GEN-2016-032

Impact Restudy for Generator Modification (POI Change)

Published November 2019

By SPP Generator Interconnections Dept.

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION
11/11/2019	SPP	Report issued.

SUMMARY

The GEN-2016-032 Interconnection Customer has requested a modification to its Interconnection Request. SPP has directed the performance of this system impact restudy to determine the effects of changing the GEN-2016-032 Point of Interconnection (POI). The GEN-2016-032 project remains comprised of one hundred (100) Vestas V110 2.0 MW wind turbine generators with a total nameplate capacity of 200 MW. The analysis evaluated the impact of moving the GEN-2016-032 POI from a tap of the Marshal to Cottonwood 138kV transmission line to two POI alternatives:

1. 138 kV POI - Crescent 138 kV substation
2. 345 kV POI - Tap on Spring Creek to Sooner 345 kV line

This study was performed by Aneden Consulting to determine whether the request for modification is considered Material. A powerflow analysis was performed for both POI alternatives. A short circuit analysis, a low-wind/no-wind condition analysis, and stability analysis was performed for the preferred 138 kV Crescent POI change request. The study report follows this executive summary.

A power flow analysis was also performed to determine the steady-state effects of the GEN-2016-032 modification on the rest of the projects within the geographical location and to determine if any additional thermal or voltage issues arise due to the modification.

The results of the power flow analysis demonstrate the following for both the ERIS and NRIS analysis;

1. 138 kV POI - Crescent 138 kV substation
   a. No additional constraints are caused by this POI modification. The Crescent 138kV POI change alleviated the previously observed overloads on the Cottonwood Creek to G16-032-Tap 138 kV. The requested modification is not considered Material.

2. 345 kV POI - Tap on Spring Creek to Sooner 345 kV line
   a. New thermal constraints not previously identified in previous studies appear due to this POI modification. The requested modification, without the GEN-2016-032 customer assuming the cost responsibility of each new mitigation, is considered Material.

Since the 138 kV POI option did not introduce additional violations, it was selected as the preferred POI option and was further evaluated in the reactive power, short circuit and dynamic stability analyses. The results of the dynamic stability analysis showed that there were several prior outage faults that caused GEN-2016-032 to become unstable. FLT9003-PO2 or FLT9004-PO2, the prior outage on the Crescent to Cottonwood 138 kV line, followed by a three-phase fault on and loss of the Twin Lake to Dover 138 kV line or Twin Lake to Cashion 138 kV line, would cause GEN-2016-032 to become unstable. Prior outage faults are categorized as TPL-001-4 P6 events which allow for system adjustments, including curtailment of generation, as mitigation. GEN-2016-032 may have to be curtailed to as low as 160 MW after the prior outage of the Crescent to Cottonwood 138 kV, Twin Lake to Dover 138 kV, or Twin Lake to Cashion 138kV line to remain stable following a subsequent fault.

There were no other machine rotor angle damping or transient voltage recovery violations observed in the simulated fault events. Additionally, the project wind farm was found to stay connected during the contingencies that were studied and, therefore, will meet the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A. The requested modification is not considered Material.

The generating facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VArs) in accordance with FERC Order 827. Additionally, the project will be required to install approximately 18.6 MVArs of reactor shunts on its substation 138 kV bus or provide an alternate means of reactive power compensation. This is necessary to offset the capacitive effect on the transmission network caused by the project's transmission line and collector system during low-wind/no-wind conditions.

This study analyzed many of the most probable contingencies, but it is not an all-inclusive list and cannot account for every operational situation. It is likely that the customer may be required to reduce its 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.

Nothing in this study should be construed as a guarantee of transmission service or delivery rights. If the customer wishes to obtain deliverability to final customers, a separate request for transmission service must be requested on Southwest Power Pool's OASIS by the customer.

A: CONSULTANT'S MATERIAL MODIFICATION STUDY REPORT

See next page for the Consultant's Material Modification Study report.

Submitted to

Southwest Power Pool

Report On

GEN-2016-032
Modification Request Impact Study

Revision R1

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anedenconsulting.com

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Executive Summary

Aneden Consulting (Aneden) was retained by the Southwest Power Pool (SPP) to perform a Modification Request Impact Study (Study) for GEN-2016-032, an active generation interconnection request with an existing point of interconnection (POI) on the Cottonwood Creek to Marshall Tap 138 kV line.

The GEN-2016-032 project is proposed to interconnect in the Oklahoma Gas & Electric Company (OKGE) control area with a capacity of 200 MW as shown in Table ES-1 below. This Study has been requested to evaluate two potential points of interconnection for GEN-2016-032:

1. 138 kV POI - Crescent 138 kV substation
2. 345 kV POI - Tap on Spring Creek to Sooner 345 kV line

In addition, the modification requests included changes to generation interconnection lines and the generator substation transformer where required. The modification request changes are shown in Table ES-2 below.

Table ES-1: GEN-2016-032 Configuration

Request	Capacity (MW)	Existing Generator Configuration	Point of Interconnection
GEN-2016-032	200	100 x Vestas V110 2.0MW	Tap on Marshal (514733) to Cottonwood (514827) 138kV Line

Table ES-2: GEN-2016-032 Modification Requests

Facility	Existing	138 kV POI	345 kV POI
Point of Interconnection	Tap on Marshal (514733) to Cottonwood (514827) 138kV Line	Crescent 4 138 kV Substation (515377)	G16-119-Tap (587959) on Sooner (514803) to Spring Creek (514881) 345 kV Line
Configuration/Capacity	100 x Vestas V110 2.0MW = 200 MW	100 x Vestas V110 2.0MW = 200 MW	100 x Vestas V110 2.0MW = 200 MW
Generation Interconnection Line	Length = 3 miles R = 0.001900 pu X = 0.012220 pu B = 0.003310 pu	Length = 6 miles R = 0.003721 pu X = 0.023919 pu B = 0.006482 pu	Length = 5 miles R = 0.001480 pu X = 0.002891 pu B = 0.037073 pu
Main Substation Transformer	Z = 8.5%, Winding 150 MVA, Rating 250 MVA	Z = 8.5%, Winding 150 MVA, Rating 250 MVA	Z = 9%, Winding 150 MVA, Rating 250 MVA
GSU Transformer	Gen 1 Equivalent Qty: 100: Z = 9.76%, Rating 206 MVA	Gen Equivalent Qty: 100: Z = 9.76%, Rating 206 MVA	Gen Equivalent Qty: 100: Z = 9.76%, Rating 206 MVA
Equivalent Collector Line	R = 0.003320 pu X = 0.005290 pu B = 0.141370 pu	R = 0.006427 pu X = 0.010262 pu B = 0.177634 pu	R = 0.006427 pu X = 0.010262 pu B = 0.177634 pu

Aneden performed power flow analysis, reactive power analysis, short circuit analysis, and dynamic stability analysis.

The power flow analysis was performed using the DISIS-2016-001-4 (ERIS and NRIS) and DISIS-2016-002-1 (ERIS) Group 8 power flow models. The reactive power, short circuit and dynamic stability analyses were completed using the DISIS-2016-002-1 Group 8 stability models.

All analyses were performed using the PTI PSS/E version 33.7 software and the results are summarized below.

The power flow analysis was performed first to determine the impact of the Crescent 138 kV POI and the Spring Creek to Sooner 345 kV POI modification requests. The TC results shown in Table ES-3 below represents the loading levels for the existing GEN-2016-032 POI.

Both POI modification requests alleviated the previously observed overloads on the Cottonwood Creek to G16-032-Tap 138 kV line. The remaining thermal constraints identified in the DISIS-2016-001-4 report persisted with both POI modifications as shown below in Table ES-3.

Table ES-3: GEN-2016-032 Modification Impacts on Existing Violations (DISIS-2016-001-4)

Monitored Element	Limiting Rate A/B (MVA)	*TC %Loading (%MVA)	Contingency	Currently Assigned Upgrades	138 kV POI	345 kV POI
LACYGNE - WAVERLY7 345.00 345KV CKT 1	1141	103.5676	System Intact	New Wolf Creek – Emporia 345 kV CKT 1	Mitigation Unchanged (103.6%)	Mitigation Unchanged (103.7%)
COTTONWOOD CREEK - G16-032-TAP 138.00 138KV CKT 1	194	125.7779	System Intact	Rebuild Cottonwood Creek - G16-032-Tap 138kV CKT 1	Mitigation Not Required (<95%)	Mitigation Not Required (<95%)
COTTONWOOD CREEK - G16-032-TAP 138.00 138KV CKT 1	270	137.6935	G15063_T 345.00 - MATHWSN7 345.00 345KV CKT 1	Rebuild Cottonwood Creek - G16-032-Tap 138kV CKT 1	Mitigation Not Required (<95%)	Mitigation Not Required (<95%)
RANCHRD7 345.00 - SOONER 345KV CKT 1	1195	102.8081	G15052_T 345.00 - ROSE HILL 345KV CKT 1	Ranch Road - Sooner 345 kV Ckt 1 Terminal Upgrades	Mitigation Unchanged (102.8%)	Mitigation Unchanged (102.8%)

*TC %Loading data is from the DISIS-2016-001-4 Group 8 Report

The results of the power flow analysis also showed that there were several new overloads not previously identified in both the DISIS-2016-001-4 and DISIS-2016-002-1 studies caused by the modification of the POI to the Spring Creek to Sooner 345 kV tap, the 345 kV POI, as shown in Table ES-4 and Table ES-5 below.

Table ES-4: GEN-2016-032 Modification New Impacts DISIS-2016-001-4

Monitored Element	Limiting Rate A/B (MVA)	TC %Loading (%MVA)	Contingency	138 kV POI %Loading	345 kV POI %Loading
514715[WOODRNG7 345.00] to 560055[G15063_T 345.00] CKT 1	1016	<99	514880[NORTWST7 345.00] to 514881[SPRNGCK7 345.00] CKT 1	<99	100.5
515497[MATHWSN7 345.00] to 560055[G15063_T 345.00] CKT 1	1192	<99	345: 514881[SPRNGCK7 345.00] to 587959[G16-032_TAP 345.00] CKT 1	<99	100.2

Table ES-5: GEN-2016-032 Modification New Impacts DISIS-2016-002-1

Monitored Element	Limiting Rate A/B (MVA)	TC %Loading (%MVA)	Contingency	138 kV POI %Loading	345 kV POI %Loading
514803[SOONER 7 345.00] to 587804[G16-100-TAP 345.00] CKT 1	1195	<99	514880[NORTWST7 345.00] to 514881[SPRNGCK7 345.00] CKT 1	<99	104.2
514881[SPRNGCK7 345.00] to 587959[G16-119-TAP 345.00] CKT 1	1195	<99	514715[WOODRNG7 345.00] to 560055[G15063_T 345.00] CKT 1	<99	125.2
515497[MATHWSN7 345.00] to 560055[G15063_T 345.00] CKT 1	1192	<99	514880[NORTWST7 345.00] to 514881[SPRNGCK7 345.00] CKT 1	<99	100.2
514880[NORTWST7 345.00] to 514881[SPRNGCK7 345.00] CKT 1	1039	98.4	Base Case	98.3	115.9

Based on the results of the power flow analysis, the Crescent 138 kV POI modification did not create adverse impacts on existing violations and did not created new violations and as such was identified as the preferred POI modification. As a result, the remaining analyses in this Study were performed using the Crescent 138 kV POI option.

A power factor analysis was not performed for GEN-2016-032 since the GEN-2016-032 Facility Study Agreement was executed after the FERC 827 and SPP does not have to demonstrate the need for power factor capabilities.

The results of the reactive power analysis, also known as the low-wind/no-wind condition analysis, performed using the three DISIS-2016-002-1 Group 8 stability models (2017 Winter Peak, 2018 Summer Peak, 2026 Summer Peak) with the modified 138 kV POI showed that the GEN-2016-032 project may require a 18.6 MVAr shunt reactor on the 138 kV bus of the project substation. The shunt reactor is needed to reduce the reactive power transfer at the POI to approximately zero during low/no wind conditions while the generation interconnection project remains connected to the grid.

The results from the short circuit analysis showed that the maximum change in the fault currents in the immediate systems at or near GEN-2016-032 was approximately 1.70 kA for the 2018SP and 2026SP 138 kV POI cases respectively. All three-phase fault current levels with the GEN-2016-032 generator online were below 45 kA for the 2018SP models and 2026SP models.

The dynamic stability analysis was performed using the three stability model cases for the 138 kV POI at the Crescent 138 kV Substation. Up to 31 events were simulated, which included three-phase faults, three-phase faults on prior outage cases, and single-line-to-ground faults with stuck breakers faults.

The results of the dynamic stability analysis showed that there were several prior outage faults that caused GEN-2016-032 to become unstable. FLT9003-PO2 and FLT9004-PO2, the prior outage on the Crescent to Cottonwood 138 kV line, followed by a three-phase fault on and loss of the Twin Lake to Dover 138 kV line or Twin Lake to Cashion 138 kV line, would cause GEN-2016-032 to become unstable. GEN-2016-032 may have to be curtailed to as low as 160 MW after the prior outage of the Crescent to Cottonwood 138 kV, Twin Lake to Dover 138 kV, or Twin Lake to Cashion 138kV line to remain stable following a subsequent fault.

There were no other machine rotor angle damping or transient voltage recovery violations observed in the simulated fault events associated with this modification request study. Additionally, the project wind farm was found to stay connected during the other contingencies that were studied and, therefore, will meet the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A.

1.0 Introduction

Aneden Consulting (Aneden) was retained by the Southwest Power Pool (SPP) to perform a Modification Request Impact Study (Study) for GEN-2016-032, an active generation interconnection request with an existing point of interconnection (POI) on the Cottonwood Creek to Marshall Tap 138 kV line.

The GEN-2016-032 project is proposed to interconnect in the Oklahoma Gas & Electric Company (OKGE) control area with a combined capacity of 200 MW as shown in Table 1-1 below.

Table 1-1: Existing GEN-2016-032 Configuration

Request	Capacity (MW)	Existing Generator Configuration	Point of Interconnection
GEN-2016-032	200	100 x Vestas V110 2.0MW	Tap on Marshal (514733) to Cottonwood (514827) 138kV Line

This Study has been requested to evaluate two potential points of interconnection for GEN-2016-032:

1. 138 kV POI - Crescent 138 kV substation
2. 345 kV POI - Tap on Spring Creek to Sooner 345 kV line

Details of the modification request are provided in Section 2.0 below.

1.1 Scope

The Study included a power flow, reactive power, short circuit and dynamic stability analyses. The methodology, assumptions, and results of the analyses are presented in the following main sections:

1. Project and Modification Request
2. Power Flow Analysis
3. Reactive Power Analysis
4. Short Circuit Analysis
5. Dynamic Stability Analysis
6. Conclusions

Aneden performed the analyses using a set of modified study models developed using the modification request data including the DISIS-2016-001-4 (ERIS and NRIS) and DISIS-2016-002-1 (ERIS) Group 8 study models. All analyses were performed using the PTI PSS/E version 33.7 software. The results of each analysis are presented in the following sections.

1.2 Study Limitations

The assessments and conclusions provided in this report are based on assumptions and information provided to Aneden by others. While the assumptions and information provided may be appropriate for the purposes of this report, Aneden does not guarantee that those conditions assumed will occur. In addition, Aneden did not independently verify the accuracy or completeness of the information provided. As such, the conclusions and results presented in this report may vary depending on the extent to which actual future conditions differ from the assumptions made or information used herein.

2.0 Project and Modification Request

GEN-2016-032 was originally studied as part of Group 8 in the DISIS-2016-001 study. The GEN-2016-032 Modification Request included the POI change with two potential locations. The two potential POIs are the Crescent 138 kV Substation and a Tap of Sooner 345 kV to Spring Creek 345 kV Substation. In addition, the modification request also included changes to the generation interconnection lines and the generator substation transformer.

Figure 2-1 shows the existing configuration GEN-2016-032 point of interconnection configuration.

Figure 2-1: GEN-2016-032 Existing 138 kV Configuration

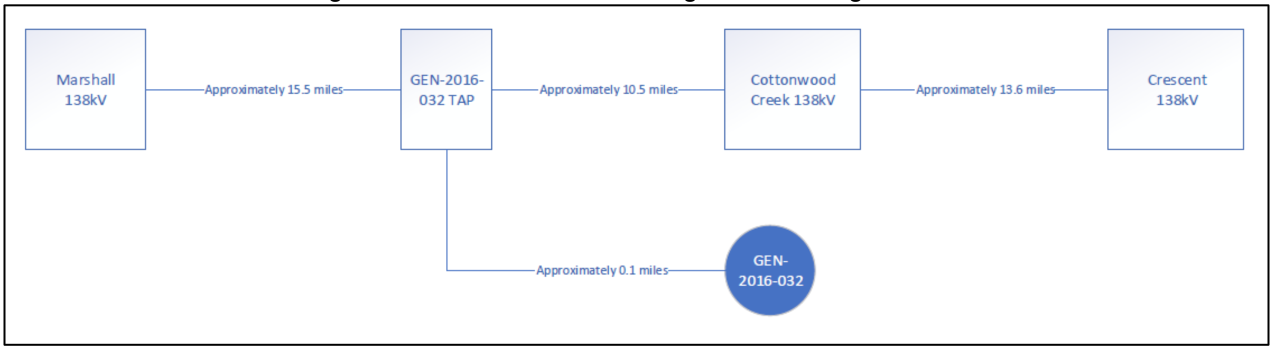

Figure 2-2 shows the configuration of the Modification Request Crescent 138 kV POI change. This POI change moved the GEN-2016-032 to the Crescent 138 kV Substation.

Figure 2-2: GEN-2016-032 New Configuration: 138 kV POI

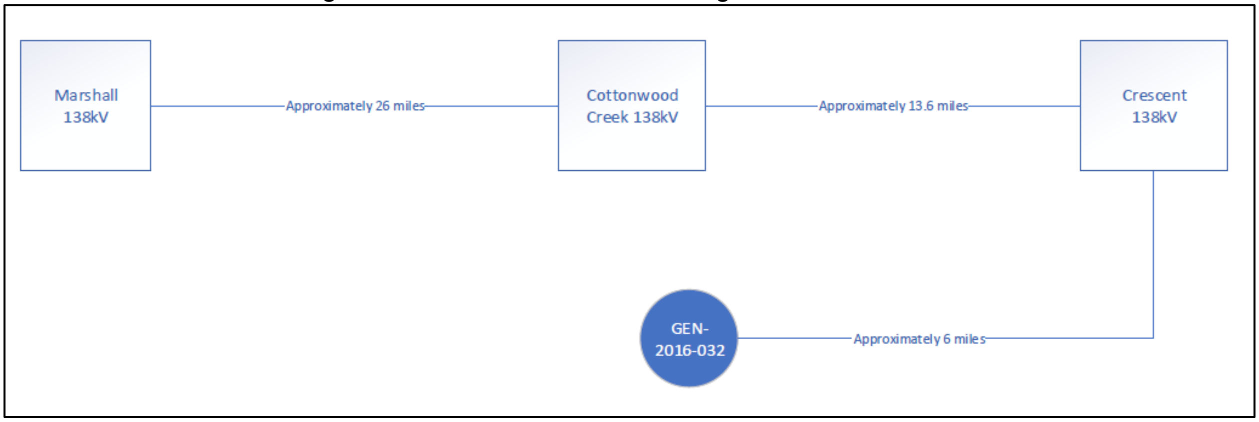

Figure 2-3 shows the existing configuration of the Spring Creek to Sooner 345 kV line and the proposed generation interconnection projects on the line – GEN-2016-100 and GEN-2016-119. Figure 2-4 shows the proposed location of the GEN-2016-032 on the Spring Creek to Sooner 345 kV line and the corresponding changes to the GEN-2016-100 and GEN-2016-119 projects. Note that GEN-2016-100 and GEN-2016-119 are part of the DISIS-2016-002 study cycle and lower queued than GEN-2016-032.

Figure 2-3: Spring Creek to Sooner 345 kV Line – Pre Modification

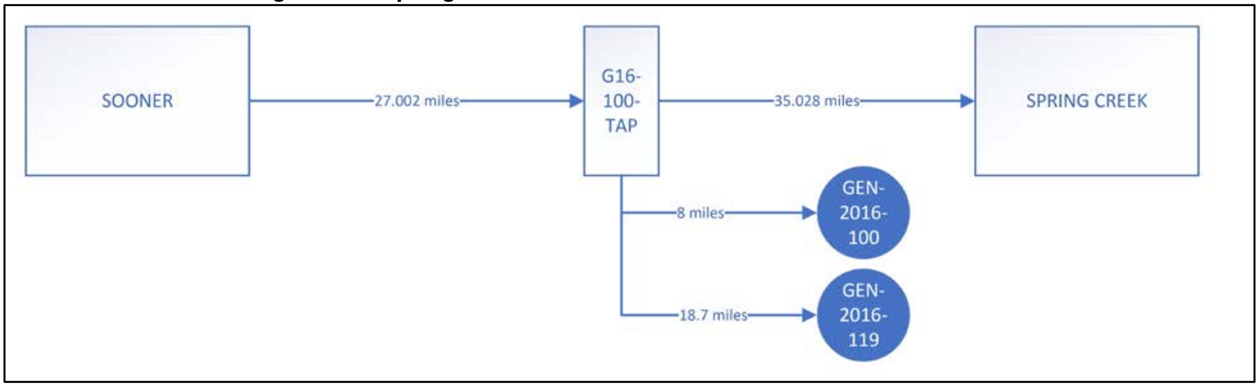

Figure 2-4: GEN-2016-032 New Configuration: 345 kV POI

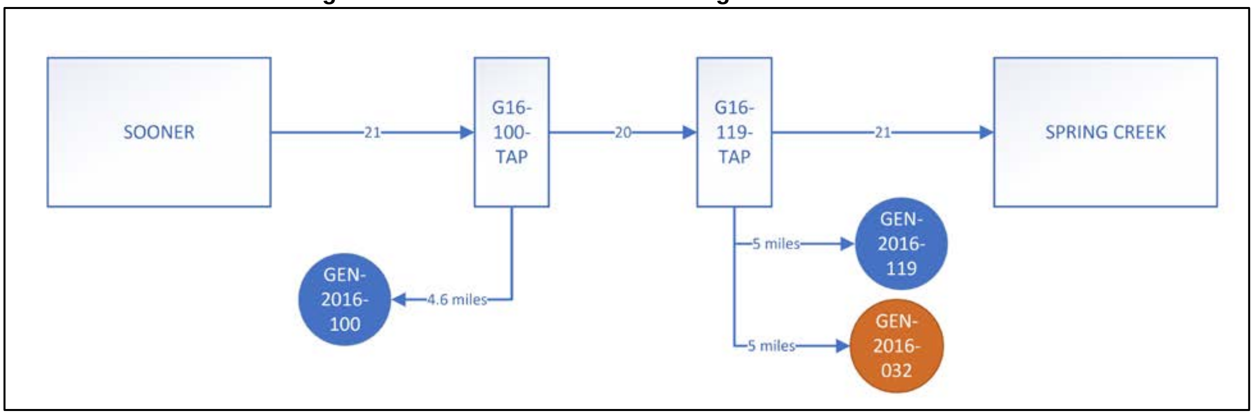

Table 2-1 shows the two modification request POI changes.

Table 2-1: GEN-2016-032 Modification Request

Facility	Existing	138 kV POI Change	345 kV POI Change
Point of Interconnection	Tap on Marshal (514733) to Cottonwood (514827) 138kV Line	Crescent 4 138 kV Substation (515377)	G16-119-Tap (587959) on Sooner (514803) to Spring Creek (514881) 345 kV Line
Configuration/Capacity	100 x Vestas V110 2.0MW = 200 MW	100 x Vestas V110 2.0MW = 200 MW	100 x Vestas V110 2.0MW = 200 MW
Generation Interconnection Line	Length = 3 miles R = 0.001900 pu X = 0.012220 pu B = 0.003310 pu	Length = 6 miles R = 0.003721 pu X = 0.023919 pu B = 0.006482 pu	Length = 5 miles R = 0.001480 pu X = 0.002891 pu B = 0.037073 pu
Main Substation Transformer	Z = 8.5%, Winding 150 MVA, Rating 250 MVA	Z = 8.5%, Winding 150 MVA, Rating 250 MVA	Z = 9%, Winding 150 MVA, Rating 250 MVA
GSU Transformer	Gen 1 Equivalent Qty: 100: Z = 9.76%, Rating 206 MVA	Gen Equivalent Qty: 100: Z = 9.76%, Rating 206 MVA	Gen Equivalent Qty: 100: Z = 9.76%, Rating 206 MVA
Equivalent Collector Line	R = 0.003320 pu X = 0.005290 pu B = 0.141370 pu	R = 0.006427 pu X = 0.010262 pu B = 0.177634 pu	R = 0.006427 pu X = 0.010262 pu B = 0.177634 pu

3.0 Power Flow Analysis

The power flow analysis was performed using the DISIS-2016-001-4 (ERIS and NRIS) and DISIS-2016-002-1 (ERIS) Group 8 power flow models. The model development, power flow analysis methodology, and power flow results are presented in this Section. Detailed power flow results are provided in Appendix A.

3.1 Model Development

The Study cases were built using SPP provided ERIS and NRIS models. They were modified to represent the two potential POI changes and remove the specific upgrade association with the existing GEN-2016-032 POI.

The two sets of cases were developed for the two POI evaluations:

1. 138 kV POI - Crescent 138 kV substation
2. 345 kV POI - Tap on Spring Creek to Sooner 345 kV line

The following changes were made to the provided cases:

1. Cottonwood Creek – G16-032 Tap 138kV line rating was reset to 240/270 MVA for winter and 194/222 MVA for all cases with the upgrade
2. The modifications to GEN-2016-100 and GEN-2016-119 were only reflected in the DISIS-2016-002 ERIS models.

The following DISIS power flow models used in the power flow analysis are summarized in Table 3-1 but listed in detail in Appendix A.

Table 3-1: Power Flow DISIS Cases Evaluated

Case Year (Both BC & TC)*	DISIS-2016-001-ERIS-S0	DISIS-2016-001-ERIS-S3	DISIS-2016-001-NRIS-S0	DISIS-2016-001-NRIS-S3	DISIS-2016-002-ERIS-S0
17WP	x	x	x	x	x
18SP	x	x	x	x	x
18G	x	x	x	x	x
21L	x	x	x	x	x
21SP	x	x	x	x	x
21WP	x	x	x	x	x
26SP	x	x	x	x	x

*BC Cases – Group 8 Models Dispatched to 0 MW, TC Cases – Group 8 Models Dispatched to Max Capacity

3.2 Power Flow Analysis Methodology

A power flow analysis was conducted using existing DISIS-2016-001 and DISIS-2016-002 power flow models as well as modified versions of DISIS-2016-001 and DISIS-2016-002 models with both Base Case (BC) conditions (GEN-2016-032 project offline) and Transfer Case (TC) conditions (GEN-2016-032 online at new POI). Both S0 cases (before SPP identified Group upgrades) and S3 cases (containing upgrades except those reverted) were analyzed.

The AC Contingency Calculation (ACCC) function of PSS/E was used to simulate system intact and contingencies provided by SPP. The system facilities were monitored for thermal and voltage impacts on all 69kV lines and above.

Network constraints were found using the PSS/E ACCC analysis along with TARA Transfer Distribution Factor (TDF) analysis for the entire cluster grouping.

For ERIS, thermal overloads are defined as being greater than 100% of Rate A for N-0 conditions, and greater than 100% of Rate B for N-1 contingencies. These overloads were then analyzed to determine if they meet any of the following three criteria:

- 3% Distribution Factor (DF) for N-0 conditions,
- 20% DF upon outage-based (N-1) conditions,
- or 3% DF on contingent elements that resulted in a non-converged solution.

For NRIS, these were studied in a separate analysis to determine if any of the constraints were greater than or equal to a 3% DF.

ACCC analysis was also used to determine voltage constraints in accordance with the guidelines in the Transmission Owner planning criteria. The identified voltage constraints were analyzed to determine if they met all the following criteria:

- 3% DF on the identified element,
- and 2% change in pu voltage.

3.3 Crescent 138 kV POI Power Flow Results

The Crescent 138kV POI change alleviated the previously observed overloads on the Cottonwood Creek to G16-032-Tap 138 kV line but did not resolve two of the previously identified overloads in the DISIS-2016-001-4 Group 8 Report as shown in Table 3-2 below.

There were no new thermal or voltage violations identified in the DISIS-2016-001 or DISIS-2016-002 models evaluated. The TC results represent the loading levels for the existing GEN-2016-032 POI.

Table 3-2: GEN-2016-032 138 kV POI Modification Impact on Existing Violations (DISIS-2016-001-4)

Monitored Element	Limiting Rate A/B (MVA)	*TC %Loading (%MVA)	Contingency	Currently Assigned Upgrades	138 kV POI
LACYGNE - WAVERLY7 345.00 345KV CKT 1	1141	103.5676	System Intact	New Wolf Creek – Emporia 345 kV CKT 1	Mitigation Unchanged (103.6%)
COTTONWOOD CREEK - G16-032-TAP 138.00 138KV CKT 1	194	125.7779	System Intact	Rebuild Cottonwood Creek - G16-032-Tap 138kV CKT 1	Mitigation Not Required (<95%)
COTTONWOOD CREEK - G16-032-TAP 138.00 138KV CKT 1	270	137.6935	G15063_T 345.00 - MATHWSN7 345.00 345KV CKT 1	Rebuild Cottonwood Creek - G16-032-Tap 138kV CKT 1	Mitigation Not Required (<95%)
RANCHRD7 345.00 - SOONER 345KV CKT 1	1195	102.8081	G15052_T 345.00 - ROSE HILL 345KV CKT 1	Ranch Road - Sooner 345 kV Ckt 1 Terminal Upgrades	Mitigation Unchanged (102.8%)

*TC %Loading data is from the DISIS-2016-001-4 Group 8 Report

3.4 Spring Creek to Sooner 345 kV POI Power Flow Results

The Tap on Spring Creek to Sooner 345 kV POI change alleviated the previously observed overloads on the Cottonwood Creek to G16-032-Tap 138 kV line but did not resolve two of the previously identified overloads in the DISIS-2016-001-4 Group 8 Report as seen in Table 3-3.

In addition, 345 kV POI change also caused several additional thermal constraints not previously identified in the DISIS-2016-001 and DISIS-2016-002 studies. These are summarized in Table 3-4 and Table 3-5.

Table 3-3: GEN-2016-032 345 kV POI Modification Impact on Existing Violations (DISIS-2016-001-4)

Monitored Element	Limiting Rate A/B (MVA)	*TC %Loading (%MVA)	Contingency	Currently Assigned Upgrades	345 kV POI
LACYGNE - WAVERLY7 345.00 345KV CKT 1	1141	103.5676	System Intact	New Wolf Creek – Emporia 345 kV CKT 1	Mitigation Unchanged (103.7%)
COTTONWOOD CREEK - G16-032-TAP 138.00 138KV CKT 1	194	125.7779	System Intact	Rebuild Cottonwood Creek - G16-032-Tap 138kV CKT 1	Mitigation Not Required (<95%)
COTTONWOOD CREEK - G16-032-TAP 138.00 138KV CKT 1	270	137.6935	G15063_T 345.00 - MATHWSN7 345.00 345KV CKT 1	Rebuild Cottonwood Creek - G16-032-Tap 138kV CKT 1	Mitigation Not Required (<95%)
RANCHRD7 345.00 - SOONER 345KV CKT 1	1195	102.8081	G15052_T 345.00 - ROSE HILL 345KV CKT 1	Ranch Road - Sooner 345 kV Ckt 1 Terminal Upgrades	Mitigation Unchanged (102.8%)

*TC %Loading data is from the DISIS-2016-001-4 Group 8 Report

Table 3-4: GEN-2016-032 Modification New Impacts DISIS-2016-001-4: 345 kV POI

Monitored Element	Limiting Rate A/B (MVA)	TC %Loading (%MVA)	Contingency	345 kV POI %Loading
514715[WOODRNG7 345.00] to 560055[G15063_T 345.00] CKT 1	1016	<99	514880[NORTWST7 345.00] to 514881[SPRNGCK7 345.00] CKT 1	100.5
515497[MATHWSN7 345.00] to 560055[G15063_T 345.00] CKT 1	1192	<99	345: 514881[SPRNGCK7 345.00] to 587959[G16-032_TAP 345.00] CKT 1	100.2

Table 3-5: GEN-2016-032 Modification New Impacts DISIS-2016-002-1: 345 kV POI

Monitored Element	Limiting Rate A/B (MVA)	TC %Loading (%MVA)	Contingency	345 kV POI %Loading
514803[SOONER 7 345.00] to 587804[G16-100-TAP 345.00] CKT 1	1195	<99	514880[NORTWST7 345.00] to 514881[SPRNGCK7 345.00] CKT 1	104.2
514881[SPRNGCK7 345.00] to 587959[G16-119-TAP 345.00] CKT 1	1195	<99	514715[WOODRNG7 345.00] to 560055[G15063_T 345.00] CKT 1	125.2
515497[MATHWSN7 345.00] to 560055[G15063_T 345.00] CKT 1	1192	<99	514880[NORTWST7 345.00] to 514881[SPRNGCK7 345.00] CKT 1	100.2
514880[NORTWST7 345.00] to 514881[SPRNGCK7 345.00] CKT 1	1039	98.4	Base Case	115.9

Based on these results, it was determined that the Tap on Spring Creek to Sooner 345 kV POI would require extensive additional mitigation and thus was not a viable modification. No further analysis was performed for the 345 kV POI change.

4.0 Reactive Power Analysis

The reactive power analysis, also known as the low-wind/no-wind condition analysis, was performed for the Crescent 138 kV POI for GEN-2016-032 to determine the reactive power contribution from the project's interconnection line and collector transformer and cables during low/no wind conditions while the project is still connected to the grid and to size shunt reactors that would reduce the project reactive power contribution to the POI to approximately zero.

4.1 Methodology and Criteria

For the GEN-2016-032 project, the generators were switched out of service while other collector system elements remained in-service. A shunt reactor was tested at the collection substation 138 kV bus to set the MVAr flow into each respective POI to approximately zero. The modified DISIS-2016-002-1 Group 8 stability models were used for this analysis.

4.2 138 kV POI Results

The results from the reactive power analysis showed that the GEN-2016-032 project required an approximately 18.6 MVAr shunt reactor at the project substation, to reduce the POI MVAr to zero. Figure 4-1 illustrates the shunt reactor size required to reduce the POI MVAr to approximately zero. Reactive compensation can be provided either by discrete reactive devices or by the generator itself if it possesses that capability.

Figure 4-1: 138 kV POI GEN-2016-032 Single Line Diagram (Shunt Reactor)

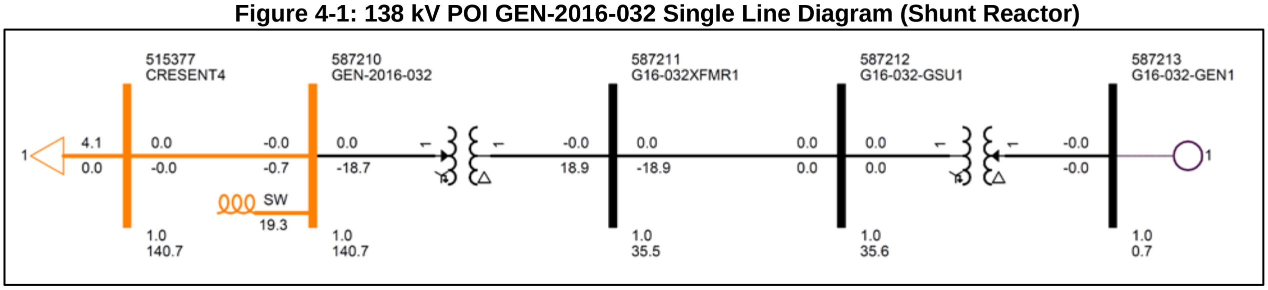

Table 4-1 shows the shunt reactor size determined for the three study models used in the assessment.

Table 4-1: 138 kV POI Shunt Reactor Size for Low Wind Study

Machine	POI Bus Number	POI Bus Name	Reactor Size (MVAr)		
			17WP	18SP	26SP
GEN-2016-032	515377	Crescent 4	18.6	18.6	18.6

5.0 Short Circuit Analysis

A short-circuit study was performed using the 2018SP and 2026SP models for the Crescent 138 kV POI for GEN-2016-032. The detailed results of the short-circuit analysis are provided in Appendix B.

5.1 Methodology

The short-circuit analysis included applying a 3-phase fault on buses up to 5 levels away from the 138 kV POI bus. The PSS/E "Automatic Sequence Fault Calculation (ASCC)" fault analysis module was used to calculate the fault current levels with and without the project online. The modified DISIS-2016-002-1 Group 8 stability models were used for this analysis.

5.2 138 kV POI Results

The 138 kV POI results of the short circuit analysis for the 2018SP and 2026SP models are summarized in Table 5-1 and Table 5-2 respectively. The maximum increase in fault current was about 21.5%, 1.70 kA. The maximum fault current calculated within 5 buses with GEN-2016-032 was less than 45kA for the 2018SP and 2026SP models respectively.

Table 5-1: 138 kV POI 2018SP Short Circuit Results

Voltage (kV)	Max. Current (kA)	Max kA Change	Max %Change
69	12.9	0.06	1.0%
138	44.9	1.70	21.5%
345	32.9	0.07	0.3%
Max	**44.9**	**1.70**	**21.5%**

Table 5-2: 138 kV POI 2026SP Short Circuit Results

Voltage (kV)	Max. Current (kA)	Max kA Change	Max %Change
69	12.8	0.07	1.0%
138	43.8	1.70	21.5%
345	32.8	0.07	0.3%
Max	**43.8**	**1.70**	**21.5%**

6.0 Dynamic Stability Analysis

Aneden performed a dynamic stability analysis to identify the impact of the Crescent 138 kV POI change and other modifications to the GEN-2016-032 project. The analysis was performed according to SPP's Disturbance Performance Requirements shown in Appendix C. The modification details are described in Section 2.0 above and the dynamic modeling data is provided in Appendix D. The simulation plots can be found in Appendix E.

Since the Power Flow Analysis presented in Section 3.0 showed that the 138 kV POI was the preferred POI option, the stability analysis was only performed for the 138 kV POI option.

6.1 Methodology and Criteria

The dynamic stability analysis was performed using models developed with the requested 100 x Vestas V110 2.0MW turbines configuration for the GEN-2016-032 generating facilities. The analysis was performed for the Crescent 138 kV POI modification. This stability analysis was performed using PTI's PSS/E version 33.7 software.

The stability models were developed using the stability models from DISIS-2016-002 for Group 8. The modifications requested to project GEN-2016-032 were used to create modified stability models for this impact study.

The modified dynamics model data for GEN-2016-032 is provided in Appendix D. The modified power flow models and associated dynamics database were initialized (no-fault test) to confirm that there were no errors in the initial conditions of the system and the dynamic data.

During the fault simulations, the active power (PELEC), reactive power (QELEC), and terminal voltage (ETERM) were monitored for GEN-2016-032 and other equally and prior queued projects in Group 8. In addition, voltages of five (5) buses away from each potential POI of GEN-2016-032 were monitored and plotted. The machine rotor angle for synchronous machines and speed for asynchronous machines within this study area including 520 (AEPW), 524 (OKGE), 525 (WFEC), 526 (SPS), 531 (MIDW), 534 (SUNC), 536 (WERE), 540 (GMO), 541 (KCPL), were monitored. In addition, the voltages of all 100 kV and above buses within the study area were monitored.

6.2 138 kV POI Fault Definitions

Aneden simulated the faults previously simulated near the 138 kV POI and selected additional fault events for GEN-2016-032 as required. The new set of faults were simulated using the modified study models. The fault events included three-phase faults, three-phase faults on prior outage cases, and single-line-to-ground faults with stuck breakers. The simulated faults are listed and described in Table 6-1 below. These contingencies were applied to the modified 2017 Winter Peak, 2018 Summer Peak, and the 2026 Summer Peak models.

Table 6-1: 138 kV POI Fault Definitions

Fault ID	Fault Descriptions
FLT68-3PH	3 phase fault on the Cottonwood Creek (514827) to Crescent (515377) 138kV line, near Cottonwood Creek. a. Apply fault at the Cottonwood Creek 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT69-3PH	3 phase fault on the Cottonwood Creek (514827) to Pine St (514829) 138kV line, near Cottonwood Creek. a. Apply fault at the Cottonwood 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT70-3PH	3 phase fault on the Cottonwood Creek (514827) to Arcadia (514907) 138kV line, near Cottonwood Creek. a. Apply fault at the Cottonwood 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT71-3PH	3 phase fault on the Cottonwood Creek (514827) to Liberty Lake (515373) 138kV line, near Cottonwood Creek. a. Apply fault at the Cottonwood 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT72-3PH	3 phase fault on the Marshall (514733) to Woodring (514714) 138kV line, near Marshall. a. Apply fault at the Marshall 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT76-SB	**Stuck Breaker on Cottonwood Creek – Arcadia 138kV circuit 1 line** a. Apply single-phase fault at Cottonwood Creek (514827) on the 138kV bus. b. After 16 cycles, trip the Cottonwood Creek – Arcadia (514907) 138kV circuit 1 line c. Trip the Cottonwood Creek – Liberty Lake (515373) 138kV circuit 1 line, and remove the fault
FLT9001-3PH	3 phase fault on the Crescent (515377) to Cottonwood Creek (514827) 138kV line, near Crescent. a. Apply fault at the Crescent 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9002-3PH	3 phase fault on the Crescent (515377) to Twin lake (521073) 138kV line, near Crescent. a. Apply fault at the Crescent 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9003-3PH	3 phase fault on the Twin lake (521073) to Cashion (520847) 138kV line, near Twin lake. a. Apply fault at the Twin lake 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9004-3PH	3 phase fault on the Twin lake (521073) to Dover (520879) 138kV line, near Twin lake. a. Apply fault at the Twin lake 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9005-3PH	3 phase fault on the Cashion (520847) to Reeding (521037) 138kV line, near Cashion. a. Apply fault at the Cashion 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9006-3PH	3 phase fault on the Dover (520879) to Doversw4 (520882) 138kV line, near Dover. a. Apply fault at the Dover 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.

Table 6-1 continued

Fault ID	Fault Descriptions
FLT9007-3PH	3 phase fault on the Liberty Lake (515373) to Watrloo (514831) 138kV line, near Liberty Lake. a. Apply fault at the Liberty Lake 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9008-3PH	3 phase fault on the Cottonwood Creek (514827) to Marshall (514733) 138kV line, near Cottonwood Creek. a. Apply fault at the Cottonwood 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9009-3PH	3 phase fault on the Marshall (514733) to Marshal4 (521006) 138kV line, near Marshall. a. Apply fault at the Marshall 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9010-3PH	3 phase fault on the Pine St (514829) to Fitzgrd (514830) 138kV line, near Pine St. a. Apply fault at the Pine St 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9011-3PH	3 phase fault on the Arcadia (514907) to Lgarber (515465) 138kV line, near Arcadia. a. Apply fault at the Arcadia 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9012-3PH	3 phase fault on the Arcadia (514907) to Rndbarn (515461) 138kV line, near Arcadia. a. Apply fault at the Arcadia 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9013-3PH	3 phase fault on the Arcadia (514907) to Jnskamo4 (514906) 138kV line, near Arcadia. a. Apply fault at the Arcadia 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9014-3PH	3 phase fault on the Arcadia (514908) to Nortwst7 (514880) 345kV line, near Arcadia. a. Apply fault at the Arcadia 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9015-3PH	3 phase fault on the Arcadia (514908) to Seminol7 (515045) 345kV line, near Arcadia. a. Apply fault at the Arcadia 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9016-3PH	3 phase fault on the Arcadia (514908) to Redbud (514909) 345kV line, near Arcadia. a. Apply fault at the Arcadia 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9017-3PH	3 phase fault on Arcadia 138kV (514907) to 345kV (514908) to 13.8kV (515704) CKT 1, near Arcadia 138kV. a. Apply fault at the Arcadia 138kV bus. b. Clear fault after 5 cycles and trip the faulted transformer.
FLT1001-SB	**Stuck Breaker at Twin lake (521073)** a. Apply single-phase fault at Twin lake (521073) on the 138kV bus. b. Clear fault after 16 cycles and trip the following elements c. Trip the Twin lake (521073) – Crescent (515377) 138kV circuit 1 line d. Trip the Twin lake (521073) – Cashion (520847) 138kV circuit 1 line
FLT1002-SB	**Stuck Breaker at Cotton Wood (514827)** a. Apply single-phase fault at Cotton wood (514827) on the 138kV bus. b. Clear fault after 16 cycles and trip the following elements c. Trip the Cotton wood (514827) – Crescent (515377) 138kV circuit 1 line d. Trip the Cotton wood (514827) – Marshall (514733) 138kV circuit 1 line

Table 6-1 continued

Fault ID	Fault Descriptions
FLT69-PO1	**Prior Outage of Crescent (515377) to Twin lake (521073) 138kV line;** 3 phase fault on the Cottonwood Creek (514827) to Pine St (514829) 138kV line, near Cottonwood Creek. a. Apply fault at the Cottonwood 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT70-PO1	**Prior Outage of Crescent (515377) to Twin lake (521073) 138kV line;** 3 phase fault on the Cottonwood Creek (514827) to Arcadia (514907) 138kV line, near Cottonwood Creek. a. Apply fault at the Cottonwood 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT71-PO1	**Prior Outage of Crescent (515377) to Twin lake (521073) 138kV line;** 3 phase fault on the Cottonwood Creek (514827) to Liberty Lake (515373) 138kV line, near Cottonwood Creek. a. Apply fault at the Cottonwood 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9008-PO1	**Prior Outage of Crescent (515377) to Twin lake (521073) 138kV line;** 3 phase fault on the Cottonwood Creek (514827) to Marshall (514733) 138kV line, near Cottonwood Creek. a. Apply fault at the Cottonwood 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9003-PO2	**Prior Outage of Crescent (515377) to Cottonwood Creek (514827) 138kV line;** 3 phase fault on the Twin lake (521073) to Cashion (520847) 138kV line, near Twin lake. a. Apply fault at the Twin lake 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
FLT9004-PO2	**Prior Outage of Crescent (515377) to Cottonwood Creek (514827) 138kV line;** 3 phase fault on the Twin lake (521073) to Dover (520879) 138kV line, near Twin lake. a. Apply fault at the Twin lake 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.

6.3 138 kV POI Results

Table 6-2 shows the results of the fault events simulated for each of the models at the 138 kV POI. The associated stability plots are provided in Appendix E.

The results of the dynamic stability analysis showed that there were several prior outage faults that caused GEN-2016-032 to become unstable. FLT9003-PO2 or FLT9004-PO2, the prior outage on the Crescent to Cottonwood 138 kV line, followed by a three-phase fault on and loss of the Twin Lake to Dover 138 kV line or Twin Lake to Cashion 138 kV line, would cause GEN-2016-032 to become unstable.

The system intact Short Circuit Ratio at Crescent 138 kV bus is 11.55 and reduces to as low as 3.95 following the prior outage and subsequent fault event. Prior outage faults are categorized as TPL-001-4 P6 events which allow for system adjustments, including curtailment of generation, as mitigation. GEN-2016-032 may have to be curtailed to as low as 160 MW after the prior outage of the Crescent to Cottonwood 138 kV, Twin Lake to Dover 138 kV, or Twin Lake to Cashion 138kV line to remain stable following a subsequent fault.

Table 6-2: 138 kV POI GEN-2016-032 Dynamic Stability Results

Fault ID	17W			18S			26S		
	Volt. Recovery	Volt. Violation	Stable	Volt. Recovery	Volt. Violation	Stable	Volt. Recovery	Volt. Violation	Stable
FLT68-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT69-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT70-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT71-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT72-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT76-SB	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9001-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9002-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9003-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9004-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9005-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9006-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9007-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9008-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9009-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9010-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9011-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9012-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9013-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9014-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9015-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9016-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9017-3PH	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT1001-SB	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT1002-SB	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT69-PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT70-PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT71-PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9008-PO1	Pass	Pass	Stable	Pass	Pass	Stable	Pass	Pass	Stable
FLT9003-PO2	Pass	Pass	Stable	Pass	Pass	Unstable	Pass	Pass	Unstable
FLT9004-PO2	Pass	Pass	Unstable	Pass	Pass	Unstable	Pass	Pass	Unstable

7.0 Conclusions

The Interconnection Customer for GEN-2016-032 requested a Modification Request Impact Study to assess the impact of two new potential points of interconnection at the Crescent 138 kV Substation and on the Sooner 345 kV to Spring Creek 345 kV line. In addition, the modification request also included changes to the generation interconnection lines and the generator substation transformer.

The power flow analysis was performed first to determine the impact of the Crescent 138 kV POI and the Spring Creek to Sooner 345 kV POI modification requests. Both POI modification requests alleviated the previously observed overloads on the Cottonwood Creek to G16-032-Tap 138 kV line. The remaining thermal constraints identified in the DISIS-2016-001-4 and DISIS-2016-002 report persisted with both POI modifications. The 138 kV POI option did not cause additional thermal or voltage constraints not previously identified. However, the 345 kV POI option caused new thermal constraints not previously identified in previous studies as shown in Table 7-1 and Table 7-2 for the DISIS-2016-001 and DISIS-2016-002 respectively. Since the 138 kV POI option did not introduce additional violations, it was selected as preferred POI option and further evaluated in the reactive power, short circuit and dynamic stability analyses.

Table 7-1: New 345 kV POI Impacts in DISIS-2016-001-4

Monitored Element	Limiting Rate A/B (MVA)	TC %Loading (%MVA)	Contingency	138 kV POI %Loading	345 kV POI %Loading
514715[WOODRNG7 345.00] to 560055[G15063_T 345.00] CKT 1	1016	<99	514880[NORTWST7 345.00] to 514881[SPRNGCK7 345.00] CKT 1	<99	100.5
515497[MATHWSN7 345.00] to 560055[G15063_T 345.00] CKT 1	1192	<99	345: 514881[SPRNGCK7 345.00] to 587959[G16-032_TAP 345.00] CKT 1	<99	100.2

Table 7-2: New 345 kV POI Impacts in DISIS-2016-002-1

Monitored Element	Limiting Rate A/B (MVA)	TC %Loading (%MVA)	Contingency	138 kV POI %Loading	345 kV POI %Loading
514803[SOONER 7 345.00] to 587804[G16-100-TAP 345.00] CKT 1	1195	<99	514880[NORTWST7 345.00] to 514881[SPRNGCK7 345.00] CKT 1	<99	104.2
514881[SPRNGCK7 345.00] to 587959[G16-119-TAP 345.00] CKT 1	1195	<99	514715[WOODRNG7 345.00] to 560055[G15063_T 345.00] CKT 1	<99	125.2
515497[MATHWSN7 345.00] to 560055[G15063_T 345.00] CKT 1	1192	<99	514880[NORTWST7 345.00] to 514881[SPRNGCK7 345.00] CKT 1	<99	100.2
514880[NORTWST7 345.00] to 514881[SPRNGCK7 345.00] CKT 1	1039	98.4	Base Case	98.3	115.9

The results of the reactive power analysis, also known as the low-wind/no-wind condition analysis, performed using all three 138 kV POI models showed that the combined GEN-2016-032 project may require an 18.6 MVAr shunt reactor on the 138kV bus of the project substation. The shunt reactor is needed to reduce the reactive power transfer at the POI to approximately zero during low/no wind conditions while the generation interconnection project remains connected to the grid.

The results from the short circuit analysis showed that the maximum change in the fault currents in the immediate systems at or near GEN-2016-032 was approximately 1.70 kA for the 2018SP and 2026SP 138 kV POI cases respectively. All three-phase fault current levels with the GEN-2016-032 generator online were below 45 kA for the 2018SP models and 2026SP models.

The results of the dynamic stability analysis showed that there were several prior outage faults that caused GEN-2016-032 to become unstable. FLT9003-PO2 or FLT9004-PO2, the prior outage on the Crescent to Cottonwood 138 kV line, followed by a three-phase fault on and loss of the Twin Lake to Dover 138 kV line or Twin Lake to Cashion 138 kV line, would cause GEN-2016-032 to become unstable. GEN-2016-032 may have to be curtailed to as low as 160 MW after the prior outage of the Crescent to Cottonwood 138 kV, Twin Lake to Dover 138 kV, or Twin Lake to Cashion 138kV line to remain stable following a subsequent fault.

Other than that, there were no machine rotor angle damping or transient voltage recovery violations observed in the simulated fault events associated with this modification request study. Additionally, the project wind farm was found to stay connected during the other contingencies that were studied and, therefore, will meet the Low Voltage Ride Through (LVRT) requirements of FERC Order #661A.