Report Number: R003-24

MISO Affected System Study for SPP DISIS-2017-001 #R4

Prepared for

MISO

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02/27/2024

Siemens PTI Project Number: 62OT-002450-B-1

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Revision History

Date	Rev.	Description
10/18/2023	A	Initial draft
02/27/2024	B	Final report

Contents

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Executive Summary

This report presents restudy results of an Affected System Impact Study (AFSIS) on MISO transmission system performed for generator interconnection requests in the Southwest Power Pool (SPP) queue 2017-001 cluster (Study Projects). The AFSIS restudy results are summarized below.

1.1 Study Projects List

The generation projects (Study Projects) in SPP DISIS 2017-001 cluster are listed in Table ES-1.

Table ES-1: SPP DISIS 2017-001 Study Projects

Project #	Town or County	State	Point of Interconnection	Generation Type	Service Request (MW)	SH (MW)
GEN-2017-004	Cloud	KS	Elm Creek - Summit 345 kV	Wind	201.6	201.6
GEN-2017-010	Bowman	ND	Rhame 230 kV	Wind	200.1	200.1
GEN-2017-014	Haakon	SD	Philip Tap 230 kV	Wind	300	300
GEN-2017-048	Williams	ND	Neset 230 kV	Wind	300	300
GEN-2017-094	Wessington / Hand	SD	Fort Thompson-Huron 230 kV	Wind	200	200

1.2 MISO AFSIS Restudy Summary

MISO AFSIS restudy steady state models were developed from the final models used in MISO AFSIS study for DISIS-2017-001 Phase 3 cycle. MISO AFSIS restudy stability package was developed from the final stability package used in MISO AFSIS study for DISIS-2017-001 Phase 2 cycle.

For this MISO AFSIS restudy, steady state analysis and stability analysis were only performed in the summer shoulder scenario.

Steady state thermal and voltage analysis was performed to identify any thermal and voltage violations in the MISO system. Thermal and voltage AFSIS Network Upgrades identified in the summer shoulder scenario for steady state analysis are listed in Table ES-2 and Table ES-3.

Table ES-2: AFSIS Restudy Thermal Network Upgrades Identified for DISIS-2017-001 Study Projects

Constraint	Owner	Mitigation	Cost ($)
Neset 230-115-13.9 kV xfmr	BEPC	Non-MISO facility. NU is not required	$0

Table ES-3: AFSIS Restudy Voltage Network Upgrades Identified for DISIS-2017-001 Study Projects

Constraint	Network Upgrades	Owner	Cost ($)
Low voltages in Wahpeton area under system intact condition	Add 40 MVar switched cap at Wahpeton 230 kV (620329)	OTP	$3,500,000
Low voltages in Buffalo area under system intact condition	Add 60 MVar switched cap at Buffalo 345 kV (620358)	OTP	$3,500,000
Low voltages in Blackhawk area under P1-P7 contingencies	100 MVAR 345kV capacitor bank at Blackhawk 345 kV (636199)	MEC	$10,000,000
Low voltage at Montezuma under P1 contingency	100 MVAR 345kV Cap Bank at Montezuma 345 kV (635730)	MEC	$6,000,000

Transient stability analysis was performed to identify any transient stability violations caused by the SPP DISIS-2017-001 Study Projects. No transient stability constraints were identified in the MISO system. No MISO AFSIS stability NUs were identified in the transient stability analysis.

1.3 Total MISO AFSIS Network Upgrades

The total cost of MISO AFSIS Network Upgrades (NU) required for the Study Projects in DISIS-2017-001 is listed in Table ES-4. The costs for Network Upgrades are planning level estimates and subject to be revised in the facility studies.

Table ES-4: Total Cost of MISO AFSIS Network Upgrades for DISIS-2017-001 Study Projects

Project Num	Network Upgrades ($)		Total Network Upgrade Cost ($)
	MISO Thermal & Voltage	Transient Stability	
GEN-2017-004	$1,976,128	$0	$1,976,128
GEN-2017-010	$4,502,925	$0	$4,502,925
GEN-2017-014	$5,913,327	$0	$5,913,327
GEN-2017-048	$6,370,542	$0	$6,370,542
GEN-2017-094	$4,237,078	$0	$4,237,078
Total ($)	**$23,000,000**	**$0**	**$23,000,000**

It should be noted that a restudy may be required should significant changes to the study assumptions occur, including but not limited to, interconnection request withdrawals and/or changes to higher-queued Network Upgrades included in the Base Case.

As the next step, MISO will initiate the Network Upgrade Facilities Study (NUFS) with the Transmission Owner(s). If the TO determines no further study is required, MISO will draft Facilities Construction Agreement (FCA) and begin negotiations between MISO, MISO TO and SPP ICs.

1.4 Per Project Summary

This section provides estimated cost of MISO AFSIS Network Upgrades on a per project basis for the Study Projects in SPP DISIS-2017-001 cluster.

MISO AFSIS Network Upgrade costs are allocated to the below projects. No injection is allowed for the projects until all the allocated Network Upgrade(s) are in service, except for a revised report provided by MISO removing the requirements, or an interim limit provided for the projects through MISO Annual ERIS or Quarterly Operating Limit studies.

1.4.1 GEN-2017-004 Summary

Network Upgrade	Owner	Cost	GEN-2017-004	NUs Type
Add 40 MVar switched cap at Wahpeton 230 kV (620329)	OTP	$3,500,000	$139,144	SH Volt
Add 60 MVar switched cap at Buffalo 345 kV (620358)	OTP	$3,500,000	$103,495	SH Volt
100 MVAR 345kV capacitor bank at Blackhawk 345 kV (636199)	MEC	$10,000,000	$1,100,324	SH Volt
100 MVAR 345kV Cap Bank at Montezuma 345 kV (635730)	MEC	$6,000,000	$633,166	SH Volt
Total Cost Per Project			**$1,976,128**	

1.4.2 GEN-2017-010 Summary

Network Upgrade	Owner	Cost	GEN-2017-010	NUs Type
Add 40 MVar switched cap at Wahpeton 230 kV (620329)	OTP	$3,500,000	$813,456	SH Volt
Add 60 MVar switched cap at Buffalo 345 kV (620358)	OTP	$3,500,000	$884,409	SH Volt
100 MVAR 345kV capacitor bank at Blackhawk 345 kV (636199)	MEC	$10,000,000	$1,779,935	SH Volt
100 MVAR 345kV Cap Bank at Montezuma 345 kV (635730)	MEC	$6,000,000	$1,025,126	SH Volt
Total Cost Per Project			**$4,502,925**	

1.4.3 GEN-2017-014 Summary

Network Upgrade	Owner	Cost	GEN-2017-014	NUs Type
Add 40 MVar switched cap at Wahpeton 230 kV (620329)	OTP	$3,500,000	$845,566	SH Volt
Add 60 MVar switched cap at Buffalo 345 kV (620358)	OTP	$3,500,000	$790,323	SH Volt
100 MVAR 345kV capacitor bank at Blackhawk 345 kV (636199)	MEC	$10,000,000	$2,588,997	SH Volt
100 MVAR 345kV Cap Bank at Montezuma 345 kV (635730)	MEC	$6,000,000	$1,688,442	SH Volt
Total Cost Per Project			**$5,913,327**	

1.4.4 GEN-2017-048 Summary

Network Upgrade	Owner	Cost	GEN-2017-048	NUs Type
Add 40 MVar switched cap at Wahpeton 230 kV (620329)	OTP	$3,500,000	$1,081,040	SH Volt
Add 60 MVar switched cap at Buffalo 345 kV (620358)	OTP	$3,500,000	$1,223,118	SH Volt
100 MVAR 345kV capacitor bank at Blackhawk 345 kV (636199)	MEC	$10,000,000	$2,588,997	SH Volt
100 MVAR 345kV Cap Bank at Montezuma 345 kV (635730)	MEC	$6,000,000	$1,477,387	SH Volt
Total Cost Per Project			**$6,370,542**	

1.4.5 GEN-2017-094 Summary

Network Upgrade	Owner	Cost	GEN-2017-094	NUs Type
Add 40 MVar switched cap at Wahpeton 230 kV (620329)	OTP	$3,500,000	$620,795	SH Volt
Add 60 MVar switched cap at Buffalo 345 kV (620358)	OTP	$3,500,000	$498,656	SH Volt
100 MVAR 345kV capacitor bank at Blackhawk 345 kV (636199)	MEC	$10,000,000	$1,941,748	SH Volt
100 MVAR 345kV Cap Bank at Montezuma 345 kV (635730)	MEC	$6,000,000	$1,175,879	SH Volt
Total Cost Per Project			**$4,237,078**	

It should be noted that a restudy may be required should significant changes to the study assumptions occur, including but not limited to, interconnection request withdrawals and/or changes to higher-queued Network Upgrades included in the Base Case.

Section

1

Model Development and Study Criteria

1.1 Model Development

Steady state models used in this AFSIS restudy were developed from the final study model used in MISO AFSIS study for DISIS-2017-001 Phase 3 cycle. The MISO AFSIS final study model for DISIS-2017-001 Phase 3 cycle is listed below:

- Summer shoulder study model: MISO18_2023_SH90_2017FebDPP-Ph3_Post_v1.sav

Stability study model used in this AFSIS restudy was developed from the final stability power flow model used in MISO AFSIS study for DISIS-2017-001 Phase 2 cycle. The stability power flow model for DISIS-2017-001 Phase 2 cycle is listed below:

- MISO18_2023_SH90_STABILITY_2017FebDPP-Ph3_StudyCase_190822_Post-All_r2.sav

1.1.1 MISO AFSIS Study Models

The steady state study model and stability power flow model for the AFSIS restudy were created as follows:

- Removed recently withdrawn SPP prior queued generation projects (Table A-1). Trued up generation dispatch for several SPP prior queued projects (Table A-2). Dispatched GEN-2017-014 project at Pmax. Removed non-existing extra 230 kV line GEN-2017-014 - PHILIP_T-BE4 (588590 – 659188). Power mismatch was balanced by scaling generation in SPP market (Table A-7) based on the load-ratio share of the Transmission Owner (TO) power flow modeling areas.
- Removed recently withdrawn MISO prior queued generation projects (Table A-3). Removed withdrawn MPC02800 generation project. Power mismatch was balanced by scaling generation in the MISO North (Table A-6).
- Removed MISO Network Upgrades no longer assigned to prior queued projects. Corrected modeling errors. These changes are in Table A-4. Power mismatch was balanced by scaling generation in the MISO North (Table A-6).
- Removed SPP Network Upgrades no longer assigned to prior queued projects. Corrected modeling errors. These changes are in Table A-5. Power mismatch was balanced by scaling generation in SPP market (Table A-7) based on the load-ratio share of the TO power flow modeling areas.

1.1.2 MISO AFSIS Benchmark Model

Summer shoulder (SH) benchmark model was created by turning off the DISIS-2017-001 Study Projects (Table ES-1) from the benchmark case. Power mismatch was balanced by scaling generation in SPP market (Table A-7) based on the load-ratio share of the TO power flow modeling areas.

Both study and benchmark power flow cases were solved with transformer tap adjustment enabled, area interchange disabled, phase shifter adjustment enabled and switched shunt adjustment enabled.

1.2 Contingency Criteria

The following contingencies were considered in the steady-state analysis:

- NERC Category P0 (system intact - no contingencies)
- NERC Category P1 contingencies
    - Single element outages, at buses with a nominal voltage of 57 kV and above.
    - Multiple-element NERC Category P1 contingencies.
    - NERC Category P2, P4, P5, P7 contingencies.

The detailed list of contingency files is in Appendix A.8

For all contingency and post-disturbance analyses, cases were solved with transformer tap adjustment enabled, area interchange adjustment disabled, phase shifter adjustment disabled (fixed) and switched shunt adjustment enabled.

1.3 Monitored Elements

The study area is defined in Table 1-1. Facilities in the study area were monitored for system intact and contingency conditions. Under NERC category P0 conditions (system intact) branches were monitored for loading above the normal (PSS®E rate A) rating. Under NERC category P1-P7 conditions, branches were monitored for loading as shown in the column labeled "Post-Disturbance Thermal Limits".

Table 1-1: Monitored Elements

Owner / Area	Thermal Limits [1]		Voltage Limits [2]	
	Pre-Disturbance	Post-Disturbance	Pre-Disturbance	Post-Disturbance
AMIL	100% of Rate A	100% of Rate B	1.05/0.95	1.075/0.90
AMMO	100% of Rate A	100% of Rate B	1.05/0.95	1.075/0.90
CWLD	100% of Rate A	100% of Rate B	1.05/0.95	1.10/0.90
CWLP	100% of Rate A	100% of Rate B	1.05/0.95	1.075/0.90
SIPC	100% of Rate A	100% of Rate B	1.07/0.95	1.09/0.91
ATCLLC	100% of Rate A	100% of Rate B	1.05/0.95	1.10/0.90
BEPC-MISO	100% of Rate A	100% of Rate B	1.05/0.95	1.10/0.90
CMMPA	100% of Rate A	100% of Rate B	1.05/0.95	1.07/0.90
DPC	100% of Rate A	100% of Rate B	1.05/0.95	1.10/0.90
GRE	100% of Rate A	100% of Rate B	1.05/0.95	1.10/0.92/0.90

Owner / Area	Thermal Limits [1]		Voltage Limits [2]	
	Pre-Disturbance	Post-Disturbance	Pre-Disturbance	Post-Disturbance
ITCM	100% of Rate A	100% of Rate B	1.07/1.05/0.95	1.10/0.93
MDU	100% of Rate A	100% of Rate B	1.05/0.95	1.10/0.90
MEC	100% of Rate A	100% of Rate B	1.05/0.96/0.95	1.05/0.96/0.95/0.94/0.93[3]
MHEB	100% of Rate A	100% of Rate B	1.12/1.1/1.07/1.05/1.04/ 0.99/0.97/0.96/0.95	1.15/1.10/0.94/0.90
MMPA	100% of Rate A	100% of Rate B	1.05/0.95	1.10/0.90
MP	100% of Rate A	100% of Rate B	1.05/1.00	1.10/0.95
MPC	100% of Rate A	100% of Rate B	1.05/0.97	1.10/0.92
MPW	100% of Rate A	100% of Rate B	1.05/0.95	1.06/0.92
MRES	100% of Rate A	100% of Rate B	1.05/0.97	1.05/0.92
OTP	100% of Rate A	100% of Rate B	1.07/1.05/0.97	1.10/0.92
RPU	100% of Rate A	100% of Rate B	1.05/0.95	1.10/0.92
SMMPA	100% of Rate A	100% of Rate B	1.05/0.95	1.10/0.90
XEL	100% of Rate A	100% of Rate B	1.05/0.95	1.05/0.92

Notes

1. PSS®E Rate A, Rate B or Rate C
2: Limits dependent on nominal bus voltage
3: For facilities in Cedar Falls Utilities or Ames Municipal Utilities, post-contingency voltage limits are 1.05/0.94 for >200 kV, and 1.05/0.93 for others.

1.4 MISO Steady State Performance Criteria

A branch is considered as a thermal injection constraint if the branch is loaded above its applicable normal or emergency rating for the post-change case, and any of the following conditions are met:

1) the generator (NR/ER) has a larger than 20% DF on the overloaded facility under post contingent condition or 5% DF under system intact condition, or
2) the megawatt impact due to the generator is greater than or equal to 20% of the applicable rating (normal or emergency) of the overloaded facility, or
3) the overloaded facility or the overload-causing contingency is at generator's outlet, or
4) for any other constrained facility, where none of the study generators meet one of the above criteria in 1), 2), or 3), however, the cumulative megawatt impact of the group of study generators (NR/ER) is greater than 20% of the applicable rating, then only those study generators whose individual MW impact is greater than 5% of the applicable rating and has DF greater than 5% (OTDF or PTDF) will be responsible for mitigating the cumulative MW impact constraint.

A bus is considered a voltage constraint if both of the following conditions are met. All voltage constraints must be resolved before a project can receive interconnection service.

1) the bus voltage is outside of applicable normal or emergency limits for the post-change case, and
2) the change in bus voltage is greater than 0.01 per unit.

All Study Projects must mitigate thermal injection constraints and voltage constraints in order to obtain unconditional Interconnection Service.

Section 2

MISO Steady-State Thermal and Voltage Analysis

Nonlinear (AC) contingency analysis was performed on the benchmark and study cases, and the incremental impact of the DISIS-2017-001 Study Projects was evaluated by comparing the steady-state performance of the transmission system in the benchmark and study cases. Network upgrades were identified to mitigate any steady state thermal and voltage constraints.

Steady-state analysis was performed in summer shoulder scenario. PSS®E version 33.12.1 and PSS®MUST version 12.4.1 were used in the study.

2.1 MISO Contingency Analysis for Summer Shoulder Condition

Steady state AC contingency analysis was performed on the MISO AFSIS summer shoulder (SH) study and benchmark cases developed in Section 1.1. The summer shoulder MISO AFSIS thermal and voltage results are in Appendix B.1.

2.1.1 Summer Shoulder System Intact Conditions

For NERC category P0 (system intact) conditions, no thermal constraints were identified (Table B-1); Voltage constraints are listed in Table B-2.

2.1.2 Summer Shoulder Post Contingency Conditions

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

For P1 contingencies, thermal constraints are listed in Table B-3, and voltage constraints are listed in Table B-4.

One category P2-P7 contingency (Table B-7) was not converged in both the benchmark and study cases. No mitigation plan is required for the DISIS-2017-001 Study Projects for this non-converged contingency.

For the non-converged contingencies in Table B-7, DC contingency analysis was performed to get the dc thermal results. The dc thermal results for non-converged contingencies are listed in Table B-8.

For P2-P7 converged contingencies, thermal constraints are listed in Table B-5, and voltage constraints are listed in Table B-6.

2.2 Summer Shoulder Worst Constraints

In the summer shoulder scenario, MISO AFSIS worst thermal constraints are listed in Table 2-1, and MISO AFSIS worst voltage constraints are listed in Table 2-2.

Table 2-1: Summer Shoulder MISO AFSIS Thermal Constraints, Maximum Screened Loading

Constraint	Rating	Owner	Worst Loading		Contingency	Cont Type
			(MVA)	(%)		
Neset 230-115-13.9 kV xfmr	188.0	BEPC	199.0	105.9	CEII Redacted	P1
Neset 230-115-13.9 kV xfmr	188.0	BEPC	199.9	106.4	CEII Redacted	P2-P7

Table 2-2: Summer Shoulder MISO AFSIS Voltage Constraints, Worst Voltage Violations

Bus			Owner	Vlow	Vhi	Benchmark	StudyCase	Delta (> 0.01 p.u.)	Contingency Details	Cont Type
						VCONT	VCONT			
1	FRANKLIN 3	345	MEC	0.96	1.05	0.9431	0.9183	-0.0248	CEII Redacted	P1
1	FRANKLIN 3	345	MEC	0.94	1.05	0.9298	0.9018	-0.0280	CEII Redacted	P2-P7
620259	ALICE 7	115	OTP	0.97	1.07	0.9934	0.9684	-0.0250	CEII Redacted	P0
620260	ENDERLN7	115	OTP	0.97	1.07	0.9908	0.9657	-0.0251	CEII Redacted	P0
620269	JAMSTWN7	115	OTP	0.97	1.07	0.9880	0.9683	-0.0197	CEII Redacted	P0
620329	WAHPETN4	230	OTP	0.97	1.05	0.9853	0.9621	-0.0232	CEII Redacted	P0
620358	BUFFALO3	345	OTP	0.97	1.05	0.9855	0.9576	-0.0279	CEII Redacted	P0

Bus			Owner	Vlow	Vhi	Benchmark VCONT	StudyCase VCONT	Delta (> 0.01 p.u.)	Contingency Details	Cont Type
620361	MAPLE R3	345	OTP	0.97	1.05	0.9890	0.9631	-0.0259	CEII Redacted	P0
620369	JAMESTN3	345	OTP	0.97	1.05	0.9863	0.9610	-0.0253	CEII Redacted	P0
631139	HAZLTON3	345	ITCM	0.93	1.10	0.9378	0.9194	-0.0184	CEII Redacted	P2-P7
631206	QUINN3	345	ITCM	0.93	1.10	0.9515	0.9264	-0.0251	CEII Redacted	P1
631206	QUINN3	345	ITCM	0.93	1.10	0.9432	0.9242	-0.0190	CEII Redacted	P2-P7
635730	MNTZUMA3	345	MEC	1.00	1.05	0.9970	0.9866	-0.0104	CEII Redacted	P1
636199	BLACKHAWK 3	345	MEC	0.96	1.05	0.9507	0.9333	-0.0174	CEII Redacted	P1
636199	BLACKHAWK 3	345	MEC	0.94	1.05	0.9391	0.9165	-0.0226	CEII Redacted	P2-P7
636300	FLOYD 5	161	MEC	0.93	1.05	0.9434	0.9286	-0.0148	CEII Redacted	P2-P7
636302	CH CITY S 8	69	MEC	1.00	1.05	0.9944	0.9833	-0.0111	CEII Redacted	P1
657923	PICKERT8	69	MPC	0.97	1.05	1.0016	0.9691	-0.0325	CEII Redacted	P0
658102	GRANTCO7	115	MRES	0.97	1.05	0.9918	0.9699	-0.0219	CEII Redacted	P0

Bus			Owner	Vlow	Vhi	Benchmark	StudyCase	Delta (> 0.01 p.u.)	Contingency Details	Cont Type
						VCONT	VCONT			
658109	FERGSFL4	230	MRES	0.97	1.05	0.9860	0.9606	-0.0254	CEII Redacted	P0

2.3 Summary of MISO AFSIS Steady State Analysis

MISO AFSIS steady state analyses were performed on the MISO summer shoulder scenario. The steady state thermal constraints and required Network Upgrades are listed in Table 2-3, and voltage constraints and required Network Upgrades are listed in Table 2-4.

Table 2-3: MISO AFSIS Thermal Constraints and Network Upgrades in Summer Shoulder Scenario

Generator	Constraint	Owner	Mitigation	Cost ($)
GEN-2017-048	Neset 230-115-13.9 kV xfmr	BEPC	Non-MISO facility. NU is not required	$0

Table 2-4: MISO AFSIS Voltage Constraints and Network Upgrades in Summer Shoulder Scenario

Constraint	Network Upgrades	Owner	Cost ($)
Low voltages in Wahpeton area under system intact condition	Add 40 MVar switched cap at Wahpeton 230 kV (620329)	OTP	$3,500,000
Low voltages in Buffalo area under system intact condition	Add 60 MVar switched cap at Buffalo 345 kV (620358)	OTP	$3,500,000
Low voltages in Blackhawk area under P1-P7 contingencies	100 MVAR 345kV capacitor bank at Blackhawk 345 kV (636199)	MEC	$10,000,000
Low voltage at Montezuma under P1 contingency	100 MVAR 345kV Cap Bank at Montezuma 345 kV (635730)	MEC	$6,000,000

Section

3

Stability Analysis

Stability analysis was performed to evaluate transient stability and impact on the region of the DISIS-2017-001 Study Projects.

3.1 Procedure

3.1.1 Computer Programs

Stability analysis was performed using PSS®E version 33.12.1.

3.1.2 Methodology

Stability package representing summer shoulder (SH) scenario with DISIS-2017-001 Study Projects was created from the final stability package used in MISO AFSIS study for DISIS-2017-001 Phase 2 cycle. The stability power flow model was developed from the final stability power flow model used in MISO AFSIS study for DISIS-2017-001 Phase 2 cycle, which was detailed in Section 1.1. Disturbances were simulated to evaluate the transient stability and impact on the region of the DISIS-2017-001 Study Projects. MISO transient stability criteria and local TOs' planning criteria were adopted for checking stability violations.

3.2 Model Development

Summer shoulder stability power flow model was developed from the final stability power flow model used in MISO AFSIS study for DISIS-2017-001 Phase 2 cycle, using the same procedure as specified in Section 1.1.

3.3 Disturbance Criteria

The stability simulations performed as part of this study considered all the regional and local contingencies listed in Table 3-1. Regional contingencies with pre-defined switching sequences were selected from the MISO MTEP study; switching sequences for local contingencies were developed based on the generic clearing times shown in Table 3-2. The admittance for local single line-to-ground (SLG) faults were estimated by assuming that the Thevenin impedance of the positive, negative and zero sequence networks at the fault point are equal.

Table 3-1: Regional and Local Disturbance Descriptions

CEII Redacted

Table 3-2: Generic Clearing Time Assumption

Voltage Level (kV)	Primary Clearing Time (cycle)	Backup Clearing Time (cycle)
345 kV	4	11
230 kV	5	13
161/138 kV	6	18
115 kV	6	20
69 kV	8	24

3.4 Performance Criteria

MISO transient stability criteria and local TOs' planning criteria were adopted. The Study Projects must mitigate the stability constraints to obtain any type of Interconnection Service.

3.5 Summer Shoulder Stability Results

The contingencies listed in Table 3-1 were simulated using the summer shoulder stability study case as developed in Section 1.1.

Appendix C.1.2 contains plots of generator rotor angles, generator power output, and bus voltages for each simulation. Simulations were performed with a 0.5 seconds steady-state run followed by the appropriate disturbance. Simulations were run for a 10-second duration.

Summer shoulder stability study results summary is in Appendix C.1.1, Table C-1.

The following stability related issues were identified in the summer shoulder stability study.

3.5.1 GEN-2017-014 Tripped by High Frequency Relay

Under two contingencies listed in Table 3-3, GEN-2017-014 generator was tripped by frequency relay (>61.7 Hz for more than 0.05 sec). If the frequency relay was blocked, no other stability violations were found in either MISO or SPP systems under the contingency of "G17-014-TAP_3PH_POI_NUNDRWD4_Fault". But under the contingency of "G17-014-TAP_3PH_POI_PHILIP_T-BE4_Fault", post-fault voltages in SPP system at G17-014 POI (588594), New Underwood (652484, 652884), Dry Creek (659376) 230 kV buses were below 0.9 pu.

Under these two contingencies, no stability violations were identified in MISO system. Therefore, MISO AFSIS Network Upgrades were not required.

Table 3-3: Two Contingencies Causing GEN-2017-014 Tripped by Freq Relay

CEII Redacted

3.5.2 GEN-2017-014 Tripped by Low Voltage Relay

Under the contingency "G17-014-TAP_SLG_POI_PHILIP_T-BE4_Fault", GEN-2017-014 generator was tripped by low voltage relay (<0.89 pu for more than 3 sec). Under the contingency "G17-014-TAP_3PH_POI_PHILIP_T-BE4_Fault', if the frequency relay (>61.7 Hz for more than 0.05 sec) was blocked, GEN-2017-014 would also be tripped by low voltage relay (<0.89 pu for more than 3 sec). Under these two contingencies listed in Table 3-4, post-fault voltages in SPP system at G17-014 POI (588594), New Underwood (652484, 652884), Dry Creek (659376) 230 kV buses were below 0.9 pu.

Under these two contingencies, no stability violations were identified in MISO system. Therefore, MISO AFSIS Network Upgrades were not required.

Table 3-4: Two Contingencies Causing GEN-2017-014 Tripped by Low Voltage Relay

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3.6 Summary of Transient Stability Analysis

Based on the MISO summer shoulder transient stability analysis, no MISO AFSIS stability Network Upgrades are required for the DISIS-2017-001 Study Projects.

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Section

4

Network Upgrades and Cost Allocation

4.1 Cost Assumptions for Network Upgrades

The cost estimate for each network upgrade was provided by the corresponding transmission owning company.

4.2 Cost Allocation Methodology

Costs of AFSIS Network Upgrades are allocated based on MISO Network Upgrade cost allocation methodology, which is detailed in the MISO Generation Interconnection Business Practices Manual BPM-015.

4.3 AFSIS Network Upgrades Required for the DISIS-2017-001 Study Projects

Based on the MISO summer shoulder steady state analysis, voltage constraints were identified in MISO system for the DISIS-2017-001 Study Projects; MISO AFSIS voltage NUs are required for the DISIS-2017-001 Study Projects. No thermal constraints were identified in MISO system for the DISIS-2017-001 Study Projects.

Based on the MISO summer shoulder transient stability analysis, no transient stability constraints were identified for the DISIS-2017-001 Study Projects; No MISO AFSIS stability NUs are required for the DISIS-2017-001 Study Projects.

The total costs of MISO AFSIS Network Upgrades for DISIS-2017-001 Study Projects are summarized in Table 4-1.

Table 4-1: Summary of MISO AFSIS Network Upgrades

Category of Network Upgrades	Cost ($)
Thermal Network Upgrades Identified in MISO Steady-State Analysis	$0
Voltage Network Upgrades Identified in MISO Steady-State Analysis	$23,000,000
Network Upgrades Identified in Stability Analysis	$0
Total	**$23,000,000**

MISO AFSIS Network Upgrades for DISIS-2017-001 Study Projects are listed below:

Table 4-2: MISO Thermal Network Upgrades and Cost

Constraint	Owner	Mitigation	Cost ($)
Neset 230-115-13.9 kV xfmr	BEPC	Non-MISO facility. NU is not required	$0

Table 4-3: MISO Steady-State Voltage Network Upgrades and Cost

Constraint	Network Upgrades	Owner	Cost ($)
Low voltages in Wahpeton area under system intact condition	Add 40 MVar switched cap at Wahpeton 230 kV (620329)	OTP	$3,500,000
Low voltages in Buffalo area under system intact condition	Add 60 MVar switched cap at Buffalo 345 kV (620358)	OTP	$3,500,000
Low voltages in Blackhawk area under P1-P7 contingencies	100 MVAR 345kV capacitor bank at Blackhawk 345 kV (636199)	MEC	$10,000,000
Low voltage at Montezuma under P1 contingency	100 MVAR 345kV Cap Bank at Montezuma 345 kV (635730)	MEC	$6,000,000

Table 4-4: MISO Transient Stability Network Upgrades and Cost

Network Upgrades	Cost ($)
No MISO stability constraints	$0

4.4 MISO AFSIS Cost Allocation

The calculated Distribution Factor (DF) results, voltage impact, and MW contribution on each MISO Affected System constraint are in Appendix D.1. The cost allocation for each NU is calculated based on the contribution of each generating facility, as detailed in Appendix D.2.

Assuming all generation projects in the DISIS-2017-001 cluster advance, a summary of the costs for total MISO AFSIS NUs allocated to each generation project is listed in Table 4-5.

No injection is allowed for the projects until the allocated Network Upgrade(s) are in service, except for a revised report provided by MISO removing the requirements, or an interim limit provided for the projects through MISO Annual ERIS or Quarterly Operating Limit studies.

Table 4-5: Summary of MISO AFSIS NU Costs Allocated to the DISIS-2017-001 Study Projects

Project Num	Network Upgrades ($)		Total Network Upgrade Cost ($)
	MISO Thermal & Voltage	Transient Stability	
GEN-2017-004	$1,976,128	$0	$1,976,128
GEN-2017-010	$4,502,925	$0	$4,502,925
GEN-2017-014	$5,913,327	$0	$5,913,327
GEN-2017-048	$6,370,542	$0	$6,370,542
GEN-2017-094	$4,237,078	$0	$4,237,078
Total ($)	**$23,000,000**	**$0**	**$23,000,000**

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Appendix

A

Model Development for Steady-State and Stability Analysis

A.1 Withdrawn SPP Prior Queued Projects

Table A-1: Withdrawn SPP Prior Queued Project

Prj #	Bus Number	Bus Name	Id	Status
GEN-2014-039	562547	G14_039_3 0.6900	1	WITHDRAWN
GEN-2015-076	563113	G15076_4 0.6500	1	WITHDRAWN
GEN-2015-076	563114	G15076_5 0.6500	1	WITHDRAWN
GEN-2016-023	587093	G16-023-GEN10.6900	1	WITHDRAWN
GEN-2016-029	587193	G16-029-GEN10.6900	1	WITHDRAWN
GEN-2016-029	587195	G16-029-GEN20.6900	1	WITHDRAWN
GEN-2016-088	587733	G16-088-GEN10.6900	1	TERMINATED
GEN-2016-092	587753	G16-092-GEN10.6900	1	WITHDRAWN
GEN-2016-096	587783	G16-096-GEN10.6900	1	WITHDRAWN
GEN-2016-096	587787	G16-096-GEN20.6900	1	WITHDRAWN
GEN-2016-103	587833	G16-103-GEN10.6900	1	WITHDRAWN
GEN-2016-106	587853	G16-106-GEN10.6900	1	WITHDRAWN
GEN-2016-110	587873	G16-110-GEN10.6900	1	WITHDRAWN
GEN-2016-164	659289	DAY_CNTY-PPW0.6900	X	WITHDRAWN
GEN-2016-165	588343	G16-165-GEN10.6900	1	WITHDRAWN
GEN-2016-159	588383	G16-159-GEN10.6900	1	WITHDRAWN
GEN-2016-159	588386	G16-159-GEN20.6900	1	WITHDRAWN
GEN-2017-008	588533	G17-008-GEN10.6900	1	WITHDRAWN
GEN-2017-008	588537	G17-008-GEN20.6900	1	WITHDRAWN
GEN-2017-013	588583	G17-013-GEN10.6900	1	WITHDRAWN
GEN-2017-030	588733	G17-030-GEN10.6900	1	WITHDRAWN
GEN-2017-031	588743	G17-031-GEN10.6900	1	WITHDRAWN
GEN-2017-032	588753	G17-032-GEN10.6900	1	WITHDRAWN
GEN-2017-055	588943	G17-055-GEN10.5500	1	WITHDRAWN

Prj #	Bus Number	Bus Name	Id	Status
GEN-2017-064	589023	G17-064-GEN10.5500	1	WITHDRAWN
GEN-2017-064	589027	G17-064-GEN20.5500	1	WITHDRAWN
GEN-2017-090	589283	G17-090-GEN10.6900	1	WITHDRAWN
GEN-2017-090	589287	G17-090-GEN20.6900	1	WITHDRAWN

A.2 SPP Prior Queued Projects with Dispatch Trued Up

Table A-2: SPP Prior Queued Projects with Dispatch Trued Up

Bus #	Bus Name	Type	Status	Dispatched MW
587433	[G16-063-GEN10.6900]	Wind	On	200.0
589133	[G17-075-GEN10.6900]	Solar	Off	0.0
589353	[G17-097-GEN10.6900]	Solar	Off	0.0
589357	[G17-097-GEN20.6900]	Solar	Off	0.0
588223	[G16-147-GEN10.5500]	Solar	Off	0.0

A.3 Withdrawn MISO Prior Queued Projects

Table A-3: Withdrawn MISO Prior Queued Project

Prj #	Bus Number	Bus Name	Id	Status
J528	65303	J528 G 0.6900	1	Withdrawn
J528	65305	J528 G2 0.6900	1	Withdrawn
J446	84464	J446 G 0.6900	1	Withdrawn
J446	84466	J446 STATCOM34.500	1	Withdrawn
J474	84744	J474 G 0.6900	1	Withdrawn
J602	86024	J602 G 0.6900	1	Withdrawn
J647	86473	J647GEN 0.4180	1	Withdrawn
J740	87403	J740GEN 0.6500	1	Withdrawn
J753	87533	J753GEN 0.5500	1	Withdrawn
J754	87541	J754GEN_1 0.6900	1	Withdrawn
J754	87543	J754GEN 0.6900	1	Withdrawn
G226	600102	G226 CHB311W0.6000	W	Withdrawn
J767	631152	J767GEN 0.6900	1	Withdrawn
J767	631152	J767GEN 0.6900	2	Withdrawn
J768	631153	J768GEN 0.6900	1	Withdrawn
J768	631153	J768GEN 0.6900	2	Withdrawn
J391	658471	J391 MSH CG 13.800	1	Withdrawn
J598	859851	J598 G1 0.6900	1	Withdrawn
J598	859852	J598 G2 0.6900	1	Withdrawn
J584	993000	J584 E1_GEN 0.6900	1	Withdrawn

A.4 MISO Model Updates

Table A-4: MISO Model Updates

Company	Python/ Idev File Name	2023 SH SS	2023 SH ST
MISO	RMV MNTZUMA-SVC_ST.py		×
SPTI	Astoria Model Correction_SS.idv	×	
MISO	RMV Wahpeton 115kV Cap.py		×
MISO	RMV Wahpeton 230kV Cap.py	×	×
MISO	RMV Grimes Cap.py		×
MISO	RMV MNTZUMA Cap.py		×
MISO	RMV BlkHawk-SVC.py		×
SPTI	Add Big SND Cap_ST.py		×
SPTI	RMV NWOODS Cap.py	×	×
MISO	Add OTP_Bagley_115cap.py	×	×

A.5 SPP Model Updates

Table A-5: SPP Model Updates

Company	Python/ Idev File Name	2023 SH SS	2023 SH ST
SPTI	Correct Bus Name.py	×	×
SPTI	SPP Topology.py	×	×
SPTI	SPP Change-Add1.py	×	×

A.6 MISO North for Power Balance

Table A-6. MISO North for Power Balance

Area #	Area Name
207	HE
208	DEI
210	SIGE
216	IPL
217	NIPS
218	METC
219	ITC
295	WEC
296	MIUP
314	BREC
333	CWLD
356	AMMO
357	AMIL
360	CWLP
361	SIPC

Area #	Area Name
600	Xcel
608	MP
613	SMMPA
615	GRE
620	OTP
627	ALTW
633	MPW
635	MEC
661	MDU
663	BEPC-MISO
680	DPC
694	ALTE
696	WPS
697	MGE
698	UPPC

A.7 SPP Market for Power Balance

Table A-7. SPP Market for Power Balance

Area #	Area Name
515	SWPA
520	AEPW
523	GRDA
524	OKGE
525	WFEC
526	SPS
527	OMPA
531	MIDW
534	SUNC
536	WERE
540	GMO
541	KCPL

Area #	Area Name
542	KACY
544	EMDE
545	INDN
546	SPRM
640	NPPD
641	HAST
642	GRIS
645	OPPD
650	LES
652	WAPA
659	BEPC-SPP

A.8 Contingency Files used in Steady-State Analysis

Table A-8: List of Contingencies used in the Steady-State Analysis

Contingency File Name	Description
Automatic single element contingencies	Single element outages at buses 57 kV and above in the study region
OTP_P1_22-October-2018.con	Specified category P1 contingencies in OTP
OTP_P2_22-October-2018.con	Specified category P2 contingencies in OTP
OTP_P5_19-June-2018.con	Specified category P5 contingencies in OTP
MEC-DPP2017FEB West Ph3 2023 Cat P1 04.17.2019.con	Specified category P1 contingencies in MEC
MEC-DPP2017FEB West Ph3 2023 Cat P2 04.17.2019.con	Specified category P2 contingencies in MEC
MEC-DPP2017FEB West Ph3 2023 Cat P5 04.17.2019.con	Specified category P5 contingencies in MEC
MEC-DPP2017FEB West Ph3 2023 Cat P7 04.17.2019.con	Specified category P7 contingencies in MEC
MISO18_2023_SUM_TA_P1_P2_P4_P5_ATC_NoLoadLoss.con	Specified category P1, P2, P4, P5 no load loss contingencies in ATC
MISO18_2023_SUM_TA_P1_P2_P4_P5_West_NoLoadLoss.con	Specified category P1, P2, P4, P5 no load loss contingencies in MISO West
MISO18_2023_SUM_TA_P1_P2_P4_P5_IL-MO_NoLoadLoss.con	Specified category P1, P2, P4, P5 no load loss contingencies in Illinois & Missouri
MISO18_2023_SUM_TA_P2_P4_P5_P7_ATC_LoadLoss.con	Specified category P2, P4, P5, P7 load loss contingencies in ATC
MISO18_2023_SUM_TA_P2_P4_P5_P7_West_LoadLoss.con	Specified category P2, P4, P5, P7 load loss contingencies in MISO West
MISO18_2023_SUM_TA_P2_P4_P5_P7_IL-MO_LoadLoss.con	Specified category P2, P4, P5, P7 load loss contingencies in Illinois & Missouri

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Appendix

B

MISO Steady State Thermal and Voltage Analysis Results

B.1 Summer Shoulder (SH) MISO AFSIS Constraints

Table B-1. SH System Intact Thermal Constraints

Table B-2. SH System Intact Voltage Constraints

Table B-3. SH Category P1 Thermal Constraints

Table B-4. SH Category P1 Voltage Constraints

Table B-5. SH Category P2-P7 Thermal Constraints

Table B-6. SH Category P2-P7 Voltage Constraints

Table B-7. SH Non-Converged Contingencies

Table B-8. SH Non-Converged Contingencies DCCC Results

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Appendix

C

Stability Analysis Results

C.1 Summer Shoulder Stability Results

Stability simulation was performed in the summer shoulder (SH) stability model.

C.1.1 SH Stability Summary

DISIS-2017-001 summer shoulder stability study results are summarized in Table C-1.

Table C-1: DISIS-2017-001 Summer Shoulder Stability Analysis Results Summary

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C.1.2 SH Stability Plots

Plots of stability simulations for summer shoulder study case are in separate files which are listed below:

AppendixC1-2_SH_DISIS-2017-001_Study_Plots.zip

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Appendix

D

Cost Allocation Results

D.1 Distribution Factor (DF), Voltage Impact, and MW Contribution Results for Cost Allocation

Table D-1: Distribution Factor and MW Contribution on Constraints for MISO Affected System Thermal NU Cost Allocation

Table D-2: Voltage Impact on MISO Voltage NUs Cost Allocation

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D.2 Cost Allocation Details

Table D-3: MISO Affected System Network Upgrades Cost Allocation

Table D-3: MISO Affected System Network Upgrades Cost Allocation

Monitored Element	English Name	Owner	Cost	GEN-2017-004	GEN-2017-010	GEN-2017-014	GEN-2017-048	GEN-2017-094	Upgrade for
659139 NESET___-BE7 115 659138 NESET___-BE4 230 659146 NES.KV2A-BE913.8 1	Neset 230-115-13.9 kV xfmr	BEPC	$0	$0	$0	$0	$0	$0	SH Thermal
Add 40 MVar switched cap at Wahpeton 230 kV (620329)	Add 40 MVar switched cap at Wahpeton 230 kV (620329)	OTP	$3,500,000	$139,144	$813,456	$845,566	$1,081,040	$620,795	SH Volt
Add 60 MVar switched cap at Buffalo 345 kV (620358)	Add 60 MVar switched cap at Buffalo 345 kV	OTP	$3,500,000	$103,495	$884,409	$790,323	$1,223,118	$498,656	SH Volt
100 MVAR 345kV capacitor bank at Blackhawk 345 kV (636199)	100 MVAR 345kV capacitor bank at Blackhawk 345 kV (636199)	MEC	$10,000,000	$1,100,324	$1,779,935	$2,588,997	$2,588,997	$1,941,748	SH Volt
100 MVAR 345kV Cap Bank at Montezuma 345 kV (635730)	100 MVAR 345kV Cap Bank at Montezuma 345 kV (635730)	MEC	$6,000,000	$633,166	$1,025,126	$1,688,442	$1,477,387	$1,175,879	SH Volt
Total Cost Per Project for each Project	**Total Cost Per Project**		**$23,000,000**	**$1,976,128**	**$4,502,925**	**$5,913,327**	**$6,370,542**	**$4,237,078**	

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