202 COLBY5 161 1	$8,250,000	$8,250,000
Total Cost Per Project for Actual NRIS Elections for each Project		**$17,550,000**

J411 Summary

Network Upgrade	Cost	J411
Not Required	$0	$0
Total Cost Per Project for Actual NRIS Elections for each Project		**$0**

J416 Summary

Network Upgrade	Cost	J416
Not Required	$0	$0
Total Cost Per Project for Actual NRIS Elections for each Project		**$0**

J426 Summary

Network Upgrade	Cost	J426
Not Required	$0	$0
Total Cost Per Project for Actual NRIS Elections for each Project		**$0**

L.1.3 Cost Allocation for 2018 Scenario

Assuming all generating facilities in the DPP 2015 February West Area group advance, the cost allocation of each NU identified in the study is listed in Appendix J.2. A summary of the costs for total NUs (NUs for ERIS, NRIS, and Interconnection Facilities) allocated to each generating facility is listed in Table L-2 for 2018 scenario.

Table L-2: Summary of Total NU Costs Allocated to Each Generation Project for 2018 Scenario

Project	Max Output (MW)	Total Cost of NU per Project ($)	$/MW	Share %
G736	200	$2,206,197	$11,031	3.33%
J299	73	$0	$0	0.00%
J385	100	$2,498,000	$24,980	3.77%
J391	50	$476,000	$9,520	0.72%
J400	62.5	$1,271,000	$20,336	1.92%
J405	40	$614,540	$15,364	0.93%

Project	Max Output (MW)	Total Cost of NU per Project ($)	$/MW	Share %
J407	200	$18,415,365	$92,077	27.80%
J411	300	$10,022,000	$33,407	15.13%
J416	200	$25,513,484	$127,567	38.51%
J426	100	$5,229,000	$52,290	7.89%
Total/Average	**1325.5**	**$66,245,586**	**$38,657**	**100.00%**

L.2 Reactive Power Requirement Analysis for 2018 Scenario

Appendix C.1 lists reactive power requirement analysis results in the 2018 scenario. The results are summarized as following:

- Low voltage violations were observed in the area of J411. Project J411 is required to have ±0.95 power factor to meet FERC Order 661-A.
- No specific reactive power range is required for renewable generation projects G736, J385, J400, J407, J416, or J426 to meet FERC Order 661-A.

L.3 Steady-State Analysis for 2018 Scenario

The incremental impact of the proposed interconnection on individual facilities was evaluated by comparing flows and voltages between benchmark cases (without DPP West Area projects) and study cases (with DPP West Area projects). Analysis was performed in the 2018 summer shoulder (SH) and summer peak (SPK) scenarios using PSS®E and PSS®MUST.

L.3.1 2018 Summer Shoulder Contingency Analysis Results

System Intact Conditions

No thermal or voltage constraints were identified for NERC category P0 (system intact) conditions (Table D-1, Table D-2).

Post Contingency Conditions

The results in this Section are for analysis of conditions following NERC Category P1-P7 contingencies. All category P1 contingencies were converged.

Six category P2-P7 contingencies (Table D-5) were not converged. They were not converged in the benchmark or study cases. No mitigation plan is required for the study projects for these contingencies.

For contingencies in the 2018 summer shoulder scenario, thermal constraints are listed in Table D-3. No voltage constraints were identified (Table D-4).

Worst Thermal Violations

Table L-3 lists worst thermal constraints in the 2018 summer shoulder scenario.

Table L-3: 2018 Shoulder Thermal Constraints, Maximum Screened Loading

Constraint	Rating	Owner	Worst Loading		Contingency	Cont Type	Generator
			(MVA)	(%)			
613210 OWATANA1 69.0 630116 PRAT T 8 69.0 1	45.0	ITCM	49.8	110.7	631036 NIW 5 161 631202 COLBY5 161 1 NIW 5 161 - COLBY5 161 1	P1	J407
613210 OWATANA1 69.0 630116 PRAT T 8 69.0 1	45.0	ITCM	50.5	112.2	P42:161:ITCM:COLBY5-NIW 5 9650:IA-MVP NIW 5 161 - COLBY5 161 1 LIME CK5 161 - COLBY5 161 1	P2-P7	J407
629990 ELLENDALE5 69.0 630131 STELCTR8 69.0 1	45.0	ITCM	51.4	114.2	631036 NIW 5 161 631202 COLBY5 161 1 NIW 5 161 - COLBY5 161 1	P1	J407
629990 ELLENDALE5 69.0 630131 STELCTR8 69.0 1	45.0	ITCM	52.1	115.7	P42:161:ITCM:COLBY5-NIW 5 9650:IA-MVP NIW 5 161 - COLBY5 161 1 LIME CK5 161 - COLBY5 161 1	P2-P7	J407
630116 PRAT T 8 69.0 630131 STELCTR8 69.0 1	45.0	ITCM	50.8	113.0	631036 NIW 5 161 631202 COLBY5 161 1 NIW 5 161 - COLBY5 161 1	P1	J407
630116 PRAT T 8 69.0 630131 STELCTR8 69.0 1	45.0	ITCM	51.5	114.5	P42:161:ITCM:COLBY5-NIW 5 9650:IA-MVP NIW 5 161 - COLBY5 161 1 LIME CK5 161 - COLBY5 161 1	P2-P7	J407
631036 NIW 5 161 631202 COLBY5 161 1	200.0	ITCM	273.4	136.7	P13:161-69:ITCM:HAYWD#25 T2:MN HAYWD#25 161 - HAYWD#15 161 1 HAYWD#25 161 - GLENWRTH5 161 1 MURPHY CR 5 161 - HAYWD#25 161 1 HAYWD#28 69.0 - HAYWD#25 161 1	P1	J407
631036 NIW 5 161 631202 COLBY5 161 1	200.0	ITCM	273.4	136.7	P22:161:ITCM:HAYWD#25 L2:MN HAYWD#25 161 - HAYWD#15 161 1 HAYWD#25 161 - GLENWRTH5 161 1 MURPHY CR 5 161 - HAYWD#25 161 1 HAYWD#28 69.0 - HAYWD#25 161 1	P2-P7	J407

L.3.2 2018 Summer Peak Contingency Analysis Results

System Intact Conditions

No thermal or voltage constraints were identified for NERC category P0 (system intact) conditions (Table D-7, Table D-8).

Post Contingency Conditions

The results in this Section are for analysis of conditions following NERC Category P1-P7 contingencies. All category P1 contingencies were converged.

Six category P2-P7 contingencies (Table D-11) were not converged. They were not converged in the benchmark or study cases. No mitigation plan is required for the study projects for these contingencies.

For contingencies in the 2018 summer peak scenario, thermal constraints are listed in Table D-9. No voltage constraints were identified (Table D-10).

Worst Thermal Violations

Table L-4 lists worst thermal constraints in the 2018 summer peak scenario.

Table L-4: 2018 Summer Peak Thermal Constraints, Maximum Screened Loading

Constraint	Rating	Owner	Worst Loading		Contingency	Cont Type	Generator
			(MVA)	(%)			
603002 WILMART7 115 603003 SWAN LK7 115 1	116.9	XEL	119.4	102.2	601050 HELENA 3 345 601072 SHEAS LK3 345 1 HELENA 3 345 - SHEAS LK3 345 1	P1	J299
603002 WILMART7 115 603003 SWAN LK7 115 1	116.9	XEL	119.1	101.9	P23:345:XEL:8S72 HNA HELENA 3 345 - GRE-CHUBLAK3 345 1 HELENA 3 345 - SHEAS LK3 345 1	P2-P7	J299

L.3.3 Network Upgrades Identified in MISO ERIS Analysis for 2018 Scenario

Based on the MISO steady state analysis, the highest loading of each facility that violates criteria in 2018 scenario (SH, SPK) is summarized in Table L-5. Potential thermal network upgrades are also included.

Costs of the network upgrades identified in the MISO steady state analysis for 2018 scenario are listed in Table L-6.

Table L-5: Network Upgrades for Thermal Constraints in 2018 Scenario, Maximum Screened Loading

Generator	Constraint	Rating	Owner	Worst Loading		Contingency	Type	Scenario	Mitigation
				(MVA)	(%)				
J299	Wilmarth-Swan Lake 115 kV	116.9	XEL	119.4	102.2	601050 HELENA 3 345 601072 SHEAS LK3 345 1 HELENA 3 345 - SHEAS LK3 345 1	P1	2018 SPK	Mitigation identified in G261 study is to replace 18 structures. Total cost is $900,000
J299	Wilmarth-Swan Lake 115 kV	116.9	XEL	119.1	101.9	P23:345:XEL:8S72 HNA HELENA 3 345 - GRE-CHUBLAK3 345 1 HELENA 3 345 - SHEAS LK3 345 1	P2-P7	2018 SPK	Mitigation identified in G261 study is to replace 18 structures. Total cost is $900,000
J407	West Owatonna-Pratt Tap 69 kV	45.0	ITCM	49.8	110.7	631036 NIW 5 161 631202 COLBY5 161 1 NIW 5 161 - COLBY5 161 1	P1	2018 SH	Rebuild approx. 4.25 miles of 69 kV with T2-4/0 ACSR. Estimated cost of rebuilding 69 kV is approximately $700k/mile
J407	West Owatonna-Pratt Tap 69 kV	45.0	ITCM	50.5	112.2	P42:161:ITCM:COLBY5-NIW 5 9650:IA-MVP NIW 5 161 - COLBY5 161 1 LIME CK5 161 - COLBY5 161 1	P2-P7	2018 SH	Rebuild approx. 4.25 miles of 69 kV with T2-4/0 ACSR. Estimated cost of rebuilding 69 kV is approximately $700k/mile
J407	Ellendale-Steel Center 69kV	45.0	ITCM	51.4	114.2	631036 NIW 5 161 631202 COLBY5 161 1 NIW 5 161 - COLBY5 161 1	P1	2018 SH	Rebuild approx. 2 miles of 69 kV with T2-4/0 ACSR. Estimated cost of rebuilding 69 kV is approximately $700k/mile
J407	Ellendale-Steel Center 69kV	45.0	ITCM	52.1	115.7	P42:161:ITCM:COLBY5-NIW 5 9650:IA-MVP NIW 5 161 - COLBY5 161 1 LIME CK5 161 - COLBY5 161 1	P2-P7	2018 SH	Rebuild approx. 2 miles of 69 kV with T2-4/0 ACSR. Estimated cost of rebuilding 69 kV is approximately $700k/mile
J407	Pratt Tap-Steel Center 69 kV	45.0	ITCM	50.8	113.0	631036 NIW 5 161 631202 COLBY5 161 1 NIW 5 161 - COLBY5 161 1	P1	2018 SH	Rebuild approx. 7 miles of 69 kV with T2-477 ACSR.

Generator	Constraint	Rating	Owner	Worst Loading		Contingency	Type	Scenario	Mitigation
				(MVA)	(%)				
J407	Pratt Tap-Steel Center 69 kV	45.0	ITCM	51.5	114.5	P42:161:ITCM:COLBY5-NIW 5 9650:IA-MVP NIW 5 161 - COLBY5 161 1 LIME CK5 161 - COLBY5 161 1	P2-P7	2018 SH	Rebuild approx. 7 miles of 69 kV with T2-477 ACSR.
J407	NIW-Colby 161 kV	200.0	ITCM	273.4	136.7	P13:161-69:ITCM:HAYWD#25 T2:MN HAYWD#25 161 - HAYWD#15 161 1 HAYWD#25 161 - GLENWRTH5 161 1 MURPHY CR 5 161 - HAYWD#25 161 1 HAYWD#28 69.0 - HAYWD#25 161 1	P1	2018 SH	Rebuild ~7.6 miles of 161 kV with T2-795 ACSR. Rating would be 335 due to terminal limit at NIW.
J407	NIW-Colby 161 kV	200.0	ITCM	273.4	136.7	P22:161:ITCM:HAYWD#25 L2:MN HAYWD#25 161 - HAYWD#15 161 1HAYWD#25 161 - GLENWRTH5 161 1MURPHY CR 5 161 - HAYWD#25 161 1HAYWD#28 69.0 - HAYWD#25 161 1	P2-P7	2018 SH	Rebuild ~7.6 miles of 161 kV with T2-795 ACSR. Rating would be 335 due to terminal limit at NIW.

Table L-6: Network Upgrades and Cost Identified in MISO Steady State Analysis for 2018 Scenario

Constraint	Owner	Mitigation	Cost ($)
Wilmarth-Swan Lake 115 kV	XEL	Mitigation identified in G261 study is to replace 18 structures. Total cost is $900,000	$0
West Owatonna-Pratt Tap 69 kV	ITCM	Rebuild approx. 4.25 miles of 69 kV with T2-4/0 ACSR. Estimated cost of rebuilding 69 kV is approximately $700k/mile	$3,000,000
Ellendale-Steel Center 69kV	ITCM	Rebuild approx. 2 miles of 69 kV with T2-4/0 ACSR. Estimated cost of rebuilding 69 kV is approximately $700k/mile	$1,400,000
Pratt Tap-Steel Center 69 kV	ITCM	Rebuild approx. 7 miles of 69 kV with T2-477 ACSR.	$4,900,000
NIW-Colby 161 kV	ITCM	Rebuild ~7.6 miles of 161 kV with T2-795 ACSR. Rating would be 335 due to terminal limit at NIW.	$8,250,000

L.4 Affected System Steady-State Analysis in 2018 Scenario

L.4.1 Local Planning Criteria Analysis for CIPCO and MPC Companies

For 2018 summer peak and summer shoulder scenarios, the additional thermal constraints in the affected CIPCO and MPC systems are listed in Appendix F.1. Whether these constraints will be mitigated or not will be determined by the affected transmission owning company's local planning criteria.

For 2018 summer shoulder scenario, the CIPCO and MPC's thermal constraints with their highest loadings and potential network upgrades are listed in Table L-7. No CIPCO or MPC's thermal constraints were identified for 2018 summer peak scenario.

Table L-7: Thermal Constraints Identified in LPC Analysis and their Highest Loadings in 2018 SH Scenario

Generator	Constraint	Rating	Owner	Worst Loading		Cont Type	Mitigation	Cost ($)
				(MVA)	(%)			
J411	Boone Jct-Fort Dodge 161 kV	199.0	MEC CIPCO	220.4	110.8	P2-P7	CIPCO: No Mitigation needed. CIPCO equipment has a rating of 335 MVA	$0

L.5 2018 Stability Analysis

L.5.1 2018 Stability Analysis Results

The following stability related issues were identified. No mitigations are required.

Tripping of J290-Rugby 230 kV OOS Relay

Out of step (OOS) relay on J290 – Rugby 230 kV line tripped under three simulated disturbances (Table L-8). The same OOS tripping also occurred in the benchmark case. No stability violations were identified if this OOS relay was disabled. The OOS relay settings should be adjusted after the J290 generation project is interconnected in the Glenboro – Rugby 230 kV line.

Table L-8: Disturbances which Cause J290-Rugby 230 kV OOS Relay Tripping

Disturbance Name
0684_w_gre__c6__es1_stanton
0685_w_gre__c6__fq1_coalcreek
0832_w_otp__c8__eg1_coalcreek-stanton

Tripping of DS Zone 2 at Ramsey to Kohlman Lake 115 kV Line

Distance relay (DS) zone 2 at Ramsey to Kohlman Lake 115 kV line tripped the line during disturbance of "0693_w_gre__c8__sb_gct_near_615295_gre-kohlmnlx". The distance relay model zone 2 reach is set as 2.6 pu at Ramsey, which is unreasonably large for the Ramsey-Kohlman Lake 115 kV line with reactance X=0.018 pu. The TO provided the correct DS zone 2 reach of 125% of the line impedance. With the DS relay settings corrected, no line tripping occurs and no stability violations are identified.

L.5.2 Network Upgrades Identified in Stability Analysis for 2018 Scenario

No additional Network Upgrades are required in stability analysis for the 2018 scenario.

L.6 2018 Deliverability Study Results

L.6.1 G736

G736 Deliverable (NRIS) Amount in Near Term Case: (Conditional on ERIS upgrades and case assumptions)	**59.11 MW (29.56%)**						
Next Upgrade for Higher NRIS Level (cumulative) (i.e. All upgrades must be made for 100% NRIS)	**Level of Service Attainable**	**Distribution Factor**	**Constraint in ERIS Analysis?**	**Projects Associated With ERIS Constraint**	**Projects Associated With NRIS Constraint**	**Upgrade Cost Allocated to Project**	**Total Cost of Upgrade**

G736 Deliverable (NRIS) Amount in Near Term Case: (Conditional on ERIS upgrades and case assumptions)	59.11 MW (29.56%)						
Next Upgrade for Higher NRIS Level (cumulative) (i.e. All upgrades must be made for 100% NRIS)	**Level of Service Attainable**	**Distribution Factor**	**Constraint in ERIS Analysis?**	**Projects Associated With ERIS Constraint**	**Projects Associated With NRIS Constraint**	**Upgrade Cost Allocated to Project**	**Total Cost of Upgrade**
Johnson Jct-Ortonville 115 kV	59.11	21.57%	Yes	G736	G736	$16,700,000	$16,700,000
Bigstone-Brownsville 230 Kv	69.35	58.96%	Yes	G736	G736	$220,000	$220,000
Johnson Jct-Morris 115 kV	94.57	21.57%	Yes	G736	G736	$8,310,000	$8,310,000
Hankinson-Wahpeton 230 kV	159.41	37.55%	No		G736	$160,000	$160,000

L.6.2 J385

J385 Deliverable (NRIS) Amount in Near Term Case: (Conditional on ERIS upgrades and case assumptions)	100 MW (100%)

L.6.3 J391

J391 Deliverable (NRIS) Amount in Near Term Case: (Conditional on ERIS upgrades and case assumptions)	50 MW (100%)

L.6.4 J400

J400 Deliverable (NRIS) Amount in Near Term Case: (Conditional on ERIS upgrades and case assumptions)	62.5 MW (100%)

L.6.5 J405

J405 Deliverable (NRIS) Amount in Near Term Case: (Conditional on ERIS upgrades and case assumptions)	0 MW (0%)						
Next Upgrade for Higher NRIS Level (cumulative) (i.e. All upgrades must be made for 100% NRIS)	**Level of Service Attainable**	**Distribution Factor**	**Constraint in ERIS Analysis?**	**Projects Associated With ERIS Constraint**	**Projects Associated With NRIS Constraint**	**Upgrade Cost Allocated to Project**	**Total Cost of Upgrade**

J405 Deliverable (NRIS) Amount in Near Term Case: (Conditional on ERIS upgrades and case assumptions)	0 MW (0%)						
Next Upgrade for Higher NRIS Level (cumulative) (i.e. All upgrades must be made for 100% NRIS)	**Level of Service Attainable**	**Distribution Factor**	**Constraint in ERIS Analysis?**	**Projects Associated With ERIS Constraint**	**Projects Associated With NRIS Constraint**	**Upgrade Cost Allocated to Project**	**Total Cost of Upgrade**
Oakes-Forman 230 kV	0	5.14%	No		J405	$140,000	$140,000
Jamestown-Buffalo 345 kV	0	11.59%	No		J405	$0	$0
Forman-Hankinson 230 kV	0	5.49%	No		J405	$100,000	$100,000

L.6.6 J407

J407 Deliverable (NRIS) Amount in Near Term Case: (Conditional on ERIS upgrades and case assumptions)	0.2 MW (0.1%)						
Next Upgrade for Higher NRIS Level (cumulative) (i.e. All upgrades must be made for 100% NRIS)	**Level of Service Attainable**	**Distribution Factor**	**Constraint in ERIS Analysis?**	**Projects Associated With ERIS Constraint**	**Projects Associated With NRIS Constraint**	**Upgrade Cost Allocated to Project**	**Total Cost of Upgrade**
Glenworth 161-69 kV xfmr	0.2	23.51%	No		J407	$2,500,000	$2,500,000
Glenworth-Hayward 161 kV	156.36	57.49%	No		J407, J416	$80,000	$63,359
Glenworth-Hayward 69 kV	185.72	13.32%	No		J407	$125,000	$125,000

L.6.7 J411

J411 Deliverable (NRIS) Amount in Near Term Case: (Conditional on ERIS upgrades and case assumptions)	300 MW (100%)

L.6.8 J416

J416 Deliverable (NRIS) Amount in Near Term Case: (Conditional on ERIS upgrades and case assumptions)	43.6 MW (21.8%)						
Next Upgrade for Higher NRIS Level (cumulative) (i.e. All upgrades must be made for 100% NRIS)	**Level of Service Attainable**	**Distribution Factor**	**Constraint in ERIS Analysis?**	**Projects Associated With ERIS Constraint**	**Projects Associated With NRIS Constraint**	**Upgrade Cost Allocated to Project**	**Total Cost of Upgrade**
NIW-Colby 161 kV	43.6	16.68%	Yes	J407	J416	$1,442,680	$8,250,000
Glenworth-Hayward 161 kV	156.36	15.10%	No		J407, J416	$16,641	$80,000

L.6.9 J426

J426 Deliverable (NRIS) Amount in Near Term Case: (Conditional on ERIS upgrades and case assumptions)	100 MW (100%)

L.7 Cost Allocation for 2018 Scenario

L.7.1 ERIS Network Upgrades for 2018 Scenario

Table L-9: Network Upgrades in MISO Steady-State Analysis for 2018 Scenario

Constraint	Owner	Mitigation	Cost ($)
Wilmarth-Swan Lake 115 kV	XEL	Mitigation identified in G261 study is to replace 18 structures. Total cost is $900,000	$0
West Owatonna-Pratt Tap 69 kV	ITCM	Rebuild approx. 4.25 miles of 69 kV with T2-4/0 ACSR. Estimated cost of rebuilding 69 kV is approximately $700k/mile	$3,000,000
Ellendale-Steel Center 69kV	ITCM	Rebuild approx. 2 miles of 69 kV with T2-4/0 ACSR. Estimated cost of rebuilding 69 kV is approximately $700k/mile	$1,400,000
Pratt Tap-Steel Center 69 kV	ITCM	Rebuild approx. 7 miles of 69 kV with T2-477 ACSR.	$4,900,000
NIW-Colby 161 kV	ITCM	Rebuild ~7.6 miles of 161 kV with T2-795 ACSR. Rating would be 335 due to terminal limit at NIW.	$8,250,000

Table L-10: Additional CIPCO & MPC Network Upgrades for 2018 Scenario

Constraint	Owner	Mitigation	Cost ($)
Boone Jct-Fort Dodge 161 kV	MEC CIPCO	CIPCO: No Mitigation needed. CIPCO equipment has a rating of 335 MVA	$0

Table L-11: PJM Network Upgrades for 2018 Scenario

Constraint	Mitigation	Owner	Cost ($)
Cordova–Nelson 345 kV line	Existing PJM baseline upgrades B2692.1 & B2692.2 are planned to be put into service by summer 2019. B2692.1 & B2692.2 will upgrade the Cordova - Nelson 345 kV line. The new line ratings will be 1679 / 2058 / 2280 MVA (SN/SE/SLD)	PJM	Existing PJM baseline upgrades
Quad Cities–ESS H471 345 kV line	Existing PJM baseline upgrades B2692.1 & B2692.2 are planned to be put into service by summer 2019. B2692.1 & B2692.2 will upgrade the Quad Cities – ESS H471 345 kV line. The new line ratings will be 1679/2011/2280 MVA (SN/SE/SLD)	PJM	Existing PJM baseline upgrades
ESS H471–Nelson 345 kV line	Existing PJM baseline upgrades B2692.1 & B2692.2 are planned to be put into service by summer 2019. B2692.1 & B2692.2 will upgrade the ESS H471 - Nelson 345 kV line. The new line ratings will be 1679/2011/2280 MVA (SN/SE/SLD)	PJM	Existing PJM baseline upgrades

Note 1: All the three constraints will be mitigated by existing PJM baseline upgrades B2692.1 & B2692.2, which are planned to be in service by summer 2019.

Note 2: Two projects J285 and J344 in the MISO DPP 2014 Cycle contribute loading to these three overloads. These projects can wait until B2692.1 & B2692.2 are placed into service or the projects can pay an advancement cost to place B2692.1 & B2692.2 into service earlier, if feasible per ComEd.

Table L-12: SPP Network Upgrades for 2018 Scenario

Constraint	Owner	Mitigation	Cost ($)
Various impacts[1]			$0[2]

Note 1: Impacts on SPP system can be mitigated by the Gentleman Generation Station (GGS) – Thedford - Holt 345kV (R-Plan) transmission line, Nebraska City – Mullin Creek – Sibley 345kV transmission line, and certain terminal equipment and line upgrades for Western Area Power Administration (WAPA) facilities.

Note 2: There will be advancement cost if certain generation projects want to put into service earlier before the Network Upgrades in Note 1 are placed into service.

Table L-13: Network Upgrades in Voltage Stability Analysis for 2018 Scenario

Constraint	Owner	Mitigation	Cost ($)
No Constraints			$0

Table L-14: Additional Network Upgrades in Transient Stability Analysis for 2018 Scenario

Constraint	Owner	Mitigation	Cost ($)
Transient voltage violation at 115 kV buses in Big Stone area	MISO	MVP projects Big Stone South-Ellendale and Big Stone South-Brookings Co 345 kV	$0

Table L-15: Shared Network Upgrade for 2018 Scenario

Shared Network Upgrades	Upgrade Cost $
None	$0

L.7.2 Cost Allocation in 2018 Scenario

Assuming all generating facilities in the DPP 2014 August West Area group advance, a summary of the costs for total NUs (NUs for ERIS, NRIS, and Interconnection Facilities) allocated to each generating facility is listed in Table L-16 for 2018 scenario.

Table L-16: Summary of Total NU Costs Allocated to Each Generation Project for 2018 Scenario

Project	Max Output (MW)	Total Cost of NU per Project ($)	$/MW	Share %
G736	200	$2,206,197	$11,031	3.33%
J299	73	$0	$0	0.00%
J385	100	$2,498,000	$24,980	3.77%
J391	50	$476,000	$9,520	0.72%
J400	62.5	$1,271,000	$20,336	1.92%
J405	40	$614,540	$15,364	0.93%
J407	200	$18,415,365	$92,077	27.80%
J411	300	$10,022,000	$33,407	15.13%
J416	200	$25,513,484	$127,567	38.51%
J426	100	$5,229,000	$52,290	7.89%
Total/Average	**1325.5**	**$66,245,586**	**$38,657**	**100.00%**

Addendum for MISO DPP-2015-FEB-West

Definitive Planning Phase

PJM Affected Systems

October 4, 2016

This addendum contains updated study results for the report entitled *MISO DPP 2015 February West Area* and dated July 16, 2016. The PJM Affected Systems analysis has been updated due to changes in both the PJM and MISO queues that occurred after the initial study.

Table 1 illustrates the cost comparison of the Affected Systems upgrade changes from the updated PJM report dated September 13, 2016 and the original report dated March 4, 2016 for projects in the Western Region.

Table 1: PJM Upgrade Cost Comparison

Project	Total PJM NU Cost Per Impacted Project		Cost Differential (Updated Cost - Originally Cost)
	Allocated Cost (3/4/2016)	Updated Allocated Cost (9/13/2016)	
G736	$0	$18,000,000	$18,000,000
J299	$0	$0	$0
J385	$0	$0	$0
J391	$0	$0	$0
J400	$0	$0	$0
J405	$0	$0	$0
J407*	$0	$2,183,000	$2,183,000
J411*	$0	$8,333,000	$8,333,000
J416*	$0	$0	$0
J426	$0	$0	$0

Note 1: Projects J407, J411 & J416 are contingent upon upgrades to mitigate overloads on the Cordova – Nelson 345 kV line, Quad Cities – EES H471 345 kV line and the EES H471 – Nelson 345 kV line. PJM baseline upgrades B2692.1 and B2692.2 are required to mitigate the identified overloads. These overloads were present before and after the PJM retool.

1.1 Project Additions

To relieve constraints identified on the Stillwell – Dumont 345 kV line the following upgrades are required and are to be cost allocated as shown in Table 2.

- The PJM AA1 queue projects drive the loading above 1409 MVA SE. The upgrade is a sag study for less than $5M which is allocated to the PJM AA1 projects only at this time. The sag study results show work will include the replacement of tower 20 with a custom steel pole, replacement of tower 24 with a custom H-frame and the removal of swing angle brackets on 2 structures. Cost estimate is $1.613M The new expected AEP-end SE rating is to be 1718 MVA SE limited by a Dumont wavetrap and possibly the conductor.
- The AEP-end 1718 MVA SE rating and the MISO-end 1779 MVA SE ratings are no longer sufficient due to the MISO 2015 DPP projects.

- The AEP-end upgrade is to rebuild 9 miles of the AEP owned line and upgrade necessary Dumont terminal equipment (wavetrap) at a cost of $20M. PJM Network Upgrade N4790. New AEP-end ratings to be 1409/2045 MVA (SN/SE), limited by Dumont risers.
- The MISO-end upgrade is to rebuild NIPSCO portion of line (2.87 miles) at a cost of $6.9M and upgrade Stillwell substation equipment at a cost of $1.2M for a total cost of $8.1M. The new expected MISO-end ratings will be 1869/2240 MVA SN/SE.
- The total cost of this upgrade for both the AEP-end and the MISO-end is $28.1M.
- The cost allocation is as follows:

Table 2: Stillwell – Dumont 345 kV Mitigation Costs

Queue	MW contribution	% of Cost	Cost ($28.1 M)
J394	25.8	0.33	9.259
J411	15.8	0.20	5.670
J298	19.6	0.25	7.034
J455	17.1	0.22	6.137

As changes to the PJM Interconnection Process occur (such as PJM or MISO projects withdrawing from the queue), the driver queue project can change and other MISO and/or PJM queue project(s) could receive cost allocation towards this upgrade going forward.

To relieve constraints identified on the WILTON - B-WILTON - 3M 345 kV line the following upgrades are required and are to be cost allocated as shown in Table 3.

- Construct the Wilton 765 kV bus to allow for 765 kV L11216 (currently on Bus 6) to be relocated to Bus 8. Along with this line relocation, installation of 2-765kV BT CB's (6-8 & 8-2). Cost estimate is $11M. Time estimate is 24-30 months. This will eliminate the stuck breaker contingencies '112-65-BT2-3__' and '112-65-BT5-6__' which cause the overloads. PJM Network Upgrade N4947
- The cost allocation is as follows:

Table 3: WILTON - B-WILTON - 3M 345 kV Mitigation Costs

Queue	MW contribution	% of Cost	Cost ($11 M)
J407	13.2	19.85%	2.183
J411	16.1	24.21%	2.663
J298	19.8	29.77%	3.275
J455	17.4	26.17%	2.878

To relieve constraints identified on the Benton – T094 345 kV line the following upgrades are required and are to be cost allocated as shown in Table 4.

Reconductor or rebuild depending on the existing structures the portions of 345 kV lines between the Benton Harbor and Sagreto 345 kV substations. The estimated cost will approximately be $18,000,000 for the ACSR 954 45/7 Rail Conductor Section 1 and $1,000,000 for the ACSR/TW 1158.4 Type 13 Hudson Conductor Section 2. PJM Network Upgrade N5106.

Table 4: Benton – T094 345 kV Mitigation Costs

Queue	MW contribution	% of Cost	Cost ($11 M)
G736	8.87	100%	18.0

Appendix A: PJM Affected Systems Study Report

Impacts of MISO DPP-2015-February-August

Projects on PJM Facilities

1. MISO generators studied:

2015 February DPP:

MISO Project	POI	Interconnection ServiceType	Summer Max Output (MFO)	Capacity MW	Energy-Only MW	Fuel Type
G736	Big Stone South 230kV Substation	NRIS	200	200	0	Wind
J299	Wilmarth Substation: MEC-CT1 15 kV	ERIS	73	0	73	Gas
J301	Rapson 345 kV	NRIS	101	101	0	Wind
J308	Rapson - Banner 345 kV line	NRIS	301	301	0	Wind
J319	ANO-Pleasant Hill 500 kV line	NRIS	500	500	0	HVDC Line
J321	Rapson - Banner 345 kV line	NRIS	151.2	151.2	0	Wind
J375	Gibson City South Substation 138 kV	ERIS	125.6	0	125.6	Wind
J384	2346 Clearview Road, Cambridge: CHA 138 kV	NRIS	21	21	0	Gas
J385	Chisago 7 115 kV	NRIS	100	100	0	Solar
J390	Townline Road 138 kV	NRIS	702	702	0	Gas
J391	MMU's N 7th Street 115 kV substation	NRIS	50	50	0	Gas
J392	Livingston to Stover 138 kV line: AlbaJ 138 kV	NRIS	434.3	434.3	0	Gas
J394	Tilden 138 kV	NRIS	280	280	0	Gas
J395	Section 34 Township 3N Range 2E: HLM - DAR 138 kV line	ERIS	98	0	98	Wind
J400	Lyon County 115kV Substation	NRIS	62.5	62.5	0	Solar
J401	Stout South Substation 138 kV	NRIS	20	20	0	Battery
J405	Lewis & Clark Jct substation: Lewis 115 kV	NRIS	40	40	0	Gas
J407	Glenworth 161 kV	NRIS	200	200	0	Wind
J411	Lehigh - Raun 345 kV line	NRIS	300	300	0	Wind
J416	Emery - Blackhawk 345 kV line	NRIS	200	200	0	Wind
J417	Grywood 230 kV	NRIS	43	43	0	Waste Heat Recovery
J419	Milan 120 kV	NRIS	100	100	0	Solar
J422	Greenwood Energy Center 26 kV	NRIS Only	30	30	0	Gas
J426	Chanarambie substation 35.4 kV	NRIS	100	100	0	Wind
J431	Goodland 69 kV	NRIS Only	106	106	0	Wind

2015 August DPP:

MISO Project	POI	Interconnection ServiceType	Summer Max Output (MFO)	Capacity MW	Energy-Only MW	FuelType
G934	METC Nelson Road 345kV substation	NRIS	150	150	0	Wind
J041	Wellsburg 161 kV Substation	NRIS	90	90	0	Wind
J264	Bingham - Cornell 138 kV	NRIS	120	120	0	Wind
J291	PPI Alsey 138kV Substation	NRIS	42	42	0	Gas
J298	Dysart 161 kV	NRIS	300.9	300.9	0	Wind
J396	Entergy Little Gypsy 230kV Power Station	NRIS	904	904	0	Gas
J399	Black Dog 115 kV substation	NRIS	214	214	0	Gas
J412	LeHigh - Raun 345 kV line	NRIS	200	200	0	Wind
J429	Big Hill 138 kV substation	NRIS	100	100	0	Wind
J436	Big Stone South 345/230 kV sub interconnecting at 345 kV	ERIS	150	0	150	Wind
J437	Big Stone South 345/230 kV sub interconnecting at 345 kV	ERIS	150	0	150	Wind
J438	Poweshiek-Parnell 161 kV line	NRIS	170.2	170.2	0	Wind
J440	Consumers DIGG 230 kV substation	External NRIS	80	80	0	Gas
J442	Big Stone substation via a radial 230 kV line	NRIS	200	200	0	Wind
J443	Greely Tap 69kV	NRIS Only	41	41	0	Wind
J449	Pioneer Prairie I substation: Mitchell Co 345kV	NRIS	202	202	0	Wind
J453	Duke Edwardsport 6951 69 kV line	ERIS	17.25	0	17.25	Solar
J454	MMU SW 7 115kV Substation	NRIS Only	18.9	18.9	0	Wind
J455	Webster-Burt 345 kV line	ERIS	300	0	300	Wind
J466	Stein 345 kV Substation	NRIS	30	30	0	Co-Gen
J469	Consumers Grayling Generation 46 kV Substation	External NRIS	1.8	1.8	0	Wood

2. Summer Peak Analysis

- Model used – PJM AA1 Queue SIS 2018 Summer Peak case. All Active PJM queue projects modeled through the AA1 Queue along with all previously studied MISO DPP projects (studied through 2014). The MISO 2015 February and August DPP generators being studied were added to the model.
- Contingencies used – All PJM category B (single) and C contingencies (tower, bus fault, fault with stuck breaker)
- Monitored areas – All PJM areas
- Analysis type – PJM Generation Deliverability Test
- MISO ERIS Projects were modeled as PJM Energy-Only projects.
- MISO NRIS Projects were modeled as PJM Capacity projects.
- Generators were scaled to their respective capacity portions for base case (N-0) and all contingencies.
- Generators were scaled to their respective summer energy-only capabilities for category C contingencies only.
- MISO generation sunk to MISO
- PJM generation sunk to PJM

3. Summer Peak Results :

1. (AEP - AEP) The 05BENTON 345/138 kV transformer (from bus 243212 to bus 243250 ckt 1) loads from 76.85% to 104.23% (AC power flow) of its emergency rating (564 MVA) for the tower line contingency outage of '7029'.

```
CONTINGENCY '7029'
  OPEN BRANCH FROM BUS 243212 TO BUS 243215 CKT 1                /
243212 05BENTON 345 243215 05COOK 345 1
  OPEN BRANCH FROM BUS 243215 TO BUS 247502 CKT 2                /
243215 05COOK 345 247502 T-094 345 2
  END
```

2. (AEP - AEP) The 05BENTON 345/138 kV transformer (from bus 243212 to bus 243250 ckt 1) loads from 76.85% to 104.23% (AC power flow) of its emergency rating (564 MVA) for the line fault with failed breaker contingency outage of '7027_C2_05COOK 345-N'.

```
CONTINGENCY '7027_C2_05COOK 345-N'
```

OPEN BRANCH FROM BUS 243212 TO BUS 243215 CKT 1 /
243212 05BENTON 345 243215 05COOK 345 1
OPEN BRANCH FROM BUS 243215 TO BUS 247502 CKT 2 /
243215 05COOK 345 247502 T-094 345 2
END

3. (AEP - MISO AMIL) The 05EUGENE-7BUNSONVILLE 345 kV line (from bus 243221 to bus 348885 ckt 1) loads from 98.36% to 107.71% (AC power flow) of its emergency rating (822 MVA) for the single contingency outage of '685_B2'.

CONTINGENCY '685_B2'
OPEN BRANCH FROM BUS 243213 TO BUS 346809 CKT 1 /
243213 05BREED 345 346809 7CASEY 345 1
END

4. (CE - CE) The LORETTO ; B-WILTON ; B 345 kV line (from bus 270704 to bus 270926 ckt 1) loads from 121.43% to 123.18% (AC power flow) of its applicable load dump rating (1577 MVA) for the line fault with failed breaker contingency outage of '012-45-BT11-14'.

CONTINGENCY '012-45-BT11-14'
TRIP BRANCH FROM BUS 270717 TO BUS 270737 CKT 1 /
DRESDEN ; R 345 ELWOOD ; R 345
TRIP BRANCH FROM BUS 270853 TO BUS 270717 CKT 1 /
PONTIAC ; R 345 DRESDEN ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 270853 CKT 1 /
PONTIAC ;2M 138 PONTIAC ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 272261 CKT 1 /
PONTIAC ;2M 138 PONTIAC ; R 138
TRIP BRANCH FROM BUS 275210 TO BUS 275310 CKT 1 /
PONTIAC ;2M 138 PONTIAC ;2C 34.5
CLOSE BRANCH FROM BUS 272260 TO BUS 272261 CKT 1 /
PONTIAC ; B 138 PONTIAC ; R 138
END

5. (CE - MISO AMIL) The KINCAID ; B-7PAWNEE 345 kV line (from bus 270796 to bus 347962 ckt 1) loads from 142.01% to 143.6% (AC power flow) of its emergency

rating (717 MVA) for the line fault with failed breaker contingency outage of '080-45-BT5-6__'.

```
CONTINGENCY '080-45-BT5-6__'
 TRIP BRANCH FROM BUS 270852 TO BUS 270668 CKT 1              /
PONTIAC ; B 345 BLUEMOUND; B 345
 TRIP BRANCH FROM BUS 270853 TO BUS 270717 CKT 1              /
PONTIAC ; R 345 DRESDEN ; R 345
 TRIP BRANCH FROM BUS 275210 TO BUS 270853 CKT 1              /
PONTIAC ;2M 138 PONTIAC ; R 345


 TRIP BRANCH FROM BUS 275210 TO BUS 272261 CKT 1              /
PONTIAC ;2M 138 PONTIAC ; R 138
 TRIP BRANCH FROM BUS 275210 TO BUS 275310 CKT 1              /
PONTIAC ;2M 138 PONTIAC ;2C 34.5
 CLOSE BRANCH FROM BUS 272260 TO BUS 272261 CKT 1               /
PONTIAC ; B 138 PONTIAC ; R 138
 END
```

6. (CE - MISO AMIL) The KINCAID ; B-7PAWNEE 345 kV line (from bus 270796 to bus 347962 ckt 1) loads from 139.85% to 141.4% (AC power flow) of its emergency rating (717 MVA) for the line fault with failed breaker contingency outage of '080-45-BT4-5__'.

```
CONTINGENCY '080-45-BT4-5__'
 TRIP BRANCH FROM BUS 270852 TO BUS 270668 CKT 1              /
PONTI; B 345 BLUEM; B 345
 TRIP BRANCH FROM BUS 270852 TO BUS 270704 CKT 1              /
PONTI; B 345 LORET; B 345
 END
```

7. (CE - MISO AMIL) The KINCAID ; B-7PAWNEE 345 kV line (from bus 270796 to bus 347962 ckt 1) loads from 137.96% to 139.76% (AC power flow) of its emergency rating (717 MVA) for the line fault with failed breaker contingency outage of '080-45-BT7-8__A'.

```
CONTINGENCY '080-45-BT7-8__A'
```

TRIP BRANCH FROM BUS 270853 TO BUS 917500 CKT 1 /
PONTIAC ; R 345 Z2-087 TAP 345
TRIP BRANCH FROM BUS 270853 TO BUS 270717 CKT 1 /
PONTIAC ; R 345 DRESDEN ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 270853 CKT 1 /
PONTIAC ;2M 138 PONTIAC ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 272261 CKT 1 /
PONTIAC ;2M 138 PONTIAC ; R 138
TRIP BRANCH FROM BUS 275210 TO BUS 275310 CKT 1 /
PONTIAC ;2M 138 PONTIAC ;2C 34.5
CLOSE BRANCH FROM BUS 272260 TO BUS 272261 CKT 1 /
PONTIAC ; B 138 PONTIAC ; R 138
END

8. (CE - MISO AMIL) The KINCAID ; B-7PAWNEE 345 kV line (from bus 270796 to bus 347962 ckt 1) loads from 133.71% to 135.3% (AC power flow) of its emergency rating (717 MVA) for the line fault with failed breaker contingency outage of '012-45-BT11-14'.

CONTINGENCY '012-45-BT11-14'
TRIP BRANCH FROM BUS 270717 TO BUS 270737 CKT 1 /
DRESDEN ; R 345 ELWOOD ; R 345
TRIP BRANCH FROM BUS 270853 TO BUS 270717 CKT 1 /
PONTIAC ; R 345 DRESDEN ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 270853 CKT 1 /
PONTIAC ;2M 138 PONTIAC ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 272261 CKT 1 /
PONTIAC ;2M 138 PONTIAC ; R 138
TRIP BRANCH FROM BUS 275210 TO BUS 275310 CKT 1 /
PONTIAC ;2M 138 PONTIAC ;2C 34.5
CLOSE BRANCH FROM BUS 272260 TO BUS 272261 CKT 1 /
PONTIAC ; B 138 PONTIAC ; R 138
END

9. (CE - CE) The PONTIAC ; B-LORETTO ; B 345 kV line (from bus 270852 to bus 270704 ckt 1) loads from 112.20% to 113.99% (AC power flow) of its applicable load dump rating (1528 MVA) for the line fault with failed breaker contingency outage of '012-45-BT11-14'.

CONTINGENCY '012-45-BT11-14'
TRIP BRANCH FROM BUS 270717 TO BUS 270737 CKT 1 /
DRESDEN ; R 345 ELWOOD ; R 345
TRIP BRANCH FROM BUS 270853 TO BUS 270717 CKT 1 /
PONTIAC ; R 345 DRESDEN ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 270853 CKT 1 /
PONTIAC ;2M 138 PONTIAC ; R 345
TRIP BRANCH FROM BUS 275210 TO BUS 272261 CKT 1 /
PONTIAC ;2M 138 PONTIAC ; R 138
TRIP BRANCH FROM BUS 275210 TO BUS 275310 CKT 1 /
PONTIAC ;2M 138 PONTIAC ;2C 34.5
CLOSE BRANCH FROM BUS 272260 TO BUS 272261 CKT 1 /
PONTIAC ; B 138 PONTIAC ; R 138
END

10. (CE - CE) The ROSCOE BE;BT-HARLEM ; B 138 kV line (from bus 272378 to bus 271638 ckt 1) loads from 97.94% to 108.58% (AC power flow) of its emergency rating (175 MVA) for the single line contingency outage of '156-L15624__'.

CONTINGENCY '156-L15624__'
TRIP BRANCH FROM BUS 271192 TO BUS 271202 CKT 1 /
CHERR; B 138 B465 ;BT 138
END

11. (CE - CE) The ROSCOE BE;BT-HARLEM ; B 138 kV line (from bus 272378 to bus 271638 ckt 1) loads from 93.65% to 104.28% (AC power flow) of its emergency rating (175 MVA) for the single line contingency outage of '138-L15624_B-R'.

CONTINGENCY '138-L15624_B-R'
TRIP BRANCH FROM BUS 271192 TO BUS 271202 CKT 1 /
CHERR; B 138 B465 ;BT 138
TRIP BRANCH FROM BUS 271202 TO BUS 271082 CKT 1 / B465
;BT 138 BELVI; B 138

TRIP BRANCH FROM BUS 271202 TO BUS 271200 CKT 1 / B465 ;BT 138 B465 ; B 138
MOVE 100 PERCENT LOAD FROM BUS 271082 TO BUS 271083 / BELVI; B 138 BELVI; R 138
DISCONNECT BUS 271200 / B465 ; B 138
END

13. (CE - CE) The KELLEY RD; B-BELVIDERE; B 138 kV line (from bus 271852 to bus 271082 ckt 1) loads from 92.02% to 101.18% (AC power flow) of its applicable load dump rating (204 MVA) for the line fault with failed breaker contingency outage of '156-38-L15626_'.

CONTINGENCY '156-38-L15626_'
TRIP BRANCH FROM BUS 271096 TO BUS 271094 CKT 1 / BHAWK;BT 138 BHAWK; B 138
TRIP BRANCH FROM BUS 271096 TO BUS 272432 CKT 1 / BHAWK;BT 138 SABRO; B 138
TRIP BRANCH FROM BUS 271192 TO BUS 271096 CKT 1 / CHERR; B 138 BHAWK;BT 138
MOVE 100 PERCENT LOAD FROM BUS 271094 TO BUS 271095 / BHAWK; B 138 BHAWK; R 138

TRIP BRANCH FROM BUS 271192 TO BUS 271202 CKT 1 / CHERR; B 138 B465 ;BT 138
END

14. (CE - CE) The KELLEY RD; B-BELVIDERE; B 138 kV line (from bus 271852 to bus 271082 ckt 1) loads from 91.95% to 101.11% (AC power flow) of its applicable load dump rating (204 MVA) for the bus fault outage of '156_CV-138B__4'.

CONTINGENCY '156_CV-138B__4'
TRIP BRANCH FROM BUS 271192 TO BUS 271096 CKT 1 / CHERR; B 138 BHAWK;BT 138
TRIP BRANCH FROM BUS 271192 TO BUS 271202 CKT 1 / CHERR; B 138 B465 ;BT 138
END

15. (CE - CE) The CORDOVA ; B-NELSON ; B 345 kV line (from bus 270700 to bus 270828 ckt 1) loads from 80.92% to 100.89% (AC power flow) of its emergency rating (1528 MVA) for the single line contingency outage of '345-L0404___-R'.

```
CONTINGENCY '345-L0404___-R'
  TRIP BRANCH FROM BUS 270864 TO BUS 270890 CKT 1                /
QUAD3-11 345 H471 ; 345
  END
```

16. (CE - CE) The CORDOVA ; B-NELSON ; B 345 kV line (from bus 270700 to bus 270828 ckt 1) loads from 80.83% to 100.81% (AC power flow) of its emergency rating (1528 MVA) for the single line contingency outage of '345-L15504__-R'.

```
CONTINGENCY '345-L15504__-R'
  TRIP BRANCH FROM BUS 270828 TO BUS 270890 CKT 1                /
NELSO; B 345 H471 ; 345
  END
```

17. (CE - CE) The QUAD 1 3-11-ESS H471 ; 345 kV line (from bus 270864 to bus 270890 ckt 1) loads from 80.89% to 100.87% (AC power flow) of its emergency rating (1528 MVA) for the single line contingency outage of '345-L15503_B-R'.

```
CONTINGENCY '345-L15503_B-R'
  TRIP BRANCH FROM BUS 270828 TO BUS 270700 CKT 1                /
NELSO; B 345 CORDO; B 345
  END
```

18. (CE - CE) The ESS H471 ;-NELSON ; B 345 kV line (from bus 270890 to bus 270828 ckt 1) loads from 80.78% to 100.76% (AC power flow) of its emergency rating (1528 MVA) for the single line contingency outage of '345-L15503_B-R'.

```
CONTINGENCY '345-L15503_B-R'
  TRIP BRANCH FROM BUS 270828 TO BUS 270700 CKT 1                /
NELSO; B 345 CORDO; B 345
  END
```

19. (CE - CE) The LEE CO EC;BP-BYRON ; B 345 kV line (from bus 274768 to bus 270678 ckt 1) loads from 89.11% to 102.24% (AC power flow) of its emergency rating (1726 MVA) for the single line contingency outage of '345-L18402_B-R'.

CONTINGENCY '345-L18402_B-R'
TRIP BRANCH FROM BUS 270932 TO BUS 270730 CKT 1 /
WALTO; B 345 ELECT; B 345
END

20. (CE - CE) The LEE CO EC;BP-BYRON ; B 345 kV line (from bus 274768 to bus 270678 ckt 1) loads from 88.81% to 101.94% (AC power flow) of its emergency rating (1726 MVA) for the single line contingency outage of '345-L15502_B-R'

CONTINGENCY '345-L15502_B-R'
TRIP BRANCH FROM BUS 270828 TO BUS 270932 CKT 1 /
NELSO; B 345 WALTO; B 345
END

21. (CE – AEP) The WILTON-05DUMONT 765 kV line (270644-243206 ckt 1) loads from 92.98% to 108.72% (AC power flow) of its emergency rating (4444 MVA) for the tower contingency outage of '345-L94507_B-S_+_345-L97008_R-S'.

CONTINGENCY '345-L94507_B-S_+_345-L97008_R-S'
TRIP BRANCH FROM BUS 274750 TO BUS 255112 CKT 1 / CRETE;BP 345 17STJOHN 345
TRIP BRANCH FROM BUS 274804 TO BUS 243229 CKT 1 / UPNOR;RP 345 05OLIVE 345
END

22. (MISO – AEP) The 17STILLWELL-05DUMONT 345 kV line (255113-243219 ckt 1) loads from 115.18% to 136.42% (AC power flow) of its emergency rating (1409 MVA) for the stuck breaker contingency outage of '2978_C2_A'.

CONTINGENCY '2978_C2_A'
OPEN BRANCH FROM BUS 243206 TO BUS 907040 CKT 1 / 243206 05DUMONT 765 907040 X1-020 TAP 765 1
OPEN BRANCH FROM BUS 243206 TO BUS 270644 CKT 1 / 243206 05DUMONT 765 270644 WILTON ; 765 1
END

23. (MISO – AEP) The 17STILLWELL-05DUMONT 345 kV line (255113-243219 ckt 1) loads from 106.81% to 128.63% (AC power flow) of its emergency rating (1409 MVA) for the stuck breaker contingency outage of '023-65-BT2-3__'.

CONTINGENCY '023-65-BT2-3__'
TRIP BRANCH FROM BUS 270644 TO BUS 243206 CKT 1 / WILTO; 765 05DUMONT 765
TRIP BRANCH FROM BUS 270607 TO BUS 270630 CKT 1 / COLLI; 765 PLANO; 765
END

24. (MISO – AEP) The 17STILLWELL-05DUMONT 345 kV line (255113-243219 ckt 1) loads from 106.69% to 128.53% (AC power flow) of its emergency rating (1409 MVA) for the stuck breaker contingency outage of '023-65-BT4-5__'.

CONTINGENCY '023-65-BT4-5__'
TRIP BRANCH FROM BUS 275168 TO BUS 270607 CKT 1 / COLLI;2M 345 COLLI; 765
TRIP BRANCH FROM BUS 275168 TO BUS 270697 CKT 1 / COLLI;2M 345 COLLI; R 345
TRIP BRANCH FROM BUS 275168 TO BUS 275268 CKT 1 / COLLI;2M 345 COLLI;2C 33

TRIP BRANCH FROM BUS 270644 TO BUS 243206 CKT 1 / WILTO; 765 05DUMONT 765
END

25. (CE – MISO) The CRETE EC;BP-17STJOHN 345 kV line (274750-255112 ckt 1) loads from 124.67% to 145.24% (AC power flow) of its emergency rating (1195 MVA) for the stuck breaker contingency outage of '2978_C2_A'.

CONTINGENCY '2978_C2_A'
OPEN BRANCH FROM BUS 243206 TO BUS 907040 CKT 1 / 243206 05DUMONT 765 907040 X1-020 TAP 765 1
OPEN BRANCH FROM BUS 243206 TO BUS 270644 CKT 1 / 243206 05DUMONT 765 270644 WILTON ; 765 1
END

26. (CE – MISO) The CRETE EC;BP-17STJOHN 345 kV line (274750-255112 ckt 1) loads from 124.23% to 145.00% (AC power flow) of its emergency rating (1195 MVA) for the stuck breaker contingency outage of '112-65-BT4-5__'.

CONTINGENCY '112-65-BT4-5__'
TRIP BRANCH FROM BUS 270644 TO BUS 243206 CKT 1 / WILTO; 765 05DUMONT 765
TRIP BRANCH FROM BUS 275233 TO BUS 270644 CKT 1 / WILTO;4M 345 WILTO; 765
TRIP BRANCH FROM BUS 275233 TO BUS 270927 CKT 1 / WILTO;4M 345 WILTO; R 345
TRIP BRANCH FROM BUS 275233 TO BUS 275333 CKT 1 / WILTO;4M 345 WILTO;4C 33
END

27. (CE – MISO) The CRETE EC;BP-17STJOHN 345 kV line (274750-255112 ckt 1) loads from 124.17% to 144.93% (AC power flow) of its emergency rating (1195 MVA) for the stuck breaker contingency outage of '112-65-BT3-4__'.

CONTINGENCY '112-65-BT3-4__'
TRIP BRANCH FROM BUS 270644 TO BUS 243206 CKT 1 / WILTO; 765 05DUMONT 765
TRIP BRANCH FROM BUS 275232 TO BUS 270644 CKT 1 / WILTO;3M 345 WILTO; 765

TRIP BRANCH FROM BUS 275232 TO BUS 270926 CKT 1 / WILTO;3M 345 WILTO; B 345
TRIP BRANCH FROM BUS 275232 TO BUS 275332 CKT 1 / WILTO;3M 345 WILTO;3C 33
END

28. (MISO - CE) The PLS PR1-ZION STA ; R 345 kV line (699432-270941 ckt 1) loads from 120.0% to 128.32% (AC power flow) of its emergency rating (1488 MVA) for the stuck breaker contingency outage of '974-45-BT1-2__'.

CONTINGENCY '974-45-BT1-2__'
TRIP BRANCH FROM BUS 270941 TO BUS 274817 CKT 1 / ZION ; R 345 ZIONE;RP 345
TRIP BRANCH FROM BUS 274817 TO BUS 270807 CKT 1 / ZIONE;RP 345 LIBER; R 345
END

29. (CE- CE) The WILTON ; B-WILTON ;3M 345 kV line (270926-275232 ckt 1) loads from 103.87% to 122.26% (AC power flow) of its load dump rating (1601 MVA) for the stuck breaker contingency outage of '112-65-BT5-6__'.

CONTINGENCY '112-65-BT5-6__'
TRIP BRANCH FROM BUS 270644 TO BUS 270607 CKT 1 / WILTO; 765 COLLI; 765
TRIP BRANCH FROM BUS 275233 TO BUS 270644 CKT 1 / WILTO;4M 345 WILTO; 765
TRIP BRANCH FROM BUS 275233 TO BUS 270927 CKT 1 / WILTO;4M 345 WILTO; R 345
TRIP BRANCH FROM BUS 275233 TO BUS 275333 CKT 1 / WILTO;4M 345 WILTO;4C 33
END

30. (CE- CE) The WILTON ; R-WILTON ;4M 345 kV line (270927-275233 ckt 1) loads from 106.06% to 124.83% (AC power flow) of its load dump rating (1601 MVA) for the stuck breaker contingency outage of '112-65-BT2-3__'.

CONTINGENCY '112-65-BT2-3__'
TRIP BRANCH FROM BUS 270644 TO BUS 270607 CKT 1 / WILTO; 765 COLLI; 765

TRIP BRANCH FROM BUS 275232 TO BUS 270644 CKT 1 / WILTO;3M 345 WILTO; 765

TRIP BRANCH FROM BUS 275232 TO BUS 270926 CKT 1 / WILTO;3M 345 WILTO; B 345
TRIP BRANCH FROM BUS 275232 TO BUS 275332 CKT 1 / WILTO;3M 345 WILTO;3C 33
END

31. (CE- CE) The ZION EC ;RP-LIBERTYVI; R 345 kV line (274817-270807 ckt 1) loads from 108.06% to 112.99% (AC power flow) of its emergency rating (1334 MVA) for the single contingency outage of 'ZION STA ; B-ZION STA ; R'.

CONTINGENCY 'ZION STA ; B-ZION STA ; R'
DISCONNECT BRANCH FROM BUS 270940 TO BUS 270941 CKT 1
END

32. (CE- CE) The ZION EC ;RP-ZION STA ; R 345 kV line (274817-270941 ckt 1) loads from 105.07% to 110.89% (AC power flow) of its emergency rating (1201 MVA) for the single contingency outage of '345-L2221__R-N'.

CONTINGENCY '345-L2221__R-N'
TRIP BRANCH FROM BUS 270941 TO BUS 699432 CKT 1 / ZION ; R 345 PLS PR2 345
END

4. Light Load analysis

- Model used – PJM AA1 Queue SIS 2018 Light Load case. All Active PJM queue projects modeled through the AA1 Queue along with all previously studied MISO DPP projects (studied through 2014). The MISO 2015 February and August DPP generators being studied were added to the model.
- Contingencies used – All PJM category B (single) and C contingencies (tower, bus fault, fault with stuck breaker)
- Monitored areas – All PJM areas
- Analysis type – PJM Generation Deliverability Test
- Analysis type – Light Load Generation Deliverability
    - All wind generators were scaled to 80% of their respective total capabilities for base case, category B, and category C events
    - The coal generator was scaled to 45% of its respective total capabilities for base case, category B, and category C events
- MISO generation sunk to MISO
- PJM generation sunk to PJM

5. Light Load Results

1. (CE - CE) The LORETTO ; B-WILTON ; B 345 kV line (from bus 270704 to bus 270926 ckt 1) loads from 109.78% to 111.18% (AC power flow) of its emergency rating (1280 MVA) for the single line contingency outage of '345-L8014_T_-S'. MISO project J375 contributes approximately 17.9829MW to this overload.

```
CONTINGENCY '345-L8014_T_-S'
 TRIP BRANCH FROM BUS 270853 TO BUS 270717 CKT 1          / PONTIAC ; R 345
DRESDEN ; R 345
 TRIP BRANCH FROM BUS 275210 TO BUS 270853 CKT 1          / PONTIAC ;2M 138
PONTIAC ; R 345
 TRIP BRANCH FROM BUS 275210 TO BUS 272261 CKT 1          / PONTIAC ;2M 138
PONTIAC ; R 138
 TRIP BRANCH FROM BUS 275210 TO BUS 275310 CKT 1          / PONTIAC ;2M 138
PONTIAC ;2C 34.5
 CLOSE BRANCH FROM BUS 272260 TO BUS 272261 CKT 1          / PONTIAC ; B 138
PONTIAC ; R 138
 END
```

2. (CE - CE) The LORETTO ; B-WILTON ; B 345 kV line (from bus 270704 to bus 270926 ckt 1) loads from 102.17% to 103.48% (AC power flow) of its emergency rating (1371 MVA) for the stuck breaker contingency outage of '012-45-BT11-14'. MISO project J375 contributes approximately 17.9739MW to this overload.

```
CONTINGENCY '012-45-BT11-14'
 TRIP BRANCH FROM BUS 270717 TO BUS 270737 CKT 1          / DRESDEN ; R 345
ELWOOD ; R 345
 TRIP BRANCH FROM BUS 270853 TO BUS 270717 CKT 1          / PONTIAC ; R 345
DRESDEN ; R 345
 TRIP BRANCH FROM BUS 275210 TO BUS 270853 CKT 1          / PONTIAC ;2M 138
PONTIAC ; R 345
 TRIP BRANCH FROM BUS 275210 TO BUS 272261 CKT 1          / PONTIAC ;2M 138
PONTIAC ; R 138
 TRIP BRANCH FROM BUS 275210 TO BUS 275310 CKT 1          / PONTIAC ;2M 138
PONTIAC ;2C 34.5
 CLOSE BRANCH FROM BUS 272260 TO BUS 272261 CKT 1          / PONTIAC ; B 138
PONTIAC ; R 138
 END
```

3. (CE - CE) The LORETTO ; B-WILTON ; B 345 kV line (from bus 270704 to bus 270926 ckt 1) loads from 101.98% to 103.29% (AC power flow) of its emergency

rating (1371 MVA) for the stuck breaker contingency outage of '080-45-BT7-8__'. MISO project J375 contributes approximately 17.9829MW to this overload.

```
CONTINGENCY '080-45-BT7-8__'
 TRIP BRANCH FROM BUS 270853 TO BUS 931361 CKT 1          / PONTIAC ; R 345 Z2-087
TAP 345
 TRIP BRANCH FROM BUS 270853 TO BUS 270717 CKT 1          / PONTIAC ; R 345
DRESDEN ; R 345
 TRIP BRANCH FROM BUS 275210 TO BUS 270853 CKT 1          / PONTIAC ;2M 138
PONTIAC ; R 345
 TRIP BRANCH FROM BUS 275210 TO BUS 272261 CKT 1          / PONTIAC ;2M 138
PONTIAC ; R 138
 TRIP BRANCH FROM BUS 275210 TO BUS 275310 CKT 1          / PONTIAC ;2M 138
PONTIAC ;2C 34.5
 CLOSE BRANCH FROM BUS 272260 TO BUS 272261 CKT 1          / PONTIAC ; B 138
PONTIAC ; R 138
 END
```

4. (CE - CE) The 05BENTON ; T-094 345 kV line (from bus 243212 to bus 247502 ckt 1) loads from 99.77% to 109.36% (AC power flow) of its emergency rating (1409 MVA) for the single line contingency outage of '7023_B2_TOR8101690'.

```
CONTINGENCY '7023_B2_TOR8101690'
 OPEN BRANCH FROM BUS 243215 TO BUS 247502 CKT 2          / 243215 05COOK 345
 247502 T-094 345    2
 END
```

6. Required System Upgrades & Cost Estimates/Allocations:

1. To relieve the Benton 345/138 kV transformer overloads:
   Add a 2nd Benton 345/138 kV transformer. Estimated cost: $3,500,000. An approximate construction time would be 24 to 36 months after signing an interconnection agreement. PJM Network Upgrade Number N4731.

   The driver for the overload is in the MISO 2015 August DPP Cycle.

The cost allocation is as follows:

Queue	MW contribution	% of Cost	3.5 Cost ($3.5 M)
G934	18.8	0.50	1.736
J264	13.3	0.35	1.228
J440	5.8	0.15	0.536

2. To relieve the Eugene – Bunsonville 345 kV line overload:

   The AEP end ratings are 1521/1718 MVA (SN/SE) and are sufficient.

   The MISO/AMIL end ratings are1692/1792 MVA (SN/SE) and are sufficient.

   No upgrades required for the Eugene – Bunsonville 345 kV line overload.

3. To relieve the Loretto – Wilton 345 kV line overload:

   There is a planned 2019 baseline upgrade, B2728, for the Loretto – Wilton Center 345kV line to mitigate sag limitations and replace station conductor at Wilton Center. New ratings to be 1364/1528/2221 SN/SE/SLD.

   MISO 2015 DPP project J375 can wait until the baseline upgrade (B2728) is placed into service or J375 can pay an advancement cost to place the baseline upgrade into service earlier, if feasible per ComEd. The feasibility of the advancement of the baseline upgrade will be determined during the PJM Facilities Study.

4. To relieve the Kincaid – Pawnee 345 kV line overloads:

   The ComEd end ALDR for this line segment is 1494 MVA and is sufficient. No ComEd end upgrade required.

   MISO/AMIL end: The MISO/AMIL end ratings are 956/956 MVA (SN/SE) for summer 2018. MISO analysis identified a violation on their end of this line during their April 2015 analysis of PJM projects. AA1-086 is responsible for this upgrade per MISO analysis. Due to MISO cost allocation rules, the 2015 MISO DPP projects do not receive any cost responsibility (MISO has confirmed). Note: if queue projects withdrawal from the Queue, the driver for

the overloads could become the MISO 2015 DPP projects and they would then receive cost responsibility. AA1-086 has withdrawn from the PJM queue and this needs to be retooled by MISO.

MISO project J375 contributes to this violation and may receive cost responsibility.

MISO Proposed Network Upgrade: Replace two switches and upgrade bus work. Cost Estimate is $1M.

5. To relieve the Pontiac - Loretto 345 kV line overload:

   There is a planned 2020 baseline upgrade, B2732.2, for the Pontiac - Loretto 345kV line to raise towers to remove the sag limitations. New ratings to be 1334/1528/1912 SN/SE/SLD. These ratings are sufficient for this 2018 study.

   MISO 2015 DPP project J375 can wait until the baseline upgrade (B2732.2) is placed into service or J375 can pay an advancement cost to place the baseline upgrade into service earlier, if feasible per ComEd. The feasibility of the advancement of the baseline upgrade will be determined during the PJM Facilities Study.

   Note: the present projected in-service date for B2732.2 is November 2016.

6. To relieve the Roscoe – Harlem 138 kV line overloads:

   Existing PJM baseline upgrade B2562 is planned to be put into service by summer 2019. B2562 will rebuild the Roscoe – Harlem 138 kV line. The new line ratings will be 269/349/498 MVA (SN/SE/ALDR).

   The only MISO 2015 DPP project contributing loading to this overload is J390. J390 can wait until B2562 is placed into service or J390 can pay an advancement cost to place B2562 into service earlier, if feasible per ComEd.

7. To relieve the Kelley Road – Belvidere 138 kV line overloads:

   Reconductor ~ 9 miles of overhead line to achieve a SN/SE/SLD rating of 208/264/275 MVA. Preliminary cost of $7M with 18-24 months construction period. PJM Network Upgrade N4732.

The only MISO 2015 DPP project contributing loading to this overload is J390. J390 is responsible for this cost.

8. To relieve the Cordova - Nelson 345 kV line overloads:

   PJM supplemental project S0704 (reconductor the line) was placed into service in early 2015. The ratings on the line are 1364/1528/1806 MVA (SN/SE/SLD). These ratings are no longer sufficient due to the MISO 2015 DPP projects.

   Existing PJM baseline upgrades B2692.1 & B2692.2 are planned to be put into service by summer 2019. B2692.1 & B2692.2 will upgrade the Cordova - Nelson 345 kV line. The new line ratings will be 1679/2058/2280 MVA (SN/SE/SLD).

   The following MISO 2015 DPP projects contribute loading to this overload: J298, J407, J411, J412, J416, J438, J442, J449. These projects can wait until B2692.1 & B2692.2 are placed into service or the projects can pay an advancement cost to place B2692.1 & B2692.2 into service earlier, if feasible per ComEd. ComEd has indicated that it is unlikely that PJM baseline upgrades B2692.1 & B2692.2 will be able to be advanced and put into service before 2019.

9. To relieve the Quad Cities – ESS H471 345 kV line overload:

   Existing PJM baseline upgrades B2692.1 & B2692.2 are planned to be put into service by summer 2019. B2692.1 & B2692.2 will upgrade the Quad Cities – ESS H471 345 kV line. The new line ratings will be 1679/2011/2280 MVA (SN/SE/SLD).

   The following MISO 2015 DPP projects contribute loading to this overload: J298, J407, J411, J412, J416, J438, J442, J449. These projects can wait until B2692.1 & B2692.2 are placed into service or the projects can pay an advancement cost to place B2692.1 & B2692.2 into service earlier, if feasible per ComEd. ComEd has indicated that it is unlikely that PJM baseline upgrades B2692.1 & B2692.2 will be able to be advanced and put into service before 2019.

10. To relieve the ESS H471 - Nelson 345 kV line overload:

    Existing PJM baseline upgrades B2692.1 & B2692.2 are planned to be put into service by summer 2019. B2692.1 & B2692.2 will upgrade the ESS H471 - Nelson 345 kV line. The new line ratings will be 1679/2011/2280 MVA (SN/SE/SLD).

    The following MISO 2015 DPP projects contribute loading to this overload: J298, J407, J411, J412, J416, J438, J442, J449. These projects can wait until B2692.1 & B2692.2 are placed into service or the projects can pay an advancement cost to place B2692.1 & B2692.2 into service earlier, if feasible per ComEd. ComEd has indicated that it is unlikely that PJM baseline upgrades B2692.1 & B2692.2 will be able to be advanced and put into service before 2019.

11. To relieve the Lee County - Byron 345 kV line overload:

    Upgrade - L0627 reconductor @ $29M (20-24 months). Based on reconductor work, SN/SE/SLD = 1679/2011/2280 MVA. PJM Network Upgrade N4737.

    The cost allocation is as follows:

Queue	MW contribution	Percentage of Cost	29 $ cost ($ 29 M)
J442	13.4	40.98%	11.8838
J449	19.3	59.02%	17.1162

12. To relieve the Wilton – Dumont 765 kV line overloads:
    a. The ComEd-end ALDR is 5466 MVA and is sufficient.
    b. AEP-end ratings are 4249/4801 MVA (SN/SE) and are sufficient.

13. To relieve the Stillwell – Dumont 345 kV line overloads:
    a. The PJM AA1 queue projects drive the loading above 1409 MVA SE. The upgrade is a sag study for less than $5M which is allocated to the PJM AA1 projects only at this time. The sag study results show work will include the replacement of tower 20 with a custom steel pole, replacement of tower 24 with a custom H-frame and the removal of swing angle brackets on 2 structures. Cost estimate is $1.613M The new expected AEP-end SE rating is to be 1718 MVA SE limited by a Dumont wavetrap and possibly the conductor.

b. The AEP-end 1718 MVA SE rating and the MISO-end 1779 MVA SE ratings are no longer sufficient due to the MISO 2015 DPP projects.
c. The AEP-end upgrade is to rebuild 9 miles of the AEP owned line and upgrade necessary Dumont terminal equipment (wavetrap) at a cost of $20M. PJM Network Upgrade N4790. New AEP-end ratings to be 1409/2045 MVA (SN/SE), limited by Dumont risers.
d. The MISO-end upgrade is to rebuild NIPSCO portion of line (2.87 miles) at a cost of $6.9M and upgrade Stillwell substation equipment at a cost of $1.2M for a total cost of $8.1M. The new expected MISO-end ratings will be 1869/2240 MVA SN/SE.
e. The total cost of this upgrade for both the AEP-end and the MISO-end is $28.1M.

f. The cost allocation is as follows:

			28.1
Queue	MW contribution	% of Cost	Cost ($28.1 M)
J394	25.8	0.33	9.259
J411	15.8	0.20	5.670
J298	19.6	0.25	7.034
J455	17.1	0.22	6.137

As changes to the PJM Interconnection Process occur (such as PJM or MISO projects withdrawing from the queue), the driver queue project can change and other MISO and/or PJM queue project(s) could receive cost allocation towards this upgrade going forward.

14. To relieve the Crete – St John 345 kV line overloads:
a. The ComEd-end ALDR is 1925 MVA and is sufficient.
b. MISO end ratings are 1206/1508 MVA (SN/SE) are not no longer sufficient due to the MISO 2015 February DPP projects.
c. MISO end upgrade is to upgrade St John substation conductor and switches. $1M cost estimate. New MISO end SE rating will be 1900 MVA.
d. The cost allocation is as follows:

			1
Queue	MW contribution	Percentage of Cost	$ cost ($ 1 M)

J390	61.4	72.58%	0.7258
J394	23.2	27.42%	0.2742

As changes to the PJM Interconnection Process occur (such as PJM or MISO projects withdrawing from the queue), the driver queue project can change and other MISO and/or PJM queue project(s) could receive cost allocation towards this upgrade going forward.

15. To relieve the Pleasant Prarie – Zion Station R 345 kV line overload, the Zion EC – Libertyville R 345 kV line overload, and the Zion EC – Zion Station R 345 kV line overload:

    The planned fix is the MTEP project 8065 which builds a new 345 kV substation by looping in the Zion - Libertyville Blue 345kV line and the Pleasant Prairie - Arcadian 345kV line. With MTEP project 8065, there are no overloads through MISO 2015 DPP. The Projected IS date for MTEP 8065 is 12-31-2020. The following projects contribute to these overloads: J390 and J394. J390 and J394 will need an interim study if coming into service prior to 12-31-2020 (i.e. the installation of MTEP 8065).

16. To relieve the WILTON ; B-WILTON ;3M 345 kV line overload and the WILTON ; R-WILTON ;4M 345 kV line overload:

    Build out the Wilton 765kV bus thereby allowing for 765kV L11216 (currently on Bus 6) to be relocated to Bus 8. Along with this line relocation, installation of 2-765kV BT CB's (6-8 & 8-2). Cost estimate is $11M. Time estimate is 24-30 months. This will eliminate the stuck breaker contingencies '112-65-BT2-3__' and '112-65-BT5-6__' which cause the overloads. PJM Network Upgrade N4947.

    The cost allocation is as follows:

Queue	MW contribution	Percentage of Cost	11 $ cost ($ 11 M)
J407	13.2	19.85%	2.183
J411	16.1	24.21%	2.663
J298	19.8	29.77%	3.275
J455	17.4	26.17%	2.878

17. To relieve the 05BENTON-T-094 345 kV line overload:

Reconductor or rebuild depending on the existing structures the portions of 345 kV lines between the Benton Harbor and Sagreto 345 kV substations. The estimated cost will approximately be $18,000,000 for the ACSR 954 45/7 Rail Conductor Section 1 and $1,000,000 for the ACSR/TW 1158.4 Type 13 Hudson Conductor Section 2. PJM Network Upgrade N5106.

MISO DPP 2015 project G736 is responsible for this cost.

The following projects contribute to this overload: J375, J407, J411, J416, J298, J412, J436, J437, J438, J442, J449, and J455.

As changes to the PJM Interconnection Process occur (such as PJM or MISO projects withdrawing from the queue), the driver queue project can change and other MISO and/or PJM queue project(s) could receive cost allocation towards this upgrade going forward.

PUBLIC DOCUMENT
NOT PUBLIC (OR PRIVILEGED) DATA HAS BEEN EXCISED

Docket No. E002/M-16-777
Reply Comments
Attachment B

Attachment B to these reply comments is marked as "Protected Data" in its entirety because it contains Trade Secret Information pursuant to Minn. Stat. § 13.37, subd. 1(b). The information contained in this attachment derives independent economic value, actual or potential, from not being generally known to, and not being readily ascertainable by proper means by other persons who can obtain economic value from its disclosure or use.

Because Attachment B is marked trade secret in its entirety, we provide the following additional information pursuant to Minn. Rule 7829.0500, subp. 3:

1. **Nature of the Material:** Energy Production Reports
2. **Authors:** AWS Truepower, LLC
3. **Importance:** Attachment B contains non-public, proprietary energy production data.
4. **Date the Information was Prepared:** November-December 2016.

PUBLIC DOCUMENT
NOT PUBLIC (OR PRIVILEGED) DATA HAS BEEN EXCISED

Capacity Factor Review of Build-Own-Transfer Projects

During the third step in the RFP evaluation process, the Company performed the Levelized Cost of Energy (LCOE) analysis using the net capacity factors (NCFs) provided by each of the respective bidders. Once the bid ranking by LCOE was complete, the company used AWSTruepower (AWS) to verify that the NCFs provided by the most competitive bidders were reasonable. AWS evaluated the top 26 bids and provided a Map Based Assessment, Loss Assessment and V110 Ranking for these bids. A summary of the AWS evaluation is included with this attachment. The results indicated that 9 out of the 26 bids did not provide reasonable NCF estimates. This analysis then fed into the non-price evaluation questions related to capacity factors and contributed to the determination of the final shortlist.

Crowned Ridge 300 MW BOT

The Crowned Ridge BOT was one of the nine bids that AWS deemed to have an unreasonable NCF. As part of the bid package, NextEra had provided a comprehensive study prepared by Windlogics, which indicated the project is expected to achieve a **[PROTECTED DATA BEGINS PROTECTED DATA ENDS]** NCF. During the development of the short-list, AWS reviewed the Windlogics study and indicated that the analysis understated losses. The Company then requested that AWS perform additional analysis on wake losses at Crowned Ridge and ultimately AWS determined that the **[PROTECTED DATA BEGINS PROTECTED DATA ENDS]** was a reasonable estimate.

During negotiations, NextEra proposed to use different turbine models than what had been included in the bid and via Windlogics indicated the revised turbines would achieve a **[PROTECTED DATA BEGINS PROTECTED DATA ENDS]** NCF. However, AWS indicated that the NCF would potentially decline as a result of the use of different turbine types and configurations. As a result, the Company adjusted the **[PROTECTED DATA BEGINS PROTECTED DATA ENDS]** NCF down to **[PROTECTED DATA BEGINS PROTECTED DATA ENDS]** based on discussions with AWS in order to use a more conservative estimate in the LCOEs presented in the wind petition.

Lake Benton BOT

Similar to Crowned Ridge, the NCF provided by NextEra for Lake Benton was also one of the nine bids initially deemed unreasonable by AWS. The Windlogics study provided for Lake Benton as part of the NextEra bid stated the project would achieve a **[PROTECTED DATA BEGINS PROTECTED DATA ENDS]** NCF. As the bid was near the top of the shortlist, the Company requested additional analysis from AWS to further screen the Lake Benton NCF. After additional analysis on wake losses, AWS still felt the NCF was unreasonable so the Company reduced the NCF to the AWS estimate of **[PROTECTED DATA BEGINS PROTECTED DATA ENDS]**to reflect a more conservative estimate in the updated LCOEs presented in the wind petition.

As with Crowned Ridge, during negotiations NextEra asked to use alternate combinations of turbines and provided a revised Windlogics analysis that estimated a **[PROTECTED DATA BEGINS PROTECTED DATA ENDS]** NCF using the new turbine types and configurations. Again, AWS did not agree that the new configurations would increase the NCFs so the Company opted to hold the NCF at **[PROTECTED DATA BEGINS PROTECTED DATA ENDS]**.

Developer	Project	Bid ID	Full Study Provided	Onsite Data	Turbine Layout	Loss Details	Wake Loss Provided	NCF Reasonable
Allete	CE1	P147		†	†			Y
[PROTECTED DATA BEGINS								
				†	†			Y
				†	†			Y
				†	†			N
				†	†			N
				†	†			N
				†	†			N
			†	†	†	†	†	Y
								Y
								Y
								N
								Y
			†	†	†	†	†	Y
			†	†	†	†	†	N
	PROTECTED DATA ENDS]							
NextEra	Crowned Ridge (600)	C31	†	†	†	†	†	N
NextEra	Lake Benton	B211	†	†	†	†	†	N
[PROTECTED DATA BEGINS								
			†		†	†	†	N
			†	†	†	†	†	Y
			†	†	†	†	†	Y
			†	†	†	†	†	Y
			†	†	†	†	†	Y
			†	†	†	†	†	Y
				†	†			Y
				†	†			Y
				†	†			Y
				†	†			Y

PROTECTED DATA ENDS]

** **[PROTECTED DATA BEGINS** **PROTECTED DATA ENDS]** is the only project of which there is enough information provided for AWST to complete a traditional Desktop Review*

***AWS would be able to conduct a full wind resource and energy analysis for the projects which have 'Onsite Data'. Pricing & timing can be provided upon request.*
Data requirements for this type of analysis are included in the 'WRA+EPE Data Requirements' tab

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Developer	Project	Client Bid				AWS Map Based Evaluation				% Diff in Gross Energy	Diff in Losses	% Diff in Net Energy	Diff in NCF Pts	Comments
		Gross Energy	% Losses	Net Energy	NCF	Gross Energy	% Losses	Net Energy	NCF					
[PROTECTED DATA BEGINS														

PROTECTED DATA ENDS]

PUBLIC DOCUMENT
NOT PUBLIC (OR PRIVILEGED) DATA HAS BEEN EXCISED

Developer	Project	Client Bid				Client Gross Adjusted w/ AWS Losses				Diff in Losses	% Diff in Net Energy	Diff in NCF Pts	Comments
		Gross Energy	% Losses	Net Energy	NCF	Gross Energy	% Losses	Net Energy	NCF				
[PROTECTED DATA BEGINS													

PROTECTED DATA ENDS]

PUBLIC DOCUMENT
NOT PUBLIC (OR PRIVILEGED) DATA HAS BEEN EXCISED

Developer	**Project**	**Net Energy**	**NCF**
[PROTECTED DATA BEGINS			

PROTECTED DATA ENDS]

[PROTECTED DATA
BEGINS

PROTECTED DATA ENDS]

AWS Truepower®

Data Requirements for Energy Production Reports

Site Meteorological Data

For each item of meteorological equipment, please provide the following information:

- Raw 10-minute or hourly binary data files from equipment data logger
- Description of equipment, including make and type
- Commissioning form:
  - At minimum the form should contain location, type, and configuration of equipment
  - Calibration certificates, particularly for anemometers
  - Conversion factors used in recording wind speed
- Maintenance history reports, detailing any changes made to the measuring equipment
- Site photos, showing surroundings of equipment and configuration of measuring instruments

Wind Turbine Information

For each type of turbine for which an energy estimate is required:

- Make and model
- Rotor diameter
- Hub height
- Power curve with details of applicable air density and turbulence intensity
- Thrust curve with details of applicable air density and turbulence intensity
- Operating parameters such as high speed cut out/cut in
- Information on any extreme weather package options, especially operating temperature range

Wind Farm Information

- Turbine layout as coordinates
- Information on nearby operating, or future planned, wind farms - farm layouts and turbine types
- Any project specific loss documentation
- Any project specific turbine suitability forms
- Any project specific curtailment scenarios, for example directional, environmental, grid, etc

Last Revised: 30 September 2015

AWS Map-Based Assessment

1. Extract Weibull A/k Values at centroid location (listed on RFP Bid form) for each project from AWST's 200-m Wind Map (at the appropriate project HH)

-- The A/k value were then used to create a frequency distribution for the project

2. Compute gross energy by applying the appropriate turbine power curve to the frequency distribution

-- The power curve used was at a similar air density as would be expected at the site per the AWST Wind Map output

-- The total energy value for each wind speed bin was summed up, to get a total energy for an individual turbine, then multiplied by the # of turbines required to meet the project plant capacity.

3. Estimate net energy by applying appropriate project losses.

-- If a wake loss was supplied; the loss was reviewed for reasonableness; if found reasonable that value was used in the AWS assessment.

-- For projects where a wake loss was not applied, a generic wake loss was applied based on plant capacity and expected # of WTGs

-- All other project losses were applied that would be appropriate for the project location and turbine technology utilized

AWS Loss Assessment

1. Utilized gross energy provided by the client for those projects which it was provided

2. Estimate net energy by applying appropriate project losses.

-- If a wake loss was supplied; the loss was reviewed for reasonableness; if found reasonable that value was used in the AWS assessment.

-- For projects where a wake loss was not applied, a generic wake loss was applied based on plant capacity and expected # of WTGs

-- All other project losses were applied that would be appropriate for the project location and turbine technology utilized

V110 Ranking

1. Extract Weibull A/k Values at centroid location (listed on RFP Bid form) for each project from AWST's 200-m Wind Map at an 80-m HH

-- The A/k value were then used to create a frequency distribution for the project

2. Compute gross energy by applying the V110 power curve to the frequency distribution

-- The power curve used was at a similar air density as would be expected at the site per the AWST Wind Map output

-- The total energy value for each wind speed bin was summed up, to get a total energy for an individual turbine, then multiplied by the # of turbines required to meet the project plant capacity.

3. Estimate net energy by applying appropriate project losses.

-- If a wake loss was supplied; the loss was reviewed for reasonableness; if found reasonable that value was used in the AWS assessment.

-- For projects where a wake loss was not applied, a generic wake loss was applied based on plant capacity and expected # of WTGs

-- All other project losses were applied that would be appropriate for the project location and assumes the Vestas V110-2.0 MW turbine is being used