MISO Affected System Studies
for
SPP DISIS-2018-001 Phase II

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Revision Table

Revision	Issue Date	Description
V1R1	02/10/2023	Initial Draft

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Executive Summary

Midcontinent Independent System Operator ("MISO") has contracted with CF Power Ltd. ("CFP") to perform Affected System Studies ("AFS") for the interconnection requests in the Southwest Power Pool ("SPP") queue (the "Projects"). SPP is commencing the Definitive Interconnection System Impact Studies ("DISIS") for their DISIS-2018-001 cycle Projects. The MISO AFS is intended to identify the impacts of these Projects on the MISO system.

The study will be done in two phases. The report here includes the methodology, assumptions and results for Phase II analysis. Phase III will commence at a later time and will utilize the data acquired in Phase II. This Affected System Study includes steady state and dynamic stability analyses. Because of a wide geographical region of the SPP Projects, the MISO AFS was divided in two groups to identify the impacts on the MISO West and MISO South regions.

The steady state analysis identified several Thermal Network Upgrades in the MISO-West regions due to SPP Projects. These Network Upgrades along with their planning level cost estimated are summarized below. Mitigations for non-MISO facilities are not required for this study.

Table ES- 1: Network Upgrades Identified in MISO Steady State Studies

NU#	Description	Planning Level Cost Estimate ($M)	Area	Area Name
1	Rebuild MINVALT4 GRANITF4 230kV line with 795ACSS, 632MVA SN/SE	4.5	600/652	XEL/WAPA
2	Rebuild MINVLTAP4 GRANITF4 230kV line with 795ACSS, 632MVA SN/SE	4.5	600/652	XEL/WAPA
3	Add 40 MVAR cap to Maynard7 Bus	1	600	XEL

Table ES- 2 shows the responsibility of each Project in accordance with the MISO business practices.

Table ES- 2: Cost Allocation Summary for the Network Upgrades

Project	NU1	NU2	NU3	Total
ASGI-2017-013			$40,000	$40,000
GEN-2018-007			$180,000	$180,000
GEN-2018-008	$4,500,000.00	$4,500,000.00	$40,000	$9,040,000
GEN-2018-039			$60,000	$60,000
GEN-2018-022			$60,000	$60,000
GEN-2018-025			$40,000	$40,000
GEN-2018-030			$60,000	$60,000
GEN-2018-033			$40,000	$40,000
GEN-2018-043			$140,000	$140,000
GEN-2018-044			$140,000	$140,000
GEN-2018-056			$40,000	$40,000
GEN-2018-057			$40,000	$40,000
GEN-2018-058			$40,000	$40,000

Project	NU1	NU2	NU3	Total
GEN-2018-059			$40,000	$40,000
GEN-2018-062			$40,000	$40,000
TOTAL	$4,500,000	$4,500,000	$1,000,000	$10,000,000

A short circuit screening analysis was conducted by comparing three phase fault currents in the benchmark and study cases for the DISIS-2018-001. Based on the screening results, MISO Transmission Owners do not plan to conduct additional studies.

Contingent facilities were identified for certain projects in the study. The identified projects will need to be included in MISO's Annual studies to determine available injection until assumptions reach their expected In-Service Date. Details are in Section 3.3.

Dynamic stability analysis showed acceptable system performance and did not identify any criteria violations that could be attributed to the study Projects.

Results of this AFS will be revisited in Phase III of the SPP DISIS process and if required, a restudy will be performed to assess the validity of results and suitability of the Network Upgrades under the revised assumptions as applicable at that time.

Section 1: Introduction

1.1 Background

Midcontinent Independent System Operator ("MISO") has contracted with CF Power Ltd. ("CFP") to perform Affected System Studies ("AFS") for the interconnection requests in the Southwest Power Pool ("SPP") queue (the "Projects"). SPP is commencing the Definitive Interconnection System Impact Studies ("DISIS") for their DISIS-2018-001 cycle Projects. The MISO AFS is intended to identify the impacts of these Projects on the MISO system.

Because of a wide geographical region of the SPP Projects, the MISO AFS was divided in two groups to identify the impacts on the MISO west and MISO South regions. Table 1- 1 shows the specifics of each study group.

Table 1- 1: MISO Study Groups for the AFS

Group	Total Requests	Total Capacity (MW)	Geographical Region of the Requests
MISO West Region	30	6772.9	IA, KS, MO, MT, ND, NE, SD
MISO South Region	13	1937.2	AR, OK, TX

1.2 Project Description

SPP Projects, to be studied as part of Phase II analysis for MISO West region, are listed in Table 1- 2 and MISO South region in Table 1- 3.

Table 1- 2: SPP Projects List for MISO West Region

Project	Capacity	Fuel Type	Area Name	State
ASGI-2017-013	40	Wind	WAPA	ND
ASGI-2018-003	20	Solar	KCPL	KS
ASGI-2018-006	20	Solar	KCPL	KS
ASGI-2018-007	20	Solar	KCPL	KS
ASGI-2018-010	35	Solar	KCPL	KS
ASGI-2018-011	35	Solar	KCPL	KS
GEN-2018-007	150	Solar	WAPA	SD
GEN-2018-008	252	Wind	WAPA	ND
GEN-2018-010	74.1	Battery/Storage	WAPA	ND
GEN-2018-012	74.1	Wind	NPPD	NE
GEN-2018-013	74.1	Wind	WERE	KS
GEN-2018-014	74.1	Wind	KCPL	MO
GEN-2018-022	300	Solar	KCPL	MO
GEN-2018-025	200	Battery/Storage	OPPD	NE
GEN-2018-030	200	Battery/Storage	SPS	CO
GEN-2018-031	50	Battery/Storage	KCPL	MO
GEN-2018-032	310	Wind	WERE	KS
GEN-2018-033	200	Battery/Storage	OPPD	NE
GEN-2018-037	100	Battery/Storage	OPPD	NE
GEN-2018-039	72	Solar	WAPA	ND
GEN-2018-043	500	Solar	OPPD	NE
GEN-2018-044	500	Solar	OPPD	NE
GEN-2018-053	100	Wind	WERE	MO
GEN-2018-054	120	Solar	KCPL	KS
GEN-2018-056	102.6	Solar	WAPA	NE
GEN-2018-057	203.4	Solar	WERE	KS
GEN-2018-058	252	Solar	WERE	KS
GEN-2018-059	252	Solar	WERE	KS
GEN-2018-060	50	Wind	NPPD	NE
GEN-2018-061	50	Wind	WERE	MO
GEN-2018-062	75.6	Solar	KACY	KS

Table 1- 3: SPP Projects List for MISO South Region

Project	Capacity	Fuel Type	Area Name	State
GEN-2018-003	150	Solar	AEPW	TX
GEN-2018-011	74.1	Battery/Storage	WFEC	OK
GEN-2018-015	252	Solar	SPS	TX
GEN-2018-021	74.1	Solar	AEPW	OK
GEN-2018-024	100	Battery/Storage	OKGE	OK
GEN-2018-026	100	Battery/Storage	OKGE	OK
GEN-2018-027	100	Battery/Storage	OKGE	OK
GEN-2018-028	200	Battery/Storage	OKGE	OK
GEN-2018-029	100	Battery/Storage	OKGE	OK
GEN-2018-048	300	Solar	OKGE	OK
GEN-2018-050	200	Solar	AEPW	LA
GEN-2018-051	35	Battery/Storage	OKGE	OK
GEN-2018-055	252	Solar	AEPW	OK

Section 2: Assumptions and Methodology

2.1 Study Models

MISO provided DPP 2020 West Phase 2 models and South Phase 3 models:

- West Region:
  - Shoulder, DPP20-2025SH90-PhaseI-Study_Discharging_FINAL_01122022.raw
  - Summer Peak, DPP20-2025SUM-PhaseI-Study_Discharging_FINAL_01122022.raw
- South Region:
  - Shoulder, DPP20-2025SH90-PhaseIII-IC-1031_Study_r1.raw
  - Summer Peak, DPP20-2025SUM-PhaseIII-IC-1031_Study_r1.raw

2.2 Model Development

Various updates were implemented to the models based on the MISO input. This section lists the updates in various categories.

2.2.1 Higher Queued Projects

Thirty-five (35) and nineteen (19) higher-queued (2017-002) were added to the model for west and south region respectively. The models for both west and south region also included upgrades from the higher-queued (HQ) Projects in the SPP generator interconnection queue (i.e., 2017-001 and 2016-002 queue). fifty-seven (57) higher-queued Projects were added. Also, six (6) and seven (7) higher-queued projects in the MPC and AECI area included in the model, respectively.

2.2.3 Study Projects Modeling

MISO also provided the idevs for thirty (30) SPP Projects for west cases (listed in Table 1- 2) and thirteen (13) SPP Projects for the south case (listed in Table 1- 3) to be studied. To create Post-Project cases, CFP added these projects to the study cases and dispatched these Projects according to Load Ratio Share (LRS) of various SPP control areas per the SPP practices. Projects were dispatched based on the fuel type in accordance with the MISO business practices as listed in

Table 2- 1 below.

Table 2- 1: Projects Dispatch based on the Fuel Type

Fuel type	Summer Case	Shoulder Case
Solar/CT/Diesel/Oil	100%	0%
Wind	15.6%	100%
Coal/Hydro/Nuclear/Waste Heat	100%	100%
Combined Cycle	100%	50%
Storage	100%	±100%

Dynamic Model Updates

Some Projects caused issues leading to simulation crash when integrated into the basecase. This is likely due to either bad parameters or a certain combination of dynamic models causing conflicts in the set up. In the interest of time, CFP made some assumptions in discussions with MISO in order to obtain a functional post-Project model. These assumptions are summarized below:

In West region Projects ASGI-2017-014, GEN-2017-108, GEN-2017-113 and GEN-2017-114 were represented using generic model from the PSSE library. Data for the generic model was provided by SPP.

In South region, Project GEN-2017-231 model was replaced with the generic model per SPP's direction.

Since the study scope included identifying overall impact of study Projects on the MISO system and the evaluation of individual Project performance was not within the MISO AFS scope, these assumptions were deemed to be acceptable considering the objective of this AFS

2.3 Methodology

CFP performed this study to determine the impact of SPP's Projects on the MISO transmission system. MISO's transmission planning criteria were used to evaluate the results.

2.3.1 Power Flow Analysis

An AC contingency analysis was performed for the selected North American Electric Reliability Corporation (NERC) Reliability Standard TPL-001-4 Category P1 through P7 contingencies within the MISO and external region as previously defined by the MISO transmission owners and available in the MISO model package. MISO facilities of 69 kV and higher voltage levels and relevant third-party facilities were monitored in the study region. CFP used Siemens PSS/E v34 and PowerGEM TARA v2202_2 software tools to perform the analysis.

The power flow analysis was performed for the Pre and Post Project cases. CFP used subsystem (SUB), monitored elements (MON) and contingencies (CON) files provided by MISO and updated them for the study as appropriate.

A 70% loading cut-off was used for Pre Project AC run and 90% is used for Post Project AC run. All MISO facilities listed in the MON file were monitored. CFP also generated distribution factors (DFs) for the study Projects to identify their impacts on the constraints.

Pre- and Post-Project power flow analyses were conducted and results were compared to identify the impacts of the SPP DISIS-2018-001 cycle Projects on the system performance.

Results were screened based on the following MISO criteria:

- Thermal Loading Criteria
  - Branch loading is >100% applicable normal or emergency rating and generator has:
    - P0 (No Contingency) : 5% DF Cutoff, or
    - P1 & P2 (Single Contingency) : 20% DF Cutoff, or
    - P4 (Fault plus stuck breaker) : 20% DF Cutoff, or
    - P7 (Common Structure): 20% DF Cutoff, or
  - MW Impact from study generator greater than or equal to 20% of the applicable line rating (normal or emergency), or
  - Overloaded facility or overload-causing contingency at generator's outlet
  - Cumulative MW Impact from study generators greater than or equal to 20% of the applicable line rating (normal or emergency), where study generators whose individual MW Impact is greater than 5% of the rating and has DFAX of greater than 5% will be responsible to mitigate the cumulative MW Impact Constraint
  - Any Transmission Owner (TO) planning criteria
- Voltage Criteria
  - Bus voltage is outside of applicable normal or emergency limits, and
  - Voltage degradation is greater than 1%

2.3.2 Dynamic Stability Analysis

Stability analysis was performed using Powertech Labs Inc. TSAT software. The Projects from Table 1-2 and Table 1-3 were modeled for stability analysis. All Projects were evaluated on the West Shoulder case dispatched at full output level. CFP simulated transmission faults on MISO's system as well as local faults close to some Project POIs to assess their impacts on the MISO system. Transmission Faults were provided by MISO as part of the study package. The west region Projects included some MISO facilities within the 3 bus radius in PSSE from the Project POI as shown in Table 2-3. Therefore, Project specific faults (near the POI) for such Projects were obtained from SPP and selected faults on these MISO facilities were simulated for west region study.

For west region Projects, other regional faults from MISO stability package for NERC Categories P1 to P7 were simulated in GRE, ALTW, MDU, MEC, MP, MRES, OPPD, OTP and XEL areas. Similarly, for south region also, selected faults in EES-EAI (Area 327) were simulated in the study. Faults were selected based on the electrical proximity from SPP seams and Project locations. A list of these faults is provided in Appendix A.

CFP performed non-disturbance simulation to check the overall response of the MISO system. Non-disturbance plots for west and south regions are included as part of the plot package for the fault events.

Stability study was conducted on the post-Project case and the fault scenarios that result in the MISO or applicable Transmission Owners' planning criteria violations, were re-run on the base case (pre-Projects

case) to identify if the violation is caused by the SPP DISIS-2018-1 cycle Projects. The study results were screened based on MISO criteria

Pertinent channels for voltage, frequency, rotor angle, active and reactive power were monitored in the study area. Primary focus of the analysis was to analyze system stability and post disturbance voltage recovery in MISO system.

Section 3: Steady State Analysis

3.1 West Region

3.1.1 Thermal Results

As per the planning criteria listed in Section 2 of this report, no thermal violations were identified as impacted by the SPP Projects in summer case. However, shoulder case showed several violations impacted by the study Projects. Few thermal violations were identified MISO and SPP area (600/652). MISO shared the results with the Transmission Owners and received their inputs on potential mitigations and validity of results. A detailed list of violations that require mitigations is provided in Appendix A.

3.1.2 Voltage Results

As per the planning criteria listed in Section 2 of this report, voltage violations were identified due to the SPP Projects. on the facilities of Maynard in area 600, West Region, as listed below. The voltage issue can be fixed by adding a Cap bank to Maynard 115 kV substation. Also, the cost allocation is provided in the next section for this upgrade based on single unit removal methodology.

Table 3- 1: Worst Voltage Violations

Redacted

3.1.3 Network Upgrades and Cost Allocation

There are several Network Upgrades identified to address the thermal and voltage violations based on the feedback from the Transmission Owners. MISO also received a planning level cost estimates for these Network Upgrades. Table 3- 2 shows the required upgrades and their planning level cost estimates. Mitigations for non-MISO facilities are not required for this study.

Table 3- 2: Network Upgrades for Thermal and Voltage Violations

NU#	Description	Planning Level Cost Estimate ($M)	Area	Area Name
1	Rebuild MINVALT4 GRANITF4 230kV line with 795ACSS, 632MVA SN/SE	4.5	600/652	XEL/WAPA
2	Rebuild MINVLTAP4 GRANITF4 230kV line with 795ACSS, 632MVA SN/SE	4.5	600/652	XEL/WAPA
3	Add 40 MVAR cap to Maynard7 Bus	1	600	XEL

MISO will further review these Network Upgrades for validity in Phase III of the study and update the requirements if needed.

CFP performed cost allocation of network upgrades identified in Table 3- 2 in accordance with the MISO business practices as documented in MISO BPM-015. Table 3- 3 presents the share of each Project on each network upgrade. The numbering for the upgrades in the Table heading corresponds to the item numbers in Table 3- 2. Mitigations for non-MISO facilities are not required for this study.

Table 3- 3: Network Upgrades Cost Allocation

Project	NU1	NU2	NU3	Total
ASGI-2017-013			$40,000	$40,000
GEN-2018-007			$180,000	$180,000
GEN-2018-008	$4,500,000.00	$4,500,000.00	$40,000	$9,040,000
GEN-2018-039			$60,000	$60,000
GEN-2018-022			$60,000	$60,000
GEN-2018-025			$40,000	$40,000
GEN-2018-030			$60,000	$60,000
GEN-2018-033			$40,000	$40,000
GEN-2018-043			$140,000	$140,000
GEN-2018-044			$140,000	$140,000
GEN-2018-056			$40,000	$40,000
GEN-2018-057			$40,000	$40,000
GEN-2018-058			$40,000	$40,000
GEN-2018-059			$40,000	$40,000
GEN-2018-062			$40,000	$40,000
TOTAL	$4,500,000	$4,500,000	$1,000,000	$10,000,000

3.2 South Region

3.2.1 Thermal Results

As per the planning criteria listed in Section 2 of this report, no thermal violations were identified as impacted by the SPP Projects in South Region.

3.2.2 Voltage Results

As per the planning criteria listed in Section 2 of this report, no voltage violations were identified due to the SPP Projects in South Region.

3.2.3 Network Upgrades

No voltage violation is identified and no upgrade is needed in south region.

Section 4: Stability Analysis

4.1 West Region

4.1.1 Stability Analysis Results

CFP simulated a total of 243 faults in the study in consultation with MISO. The performance of the MISO transmission system electrically closer to the SPP seams was monitored for these fault scenarios. The study did not identify any loss of synchronism or tripping for the monitored MISO units under the fault events that could be attributed to the study Projects. Post fault voltages recovered to acceptable voltage levels within the simulation time. There were no sustained oscillations identified for on the MISO transmission system and the oscillations appear to be sufficiently damped within the simulation time frame. Overall, MISO's transmission system was found to be stable for all the studied fault scenarios with no significant impacts from the study Projects. Simulation plots for the studied faults are reported in Appendix C.

4.1.2 Network Upgrades

No Network Upgrades were identified for West region to meet the stability performance criteria.

4.2 South Region

4.2.1 Stability Analysis Results

CFP simulated a total of 444 faults in consultation with MISO. The performance of the MISO transmission system electrically closer to the SPP seams was monitored for these fault scenarios. The study did not identify any loss of synchronism or tripping for the monitored MISO units under the fault events that could be attributed to the study Projects. Post fault voltages recovered to acceptable voltage levels within the simulation time. There were no sustained oscillations identified for on the MISO transmission system and the oscillations appear to be sufficiently damped within the simulation time frame. Overall, MISO's transmission system was found to be stable for all the studied fault scenarios with no significant impacts from the study Projects. Simulation plots for the studied faults are reported in Appendix D.

4.2.2 Network Upgrades

No Network Upgrades were identified for South region to meet the stability performance criteria.

Section 5: Contingent Facilities

The table below describes transmission assumptions modeled in the studies that were deemed necessary to allow for the Interconnection Service of study unit. If the transmission assumptions are not completed or significantly modified, the Interconnection Service of study unit may be restricted until a re-study is performed to determine the applicable service level that results. If any of the higher queued and/or same group study generators in the model drop out, the Interconnection Customer may be subject to restudy. If there are no modifications to the table, the study projects will be included in MISO's Annual studies to determine available injection until assumptions reach their expected In-Service Date.

Table 3-4 Contingent Facilities

Project **Name**	**Status**	**MTEP ID**	**MOD ID**	**Project Name**	**MTEP Cycle**	**Project Description**	**Project Status**	**Expected completion Date**
ASGI-2017-013	N/A	TBD	TBD	Blue Lake-Scott Co 345 kV upgrade	TBD	Prior Queued Upgrade, Rebuild 8.1 miles of 345 kV to bundled 954 ACSS, 1792MVA SN/SE, $2,025,000	N/A	TBD
GEN-2018-007	DISIS STAGE	TBD	TBD	Blue Lake-Scott Co 345 kV upgrade	TBD	Prior Queued Upgrade, Rebuild 8.1 mi of 345 kV to bundled 954 ACSS, 1792MVA SN/SE, $2,025,000	N/A	TBD
GEN-2018-037	DISIS STAGE	15669	116740	Sub 701: Install 2nd 161-69 kV transformer	MTEP19	Install a second 161-69 kV transformer and complete the 161 kV ring bus at Sub 701. Install two new 161 kV circuit breakers.	Under Construction	8/1/2023

Appendix A: Steady State Thermal Results

Table A- 1: Thermal results for West Region, Shoulder Case

Redacted

Appendix B: Fault List

Table B-1 Fault Events Simulated in Stability Study – West Region

Redacted

Table B-2 Fault Events Simulated in Stability Study – South Region

Redacted

Appendix C: Simulation Plots – West Region

Available upon request

Appendix D: Simulation Plots – South Region

Available upon request