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Southwest Power Pool, Inc. (SPP)

DISIS-2016-002-2 (Group 09) Definitive Impact Study

Final Report

REP-1099
Revision #01

April 2021

Submitted By:
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Report Revision Table

Revision	Report Revision Table	Date
0	Issue Report for Group 9 Stability Sensitivity	04/21/2021

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Title: **DISIS-2016-002-2 (Group 09) Definitive Impact Re-Study: Draft Report for Review REP-1099**
Date: April 2021
Author: Nicholas Tenza; M Principal Consultant, Power Systems Engineering Division *Nicholas Tenza*
Reviewed: Samir Dahal; Principal Consultant, Power Systems Engineering Division *Samir Dahal*

EXECUTIVE SUMMARY

SPP requested a Definitive Interconnection System Impact Study (DISIS) following several Group 09 study request withdrawals and the subsequent alleviated need for several Network Upgrades. The DISIS required a Stability Analysis detailing the impacts of the interconnecting projects as shown in Table ES-1.

Table ES-1
Interconnection Projects Evaluated

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2016-074	200	Vestas 2.0 MW (587683)	Sweetwater 345kV (640374)
GEN-2016-096	227.7	Siemens 2.3 MW (587783, 587787)	Tap Moore – Pauline 345kV (560062)
GEN-2016-147	40	GE PV Solar 2.0 MW (588223)	Sidney 115kV (653572)

SUMMARY OF STABILITY ANALYSIS

The Stability Analysis determined that there were multiple contingencies across all seasons and dispatch scenarios that resulted in voltage collapse/instability, generation tripping offline, and poor post-fault voltage recovery when all generation interconnection requests were at 100% output. The voltage collapse/instability was observed in the vicinity of Gerald Gentleman Station and Laramie River Station for P4 and P6 fault events.

The P1 events at Holt County and P4 event at Gerald Gentleman Station that resulted in low post-fault voltage recovery and voltage collapse/instability, respectively, could be mitigated by the R-Plan (NTC 200220) Network Upgrade:

- Thedford 345/115/13.8 kV transformer
- Gerald Gentleman Station to Thedford 345kV circuit #1
- Holt County to Thedford 345kV circuit #1

The R-Plan Network Upgrade identified above mitigated the low post-fault voltage and voltage collapse/instability observed for P1 and P4 events evaluated in all seasons and dispatch scenarios. However, with this solution set, generation curtailment is required for several prior outage conditions, P6 events. Prior outage conditions, in anticipation of a subsequent fault events, required additional generation curtailment for the Normal Dispatch Scenario and High GGS Sensitivity Dispatch Scenario for circuits terminated at the following stations:

- Laramie River Station 345kV
- Sidney 345kV
- Sidney 230kV
- Stegall 345kV
- Holt County 345kV

Following the prior outages as described above, to maintain system stability following the three phase faults, the analysis determined that curtailing generation by up to 275 MW in the vicinity of Laramie River Station 345kV and by up to 50 MW at Grand Prairie 345kV resulted in a stable response with no generation tripping or system instability observed.

With the R-Plan Network Upgrade and curtailment above, the Stability Analysis determined that there was no generation tripping or system instability observed as a result of interconnecting all study projects at 100% output.

SECTION 1: OBJECTIVES

The objective of this report is to provide Southwest Power Pool, Inc. (SPP) with deliverables for the DISIS-2016-002-2 (Group 09) Re-Study. SPP requested an Interconnection System Impact Study for three (3) generation interconnections for 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak, which requires a Stability Analysis and an Impact Study Report.

SECTION 2: BACKGROUND

The Siemens Power Technologies International PSS/E power system simulation program Version 33.10 was used for this study. The stability cases for 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak cases under normal dispatch and Gerald Gentleman Station dispatch (referred to as High GGS Sensitivity Scenario) conditions and studied contingencies were utilized from the DISIS-2016-002 Group 09 study. The models include the DISIS-2016-002 study projects shown in Table 2-1 and the previously queued projects listed in Table 2-2. The withdrawn DISIS-2016-001 study projects shown in Table 2-3 and withdrawn MISO projects shown in Table 2-4 were removed from the study models to reflect current system configurations (GEN-2016-106 and GEN-2016-110 were most recently withdrawn and the reason for this restudy). Refer to Section 3.1 for the changes made to the base cases to reflect the removal of previously assigned Network Upgrades and study projects associated with DISIS-2016-002 conditions.

A power flow one-line diagram for each generation interconnection project is shown in Figures 2-1 through 2-3. Note that the one-line diagrams represent 2017 Winter Peak conditions. The Stability Analysis determined the impacts of the new interconnecting projects on the stability and voltage recovery of the nearby system and the ability of the interconnecting projects to meet FERC Order 661A. If problems with stability or voltage recovery are identified, the need for reactive compensation or system upgrades were investigated. Three-phase faults and single line-to-ground faults were examined as listed in Table 2-5 prior to any mitigation implemented.

Prior studies, including DISIS-2015-001 and DISIS-2016-001, modeled the Grand Prairie generating facility with the user-written PSS/E Model for Vestas OptiSpeed™ Wind Turbines Version 7.6. This study used the updated user-written Vestas Generic Model Structure V7 to represent these generating facilities in the study models. In discussions with the Grand Prairie generating facility turbine vendor regarding the previously observed instability, SPP was advised to replace the PSS/E Vestas WTG user-written model with the newer version of the Vestas WTG user-written model. This newer user-written model version incorporates the dynamic adjustment of the reactive power set point value during simulation to more accurately reproduce the WTG capabilities with voltage regulation as a standard feature in all Vestas wind turbine projects. The dynamic data file (dyre) parameters, appropriate to represent the Grand Prairie project specific design, were provided by the vendor.

Table 2-1: Interconnection Projects Evaluated

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2016-074	200	Vestas 2.0 MW (587683)	Sweetwater 345kV (640374)
GEN-2016-096	227.7	Siemens 2.3 MW (587783, 587787)	Tap Moore – Pauline 345kV (560062)
GEN-2016-147	40	GE PV Solar 2.0 MW (588223)	Sidney 115 kV Sub (653572)

Table 2-2: Previously Queued Nearby Interconnection Projects Included

Request	Size (MW)	Generator Model	Point of Interconnection
Beatrice Power Station	250	Thermal 80/90MW	Beatrice 115kV (640088)
Broken Bow	7.3		Broken Bow 115kV (640089)
Buffalo County Solar	10		Kearney Northeast (640249)
Burt County Wind	12		Tekamah & Oakland 115kV (640300)
Burwell	3.3		Ord 115kV (640308)
Columbus Hydro	45	Hydro 15MW	Columbus 115kV (640136)
North Platte - Lexington	66.7	Hydro 21.6/23.5MW	Multiple: Jeffrey 115kV, John_1 115kV, John_2 115kV (640238, 640240, 640242)
Ord	10.8		Ord 115kV (640308)
Stuart	1.8		Ainsworth 115kV (640051)
Ft Randle Hydro	352	Hydro 44/45MW	Ft Randle (WAPA) 230kV & 115kV (652510)
Gavins Pt Hydro	102	Hydro 34MW	Gavins Point (WAPA) 115kV (652511)
Spirit Mound Heat	120	Thermal 60MW	Spirit Mound (WAPA) 115kV (659121)
GEN-2003-021N	74.25	Vestas V82 1.65MW	Ainsworth Wind Tap 115kV (640050)
GEN-2004-023N	75	Thermal 75MW	Columbus 115kV (640119)
GEN-2006-020N	42.3	Vestas V190 VCUS 1.815MW, Vestas V90 VCRS 3.0MW	Bloomfield 115kV (640084)
GEN-2006-037N1	73.1	GE 1.7MW	Broken Bow North 115kV (640089)
GEN-2006-038N005	80	GE 1.6MW	Broken Bow North 115kV (640089)
GEN-2006-038N019	81	GE 1.5MW	Petersburg 115kV (640444)
GEN-2006-044N	40.5	GE 1.5MW	Petersburg 115kV (640444)

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2007-011N08	81	Vestas V90 VCRS 3.0MW	Bloomfield 115kV (640084)
GEN-2007-017IS/GEN-2007-018IS	400	Vestas 2.0MW	Tap Ft. Thompson – Grand Island 345kV (Grand Prairie, 652532)
GEN-2008-086N02/GEN-2014-032	211.22	GE 100m 1.79MW	Meadow Grove 230kV (640540)
GEN-2008-119O	60	GE 1.5MW	S1399 161kV (646399)
GEN-2008-123N	89.7	GE 103m 1.79/2/2.3MW	Tap Pauline – Guide Rock (Rosemont 115kV 560134)
GEN-2009-040	72	Vestas V110 VCSS 2.0MW	Marshall 115kV (533303)
GEN-2010-051	198.9	GE 100m 1.7MW	Tap on the Twin Church – Hoskins 230kV line (560347)
GEN-2011-018/GEN-2013-008/GEN-2014-004	78.76	GE 100m 1.79MW, GE 97.4m 1.79MW	Steele County 115kV (640426)
GEN-2011-027	120.25	GE 1.85MW	Tap Twin Church-Hoskins 230kV (560347)
GEN-2011-056	3.6 MW increase (Pmax=21.6MW)	Hydro 21.6MW	Jeffrey 115kV (640238)
GEN-2011-056A	3.6 MW increase (Pmax=21.6MW)	Hydro 21.6MW	Johnson 1 115kV (640240)
GEN-2011-056B	4.5 MW increase (Pmax=23.5MW)	Hydro 23.5MW	Johnson 2 115kV (640242)
GEN-2012-021	4.8 MW increase	Thermal 4.8MW	Terry Bundy Generating Station 115kV (650275)
GEN-2013-002	50.6	Siemens 108m 2.3MW	Monolith 115kV (640591)
GEN-2013-019	73.6	Siemens 108m 2.3MW	Monolith 115kV (640591)
GEN-2013-032	204	GE 97.4m 1.7MW	Antelope 115kV (640521)
GEN-2014-013	73.39	GE 100m 1.79MW	Meadow Grove 230kV (640540)

Request	Size (MW)	Generator Model	Point of Interconnection
GEN-2014-031	35.8	GE 1.79MW	Meadow Grove 230kV (640540)
GEN-2014-039	73.34	Vestas V110 VCSS 1.905/2.0MW	Friend 115kV (640174)
GEN-2015-007	160	GE 116m 2.0MW	Hoskins 345kV (640226)
GEN-2015-023	300.72	GE 100m 1.79MW	Holt County 345kV (640510)
GEN-2015-076	158.4	Vestas V117 GridStreamer 3.3MW	Belden 115kV (640080)
GEN-2015-088	300	Vestas V100 VCSS 2.0MW	Tap on Moore (640277) to Pauline (640312) 345kV (560062)
GEN-2015-089	200	GE 2.0MW	Utica 230kV (652526)
GEN-2016-021	300	Vestas V110 VCSS 2.0MW	Hoskins 345kV (640226)
GEN-2016-043	226.8	Vestas V136 3.6MW	Hoskins 345kV (640226)
GEN-2016-050	250.7	GE 2.3MW	Axtell (640065)-Post Rock (530583) 345kV (560082)
GEN-2016-075	50	Vestas V110 VCSS 2.0MW	Tap Ft. Thompson – Grand Island 345kV (Grand Prairie 652532)

Table 2-3: SPP Interconnection Projects Removed from the Model

Request	Size (MW)	Generator Model (Gen Bus Number)	Point of Interconnection
GEN-2010-041	10.5	GE 1.5MW (580071)	S1399 161kV (646399)
GEN-2015-053	50	GE 2.5MW (wind; 583783 & 583786)	Antelope 115kV (640521)
GEN-2015-087	66	Vestas V100 2.0 MW (wind; 585233)	Tap on Fairbury (640169) to Hebron (640218) 115kV
GEN-2016-023	150.5	GE 2.0MW and 1.79MW Wind (587093, 587095)	Tap Sidney (659426) - Laramie River (659131) 345kV (560075)
GEN-2016-029	150.5	GE 2.0MW and 1.79MW Wind (587193,587195)	Tap Sidney (659426) - Laramie River (659131) 345kV (560075)
GEN-2016-106	400	Vestas 2.0 MW (587853)	Gentleman Substation 345kV (640183)
GEN-2016-110	152	GE 2.0 MW (587873)	Tap Laramie River – (GEN-2016-110 Tap) Stegall 345kV (587874)
GEN-2016-165	202	GE 2.0 MW (588343)	Tap Holt County – Grand Prairie 345kV (588344)

Table 2-4: MISO Interconnection Projects Removed from the Model

Request	Size (MW)	Generator Model (Gen Bus Number)	Point of Interconnection
J414	120	Vestas V110 2.0 MW (84143)	Freeborn 161 kV (631180)
J415	200	GE Wind Turbine (84150, 84155, 84158, 84159)	Quinn – Blackhawk 345kV (84151)
J439	500	Vestas V110 2.0 MW (84397, 84398)	Obrien – Kossuth 345kV (84390)
J459	200	Vestas V110 2.0 MW (84593)	Big Stone South – Brookings County 345kV (84590)
J489	151.8	GE Wind Turbine (61421)	Big Stone – Ellendale 345kV (61418)
J511	200	Vestas V110 2.0 MW (85115, 85116)	Stanton 230 kV (615901)

J525	33	Solar (68922)	Lake Wilson – Hadley 69 kV (618920)
J575	100	GE Wind Turbine (85753)	Brookings County 345kV (601031)
J577	100	GE Wind Turbine (85773)	Brookings County 345kV (601031)
J593	224	Vestas V110 2.0 MW (85934)	Tioga 230 kV (661084)
J594	300	Vestas V110 2.0 MW (859441, 859442)	Jackson North 161 kV (631210)
J596	100	Vestas V110 2.0 MW (85965)	Morris – Moro 115 kV (85961)
J597	300	Vestas V110 2.0 MW (859741, 859742)	Brookings County 345kV (601031)
J599	200	Vestas V110 2.0 MW (85994)	Glenham 230 kV (661038)
J637	98	Gamesa Wind (86375)	Big Stone South – Brookings County 345kV (86371)
J638	204	Gamesa Wind (863841, 863842)	Big Stone South – Brookings County 345kV (86371)

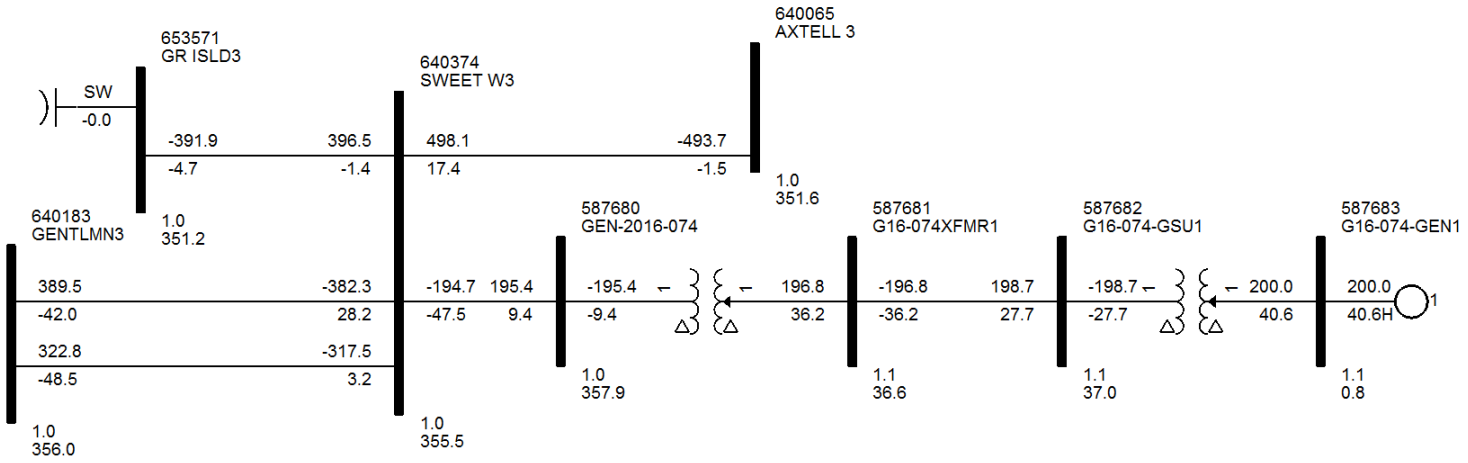

Figure 2-1. Power flow one-line diagram for interconnection project at Sweetwater 345kV (GEN-2016-074).

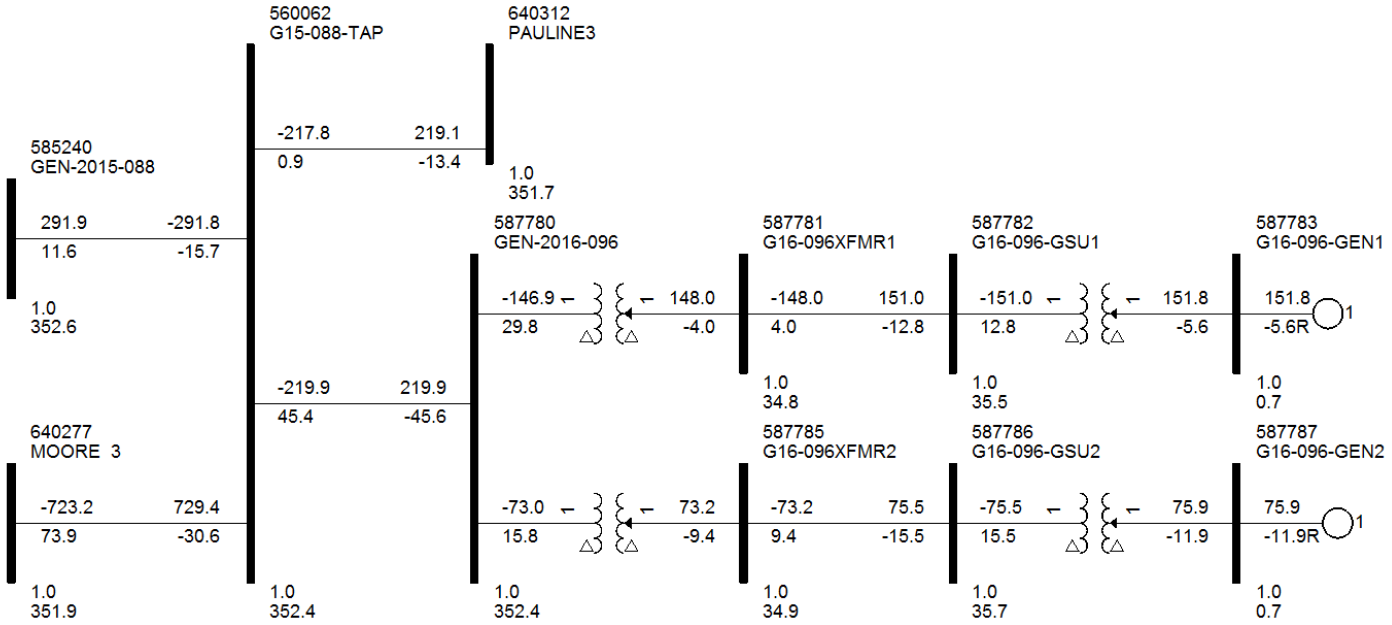

Figure 2-2. Power flow one-line diagram for interconnection project at GEN-2015-088 Tap 45 kV (GEN-2016-096).

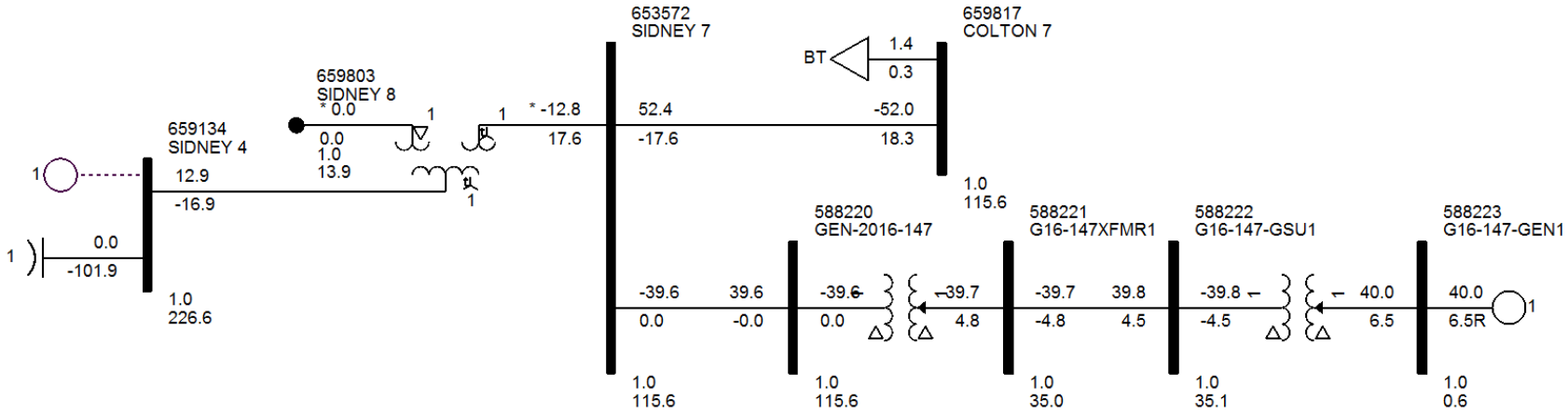

Figure 2-3. Power flow one-line diagram for interconnection project at Sidney 115 kV (GEN-2016-147).

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
1	FLT01-3PH	3 phase fault on the Laramie (659131) to Stegall (659135) 345kV line circuit 1, near Stegall. a. Apply fault at the Stegall 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
2	FLT02-3PH	**Removed**
3	FLT03-3PH	3 phase fault on the Laramie (659131) to Sidney LNX (659426) to Sidney (659133) 345kV line circuit 1, near Laramie. a. Apply fault at the Laramie 345kV bus. b. Clear fault after 4 cycles by tripping the faulted line.
4	FLT04-3PH	3 phase fault on the Laramie (659131) to Stegall (659135) 345kV line circuit 1, near Laramie. a. Apply fault at the Laramie 345kV bus. b. Clear fault after 4 cycles by tripping the faulted line.
5	FLT05-3PH	3 phase fault on the Sidney (659133) to SIDNEY1-LNX (659425) to Keystone (640252) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
6	FLT06-3PH	3 phase fault on the Sidney 345/230/13.8kV (659133/659210/659168) Transformer, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
7	FLT07-3PH	3 phase fault on the Sidney (659133) to Stegall (659135) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
8	FLT08-3PH	3 phase fault on the Sidney (659133) to SIDNEY2-LNX (659426) to Laramie (659131) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
9	FLT09-3PH	3 phase fault on the Sidney (659134) to Sidney West (652584) 230kV line circuit 1, near Sidney. a. Apply fault at the Sidney 230 kV bus. b. Clear fault after 6 cycles, trip the faulted line, and remove the fault. c. Block the DC tie at SIDNEY 4.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
10	FLT10-3PH	3 phase fault on the Ogalala (640302) to Sidney (659134) 230 kV line circuit 1, near Ogalala. a. Apply fault at the Ogalala 230kV bus. b. Clear fault after 6 cycles and trip the faulted line and remove fault.
11	FLT11-3PH	3 phase fault on the Ogalala 230/115/13.8kV (640302/640304/643115) Transformer circuit 1, near Ogalala 230 kV. a. Apply fault at the Ogalala 230 kV bus. b. Clear fault after 6 cycles and trip the faulted transformer.
12	FLT12-3PH	3 phase fault on the Ogalala (640302) to Gentleman (640184) 230 kV line circuit 1, near Ogalala. a. Apply fault at the Ogalala 230kV bus. b. Clear fault after 6 cycles and trip the faulted line and remove fault.
13	FLT13-3PH	3 phase fault on the Gentleman (640183) to Keystone (640252) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
14	FLT14-3PH	3 phase fault on the Gentleman 345/230/13.8kV (640183/640184/643066) Transformer, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
15	FLT15-3PH	3 phase fault on the Gentleman 345/230/13.8kV (640183/640184/640185) Transformer, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
16	FLT16-3PH	3 phase fault on the Gentleman (640183) to Red Willow (640325) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
17	FLT17-3PH	3 phase fault on the Gentleman (640183) to Sweetwater (640374) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
18	FLT18-3PH	3 phase fault on the Keystone (640252) to Gentleman (640183) 345kV line circuit 1, near Keystone. a. Apply fault at the Keystone 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
19	FLT19-3PH	3 phase fault on the Keystone (640252) to SIDNEY1-LNX (659425) to Sidney (659133) 345kV line circuit 1, near Keystone. a. Apply fault at the Keystone 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
20	FLT20-3PH	3 phase fault on the Keystone 345/115/13.8kV (640252/640253/640254) Transformer, near Keystone. a. Apply fault at the Keystone 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
21	FLT21-3PH	3 phase fault on the Holt County (640510) to GRPRAR1-LNX3 (652832) to Grand Prairie (652532) 345kV line circuit 1, near Holt County. a. Apply fault at the Holt County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
22	FLT22-3PH	3 phase fault on the Holt County (640510) to GRISLD-LNX3 (653871) to Grand Island (653571) 345kV line circuit 1, near Holt County. a. Apply fault at the Holt County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
23	FLT23-3PH	3 phase fault on the Grand Prairie (652532) to GRPRAR1-LNX3 (652832) to Holt County (640510) 345kV line circuit 1, near Grand Prairie. a. Apply fault at the Grand Prairie 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
24	FLT24-3PH	3 phase fault on the Grand Prairie (652532) to GRPRAR2-LNX3 (652833) to FTTHOM2-LNX3 (652807) to Ft Thompson (652506) 345kV line circuit 1, near Grand Prairie. a. Apply fault at the Grand Prairie 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
25	FLT25-3PH	3 phase fault on the Grand Island (653571) to GRISLD-LNX3 (653871) to Holt County (640510) 345kV line circuit 1, near Grand Island. a. Apply fault at the Grand Island 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
26	FLT26-3PH	3 phase fault on the Grand Island (653571) to Sweetwater (640374) 345kV line circuit 1, near Grand Island. a. Apply fault at the Grand Island 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
27	FLT27-3PH	3 phase fault on the Grand Island (653571) to McCool (640271) 345kV line circuit 1, near Grand Island. a. Apply fault at the Grand Island 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
28	FLT28-3PH	3 phase fault on the Grand Island 345/115/13.8kV (653571/640200/653314) Transformer, near Grand Island. a. Apply fault at the Grand Island 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
29	FLT29-3PH	3 phase fault on the Sweetwater (640374) to Axtell (640065) 345kV line circuit 1, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
30	FLT30-3PH	3 phase fault on the Sweetwater (640374) to Grand Island (653571) 345kV line circuit 1, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
31	FLT31-3PH	3 phase fault on the Sweetwater (640374) to Gentleman (640183) 345kV line circuit 1, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
32	FLT32-3PH	3 phase fault on the Axtell (640065) to Pauline (640312) 345kV line circuit 1, near Axtell. a. Apply fault at the Axtell 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
33	FLT33-3PH	3 phase fault on the Axtell 345/115/13.8kV (640065/640066/640067) Transformer, near Axtell. a. Apply fault at the Axtell 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
34	FLT34-3PH	3 phase fault on the Axtell (640065) to G16-050-Tap (560082) 345kV line circuit 1, near Axtell. a. Apply fault at the Axtell 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
35	FLT35-3PH	3 phase fault on the G16-050-Tap (560082) to Post Rock (530583) 345kV line circuit 1, near G16-050-Tap. a. Apply fault at the G16-050-Tap 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
36	FLT36-3PH	3 phase fault on the Stegall 3 (659135) to Sidney (659133) 345kV line circuit 1, near Stegall 3. a. Apply fault at the Stegall 3 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
37	FLT37-3PH	3 phase fault on the Stegall 345/230/13.8kV (659135/659206/659167) Transformer, near Stegall3. a. Apply fault at the Stegall 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
38	FLT38-3PH	**Removed (replaced with FLT01)**
39	FLT39-3PH	3 phase fault on the Sidney (653572/659134/659803) 115/230/13.8kV transformer, near Sidney. a. Apply fault at the Sidney 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.
40	FLT40-3PH	3 phase fault on the Sidney (653572) to Colton (659817) 115kV line circuit 1, near Sidney. a. Apply fault at the Sidney 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.
41	FLT41-3PH	3 phase fault on the Colton (659817) to Chappel (653300) 115kV line circuit 1, near Colton. a. Apply fault at the Colton 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.
42	FLT42-3PH	3 phase fault on the Sidney (659134) to Sidney Transformer (659210) 230kV line circuit 1, near Sidney. a. Apply fault at the Sidney 230kV bus. b. Clear fault after 6 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
43	FLT43-3PH	3 phase fault on the Chappel (653300) to JULSTAP7 (640246) 115kV line circuit 1, near Colton. a. Apply fault at the Chappel 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.
44	FLT44-3PH	3 phase fault on the Pauline (640312) to G15-088-Tap (560062) 345kV line circuit 1, near Pauline. a. Apply fault at the Pauline 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
45	FLT45-3PH	3 phase fault on the Pauline (640312) to Axtell (640065) 345kV line circuit 1, near Pauline. a. Apply fault at the Pauline 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
46	FLT46-3PH	3 phase fault on the Pauline (640312/640313/640315) 345/115/13.8kV transformer, near Pauline. a. Apply fault at the Pauline 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
47	FLT47-3PH	3 phase fault on the Moore (640277) to Cooper (640139) 345kV line circuit 1, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
48	FLT48-3PH	3 phase fault on the Moore (640277) to Rokeby (650189) 345kV line circuit 1, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
49	FLT49-3PH	3 phase fault on the Moore (640277) to NW68HOLDRG3 (650114) 345kV line circuit 1, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
50	FLT50-3PH	3 phase fault on the Moore (640277) to G15-088-Tap (560062) 345kV line circuit 1, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
51	FLT51-3PH	3 phase fault on the Moore/Sheldon (640277/640278/640280) 345/115/13.8kV transformer, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
52	FLT52-SB	**Stegall 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Stegall (659135) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Stegall (659135) to Laramie (659131) 345kV line circuit 1. d. Trip Stegall (659135) to Sidney (659133) 345kV line circuit 1
53	FLT53-SB	**Stegall 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Stegall (659135) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Stegall 345/230/13.8kV (659135/659206/659167) Transformer d. Trip Stegall 345/115/13.8kV (659135/640530/640531) Transformer
54	FLT54-SB	**Sidney 230 kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Sidney (659134) 230kV bus. b. Wait 16 cycles and remove fault. c. Trip Sidney (659134) to Sidney Transformer (659210) 230kV line circuit 1. d. Trip Sidney (659134) to Ogalala (640302) 230kV line circuit 1. e. Block the DC tie at SIDNEY 4 f. Drop shunt at SIDNEY 4
55	FLT55-SB	**Sidney 230 kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Sidney (659134) 230kV bus. b. Wait 16 cycles and remove fault. c. Trip Sidney (659134) to Sidney Transformer (659210) 230kV line circuit 1. d. Trip Sidney (659134) 230 kV / (653572) 115 kV / (659803) 13.8 kV transformer circuit 1. e. Block the DC tie at SIDNEY 4 f. Drop shunt at SIDNEY 4
56	FLT56-SB	**Sidney 115 kV Stuck Breaker** a. Apply single phase fault at the Sidney (653572) 115kV bus. b. Wait 16 cycles and remove fault. c. Trip Sidney (653572) to Colton (659817) 115kV line circuit 1. d. Trip Sidney (653572/659134/659803) 115/230/13.8kV transformer.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
57	FLT57-SB	**Keystone 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Keystone (640252) 345kV b. Run 16 cycles, remove fault. c. Trip line from Keystone (640252) to SIDNEY-LNX (659425) to Sidney (659133) 345kV line circuit 1 d. Trip line from Keystone (640252) to Gentleman (640183) 345kV line circuit 1
58	FLT58-SB	**Keystone 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Keystone (640252) 345kV b. Run 16 cycles, remove fault. c. Trip line from Keystone (640252) to Gentleman (640183) 345kV line circuit 1 d. Disconnect three winding transformer at bus 640252/640253/640254
59	FLT59-SB	**Gentleman 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Gentleman (640183) 345kV bus. b. Wait 13.5 cycles and remove fault. c. Trip Gentleman (640183) to Keystone (640252) 345kV line circuit 1. d. Trip Gentleman 345/230/13.8kV (640183/640184/640185) Transformer.
60	FLT60-SB	**Removed**
61	FLT61-SB	**Gentleman 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Gentleman (640183) 345kV bus. b. Wait 13.5 cycles and remove fault. c. Trip Gentleman (640183) to Sweetwater (640374) 345kV line circuit 2. d. Trip Gentleman (640183) to Red Willow (640325) 345kV line circuit 1.
62	FLT62-SB	**Removed**
63	FLT63-SB	**Holt County 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Holt County (640510) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Holt County (640510) to GR ISLD-LNX (653871) to Grand Island (653571) 345kV line circuit 1
64	FLT64-SB	**Gentleman 230 kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Gentleman (640184) 230kV bus. b. Wait 15.5 cycles and remove fault. c. Trip Gentleman (640184) to Ogalala (640302) 230kV line circuit 1. d. Trip Gentleman 345/230/13.8kV (640183/640184/640185) Transformer.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
65	FLT65-SB	**Sweetwater 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Sweetwater (640374) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Sweetwater (640374) to Gentleman (640183) 345kV line circuit 1. d. Trip Sweetwater (640374) to Axtell (640065) 345kV line circuit 1.
66	FLT66-SB	**Sweetwater 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Sweetwater (640374) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Sweetwater (640374) to Gentleman (640183) 345kV line circuit 2. d. Trip Sweetwater (640374) to Grand Island (653571) 345kV line circuit 1.
67	FLT67-SB	**Sweetwater 345kV Stuck Breaker Scenario 3** a. Apply single phase fault at the Sweetwater (640374) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Sweetwater (640374) to Axtell (640065) 345kV line circuit 1. d. Trip Sweetwater (640374) to Grand Island (653571) 345kV line circuit 1.
68	FLT68-SB	**Pauline 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Pauline (640312) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Pauline 345/115/13.8kV (640312/640313/640315) transformer. d. Trip Pauline (640312) to Axtell (640065) 345kV line circuit 1.
69	FLT69-SB	**Pauline 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Pauline (640312) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Pauline 345/115/13.8kV (640312/640313/640315) transformer. d. Trip Pauline (640312) to G15-088-TAP (560062) 345kV line circuit 1.
70	FLT70-SB	**Moore 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Moore (640277) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Moore 345/115/13.8kV (640277/640278/640280) transformer. d. Trip Moore (640277) to McCool (640271) 345kV line circuit 1.
71	FLT71-SB	**Moore 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Moore (640277) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Moore (640277) to NW68HOLDRG3 (650114) 345kV line circuit 1. d. Trip Moore (640277) to 103&ROKEBY3 (650189) 345kV line circuit 1.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
72	FLT72-SB	**Moore 345kV Stuck Breaker Scenario 3** a. Apply single phase fault at the Moore (640277) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Moore (640277) to Cooper (640139) 345kV line circuit 1. d. Trip Moore (640277) to G15-088-TAP (560062) 345kV line circuit 1.
73	FLT73-SB	**Grand Island 345kV Stuck Breaker Scenario** a. Apply fault at the Grand Island 345kV bus. b. Clear fault after 16 cycles and trip the following elements c. Trip Grand Island (653571) to GR ISLD-LNX3 (653871) to Holt County (640510) 345kV circuit 1 d. Trip Grand Island (653571) to Sweetwater (640374) 345kV circuit 1
74	FLT74-PO	**Prior outage on the Sidney (659133) – Laramie (659131) 345kV line circuit 1** 3 phase fault on the Stegall (659135) to Sidney (659133) 345kV line circuit 1, near Stegall. a. Apply fault at the Stegall 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
75	FLT75-PO	**Prior outage on the Laramie (659131) – Stegall (659135) 345kV line circuit 1** 3 phase fault on the Sidney (659133) to Stegall (659135) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
76	FLT76-PO	**Prior outage on the Laramie (659131) – Stegall (659135) 345kV line circuit 1** 3 phase fault on the Sidney (659133) to SIDNEY-LNX (659425) to Keystone (640252) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
77	FLT77-PO	**Prior outage on the Sidney (659133) – Stegall (659135) 345kV line circuit 1** 3 phase fault on the Sidney (659133) to SIDNEY-LNX (659425) to Keystone (640252) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
78	FLT78-PO	**Prior outage on the Sidney (659133) – Stegall (659135) 345kV line circuit 1** 3 phase fault on the Sidney (659133) to SIDNEY2-LNX (659426) to Laramie (659131) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
79	FLT79-PO	**Prior outage on the Sidney (659133) – Stegall (659135) 345kV line circuit 1** 3 phase fault on the Sidney 345/230/13.8kV (659133/659210/659168) Transformer, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
80	FLT80-PO	**Prior outage on the Sidney (659134) – Sidney Transformer (659210) 230 kV line circuit 1** 3 phase fault on the Sidney (659133) to Stegall (659135) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 6 cycles by tripping the faulted line.
81	FLT81-PO	**Prior outage on the Sidney (659134) – Sidney Transformer (659210) 230 kV line circuit 1** 3 phase fault on the Sidney (659133) to SIDNEY-LNX (659425) to Keystone (640252) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
82	FLT82-PO	**Prior outage on the Sidney (659134) – Sidney Transformer (659210) 230 kV line circuit 1** 3 phase fault on the Sidney (659133) to SIDNEY2-LNX (659426) to Laramie (659131) 345kV line circuit 1, near Sidney. a. Apply fault at the Sidney 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
83	FLT83-PO	**Prior outage on the Sweetwater (640374) – Axtell (640065) 345kV line circuit 1** 3 phase fault on the Sweetwater (640374) to Grand Island (653571) 345kV line circuit 1, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
84	FLT84-PO	**Prior outage on the Sweetwater (640374) – Axtell (640065) 345kV line circuit 1** 3 phase fault on the Sweetwater (640374) to Gentleman (640183) 345kV line circuit 1, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
85	FLT85-PO	**Prior outage on the Sweetwater (640374) – Gentleman (640183) 345kV line circuit 1** 3 phase fault on the Sweetwater (640374) to Grand Island (653571) 345kV line circuit 1, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
86	FLT86-PO	**Prior outage on the Sweetwater (640374) – Gentleman (640183) 345kV line circuit 1** 3 phase fault on the Sweetwater (640374) to Axtell (640065) 345kV line circuit 1, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
87	FLT87-PO	**Prior outage on the Sweetwater (640374) – Gentleman (640183) 345kV line circuit 1** 3 phase fault on the Sweetwater (640374) to Gentleman (640183) 345kV line circuit 2, near Sweetwater. a. Apply fault at the Sweetwater 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
88	FLT88-PO	**Prior outage on the Pauline 345/115/13.8kV (640312/640313/640315) transformer** 3 phase fault on the Pauline (640312) to Axtell (640065) 345kV line circuit 1, near Pauline. a. Apply fault at the Pauline 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
89	FLT89-PO	**Prior outage on the Pauline 345/115/13.8kV (640312/640313/640315) transformer** 3 phase fault on the Pauline (640312) to G15-088-Tap (560062) 345kV line circuit 1, near Pauline. a. Apply fault at the Pauline 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
90	FLT90-PO	**Prior outage on the Pauline 345/115/13.8kV (640312/640313/640315) transformer** 3 phase fault on the G15-088-Tap (560062) to Moore (640277) 345kV line circuit 1, near G15-088-Tap. a. Apply fault at the G15-088-Tap 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
91	FLT91-PO	**Prior outage on the Moore (640277) - COOPER 3 (640139) 345kV kV line circuit 1** 3 phase fault on the Moore (640277) to COOPER 3 (640139) 345kV line circuit 1, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
92	FLT92-PO	**Prior outage on the Moore (640277) - COOPER 3 (640139) 345kV kV line circuit 1** 3 phase fault on the Moore (640277) to 103&ROKEBY3 (650189) 345kV line circuit 1, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
93	FLT93-PO	**Prior outage on the Moore (640277) - COOPER 3 (640139) 345kV kV line circuit 1** 3 phase fault on the Moore (640277) to NW68HOLDRG3 (650114) 345kV line circuit 1, near Moore. a. Apply fault at the Moore 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
94	FLT94-PO	**Prior outage on the Moore (640277) - COOPER 3 (640139) 345kV kV line circuit 1** 3 phase fault on the G15-088-Tap (560062) to Pauline (640312) 345kV line circuit 1, near G15-088-Tap. a. Apply fault at the G15-088-Tap 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
95	FLT95-PO	**Prior outage on the Gentleman (640183/640184/640185) 345/230/13.8kV transformer** 3 phase fault on the Gentleman (640183) to Keystone (640252) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
96	FLT96-PO	**Prior outage on the Gentleman (640183/640184/640185) 345/230/13.8kV transformer** 3 phase fault on the Gentleman (640183) to Red Willow (640325) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
97	FLT97-PO	**Prior outage on the Gentleman (640183/640184/640185) 345/230/13.8kV transformer** 3 phase fault on the Gentleman (640183) to Sweetwater (640374) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
98	FLT98-PO	**Prior Outage of Sidney (653572) to Colton (659817) 115kV line circuit 1;** 3 phase fault on the Sidney (653572/659134/659803) 115/230/13.8kV transformer, near Sidney. a. Apply fault at the Sidney 115kV bus. b. Clear fault after 6.5 cycles by tripping the faulted line.
99	FLT99-PO	**Prior Outage of Grand Prairie 345kV (652532) to GRPRAR1-LNX3 (652832) to Holt County (640510) 345kV CKT 1;** 3 phase fault on the Grand Island (653571) to Sweetwater (640374) 345kV line circuit 1, near Grand Island. a. Apply fault at the Grand Island 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

Table 2-5: Case List with Contingency Description

Ref. No.	Cont. Name	Description
100	FLT100-PO	**Prior Outage of Grand Prairie 345kV (652532) to GRPRAR1-LNX3 (652832) to Holt County (640510) 345kV CKT 1;** 3 phase fault on the Grand Island (653571) to McCool (640271) 345kV line circuit 1, near Grand Island. a. Apply fault at the Grand Island 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
101	FLT101-SB	**Red Willow 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Red Willow (640325) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Red Willow (640325/640326/640327) 345/115kV transformer. d. Trip Red Willow (640325) to Mingo (531451) 345kV line circuit 1.
102	FLT102-SB	**Red Willow 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Red Willow (640325) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Red Willow (640325) to Gentleman (640183) 345kV line circuit 1. d. Trip Red Willow (640325) to Mingo (531451) 345kV line circuit 1.
103	FLT103-SB	**Post Rock 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Post Rock (530583) 345kV b. Run 16 cycles, remove fault. c. Trip Post Rock (530583) to GEN-2016-050-Tap (560082) 345kV line circuit 1 d. Trip Post Rock (530583) to Spearville (531469) 345kV line circuit 1
104	FLT104-SB	**Post Rock 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Post Rock (530583) 345kV b. Run 16 cycles, remove fault. c. Trip Post Rock (530583/530584/530673) 345/230kV transformer d. Trip Post Rock (530583) to Spearville (531469) 345kV line circuit 1

Table 2-6: Additional Contingencies with Mitigation Implemented

Ref. No.	Cont. Name	Description
105	FLT105-3PH	3 phase fault on the Holt County (640510) to Thedford (640500) 345kV line circuit 1, near Holt County. a. Apply fault at the Holt County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
106	FLT106-3PH	3 phase fault on the Thedford (640500) to Holt County (640510) 345kV line circuit 1, near Thedford. a. Apply fault at the Thedford 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
107	FLT107-3PH	3 phase fault on the Thedford (640500) to Gentleman (640183) 345kV line circuit 1, near Thedford. a. Apply fault at the Thedford 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
108	FLT108-3PH	3 phase fault on the Thedford 345/115/13.8kV (640500/640381/640570) Transformer, near Thedford. a. Apply fault at the Thedford 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
109	FLT109-SB	**Thedford 345kV Stuck Breaker Scenario 1** a. Apply single phase fault at the Thedford (640500) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Thedford (640500) to Holt County (640510) 345kV line circuit 1. d. Trip Thedford (640500) to Gentleman (640183) 345kV line circuit 1
112	FLT110-SB	**Holt County 345kV Stuck Breaker Scenario 2** a. Apply single phase fault at the Holt County (640510) 345kV bus. b. Wait 16 cycles and remove fault. c. Trip Holt County (640510) to GR ISLD-LNX (653871) to Grand Island (653571) 345kV line circuit 1. d. Trip Holt County (640510) to GRPRAR1-LNX3 (652832) to Grand Prairie (652532 345kV line circuit 1
113	FLT111-SB	**Gentleman 345kV Stuck Breaker Scenario 3** a. Apply single phase fault at the Gentleman (640183) 345kV bus. b. Wait 13.5 cycles and remove fault. c. Trip Gentleman (640183) to Sweetwater (640374) 345kV line circuit 1. d. Trip Gentleman (640183) to Thedford (640500) 345kV line circuit 1.

Table 2-6: Additional Contingencies with Mitigation Implemented

Ref. No.	Cont. Name	Description
114	FLT112-PO	**Prior Outage of Thedford (640500) to Gentleman (640183) 345kV line circuit 1;** 3 phase fault on the Holt County (640510) to GR ISLD-LNX (653871) to Grand Island (653571) 345kV line circuit 1, near Holt County a. Apply fault at the Holt County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
115	FLT113-PO	**Prior Outage of Thedford (640500) to Gentleman (640183) 345kV line circuit 1;** 3 phase fault on the Holt County (640510) to GRPRAR1-LNX3 (652832) to Grand Prairie (652532) 345kV line circuit 1, near Holt County a. Apply fault at the Holt County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
116	FLT114-PO	**Prior Outage of Thedford (640500) to Holt County (640510) 345kV line circuit 1;** 3 phase fault on the Holt County (640510) to GR ISLD-LNX (653871) to Grand Island (653571) 345kV line circuit 1, near Holt County a. Apply fault at the Holt County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
117	FLT115-PO	**Prior Outage of Thedford (640500) to Holt County (640510) 345kV line circuit 1;** 3 phase fault on the Holt County (640510) to GRPRAR1-LNX3 (652832) to Grand Prairie (652532) 345kV line circuit 1, near Holt County a. Apply fault at the Holt County 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
118	FLT116-PO	**Prior Outage of Thedford (640500) to Holt County (640510) 345kV line circuit 1;** 3 phase fault on the Gentleman (640183) to Keystone (640252) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
119	FLT117-PO	**Prior Outage of Thedford (640500) to Holt County (640510) 345kV line circuit 1;** 3 phase fault on the Gentleman (640183) to Red Willow (640374) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
120	FLT118-PO	**Prior Outage of Thedford (640500) to Holt County (640510) 345kV line circuit 1;** 3 phase fault on the Gentleman (640183) to Sweetwater (640374) 345kV line circuit 1, near Gentleman. a. Apply fault at the Gentleman 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.

SECTION 3: STABILITY ANALYSIS

The objective of the Stability Analysis was to determine the impacts of the generator interconnections on the stability and voltage recovery on the SPP transmission system. If problems with stability or voltage recovery were identified, the need for reactive compensation or Network Upgrades was investigated.

3.1 Approach

MEPPI utilized the three (3) following DISIS-2016-002-1 Normal Dispatch Scenario power flow cases and dynamic databases:

- MDWG16-17W_DIS16021_G09
- MDWG16-18S_DIS16021_G09
- MDWG16-26S_DIS16021_G09

MEPPI utilized the three (3) following DISIS-2016-002-1 High GGS Sensitivity Dispatch Scenario power flow cases and dynamic databases:

- MDWG16-17W_DIS16021_G09_GGS
- MDWG16-18S_DIS16021_G09_GGS
- MDWG16-26S_DIS16021_G09_GGS

Each case was examined prior to the Stability Analysis to ensure the case contained the proposed study projects and any previously queued projects listed in Tables 2-1 and 2-2 respectively. The Normal Dispatch Scenario and High GGS Sensitivity Scenario included previously assigned upgrades that were identified to mitigate violations of stability damping criteria, voltage recovery criteria, and generation tripping previously identified in the DISIS-2016-002 Group 09[1] System Impact Study, published on April 24, 2019 and the DISIS-2016-002-2 Group 09[2] System Impact Study, published on June 30, 2020, both by SPP Generator Interconnections Department. The following previously assigned upgrades were removed from the DISIS-2016-002-2 Group 09 cases prior to running the analysis:

- SPP R Plan
  - Thedford 345/115/13.8 kV transformer
  - Gerald Gentleman Station to Thedford 345kV circuit #1
  - Holt County to Thedford 345kV circuit #1

[1] http://opsportal.spp.org/documents/studies/files/2016_Generation_Studies/DISIS-2016-001-4_Final_Rev2.pdf

[2]https://opsportal.spp.org/documents/studies/files/2016_Generation_Studies/DISIS-2016-002-2%20Stability%20Analysis.pdf

- GEN-2016-110 Tap on the Laramie River Station to Stegall 345kV circuit #1
- Holt County to Antelope 345kV circuit #1
- Keystone to Red Willow 345kV circuit #1
- Red Willow to Post Rock 345kV circuit #1

After updating the power flow cases with the above changes and dispatching units local to the study area according to SPP criteria, there was no suspect power flow data in the study area. The dynamic datasets were also verified and stable initial system conditions (i.e., "flat lines") were achieved. Three-phase and single phase-to-ground faults listed in Table 2-5 were examined. Single-phase fault impedances were calculated for each season to result in a voltage of approximately 60% of the pre-fault voltage. Refer to Table 3-1 for a list of the calculated single-phase fault impedances.

Table 3-1: Calculated Single-Phase Fault Impedances

[1]Ref. No.	Cont. Name	Faulted Bus	Single-Phase Fault Impedance (MVA)		
			2017 Winter	2018 Summer	2026 Summer
1	FLT52-SB	Stegall (659135) 345kV	-1750.0	-1750.0	-1750.0
2	FLT53-SB	Stegall (659135) 345kV	-1750.0	-1750.0	-1750.0
3	FLT54-SB	Sidney (659134) 230 kV	-1375.0	-1375.0	-1375.0
4	FLT55-SB	Sidney (659134) 230 kV	-1375.0	-1375.0	-1375.0
5	FLT56-SB	Sidney (653572) 115 kV	-562.5	-562.5	-562.5
6	FLT57-SB	Keystone (640252) 345kV	-3218.8	-3218.8	-3218.8
7	FLT58-SB	Keystone (640252) 345kV	-3218.8	-3218.8	-3218.8
8	FLT59-SB	Gentleman (640183) 345kV	-5656.3	-5656.3	-6062.5
11	FLT61-SB	Gentleman (640183) 345kV	-5656.3	-5656.3	-6062.5
13	FLT63-SB	Holt County (640510) 345kV	-2531.2	-2265.6	-2398.4
14	FLT64-SB	Gentleman (640184) 230kV	-4640.6	-4640.6	-4843.8
15	FLT65-SB	Sweetwater (640374) 345kV	-4031.3	-4031.3	-4031.3
16	FLT66-SB	Sweetwater (640374) 345kV	-4031.3	-4031.3	-4031.3
17	FLT67-SB	Sweetwater (640374) 345kV	-4031.3	-4031.3	-4031.3
18	FLT68-SB	Pauline (640312) 345kV	-3015.6	-3218.8	-3218.8
19	FLT69-SB	Pauline (640312) 345kV	-3015.6	-3218.8	-3218.8
20	FLT70-SB	Moore (640277) 345kV	-7687.5	-8500.0	-8500.0
21	FLT71-SB	Moore (640277) 345kV	-7687.5	-8500.0	-8500.0
22	FLT72-SB	Moore (640277) 345kV	-7687.5	-8500.0	-8500.0
23	FLT73-SB	Grand Island (653571) 345kV	-4437.5	-4437.5	-4437.5
101	FLT102-SB	Red Willow (640325) 345kV	-2265.6	-2265.6	-2265.6
102	FLT101-SB	Red Willow (640325) 345kV	-2265.6	-2265.6	-2265.6
103	FLT103-SB	Post Rock (530583) 345kV	-2796.8	-3062.5	-3062.5

[1]Ref. No.	Cont. Name	Faulted Bus	Single-Phase Fault Impedance (MVA)		
			2017 Winter	2018 Summer	2026 Summer
104	FLT104-SB	Post Rock (530583) 345kV	-2796.8	-3062.5	-3062.5
109	FLT109-SB	Thedford (640500) 345kV	-2406.3	-2406.3	-2406.3
110	FLT110-SB	Holt County (640510) 345kV	-2796.8	-2796.8	-2796.8
111	FLT111-SB	Gentleman (640183) 345kV	-6250.0	-6250.0	-6250.0

(1) Refer to Table 2-3 for a description of the contingency scenario. Note the fault impedances were recalculated for each change in topology (i.e. mitigation cases)

Bus voltages, machine rotor angles, and previously queued generation in the study area were monitored in addition to bus voltages and machine rotor angles in the following areas:

- 534 SUNC
- 536 WERE
- 540 GMO
- 541 KCPL
- 635 MEC
- 640 NPPD
- 645 OPPD
- 650 LES
- 652 WAPA

Requested and previously queued generation outside the above study area was also monitored.

The results of the analysis determined if reactive compensation or system upgrades were required to obtain acceptable system performance. If additional reactive compensation was required, the size, type, and location were determined. The proposed reactive reinforcements would ensure the wind or solar farm meets FERC Order 661A low voltage requirements and return the wind or solar farm to its pre-disturbance operating voltage. If the results indicated the need for fast responding reactive support, dynamic support such as an SVC or STATCOM was investigated.

3.2 Normal Dispatch Stability Analysis Results

The Normal Dispatch Stability Analysis determined that there were multiple contingencies across all seasons that resulted in voltage collapse/instability, generation tripping offline, and poor post-fault voltage recovery when all generation interconnection requests were at 100% output. The 2017 Winter Peak (“17WP”), 2018 Summer Peak (“18SP”) and 2026 Summer Peak (“26SP”) cases were observed to result in voltage collapse and voltage instability in the Gentleman 345kV and Laramie River Station 345kV local area.

Refer to Table 3-2 for a summary of the Stability Analysis results without additional reinforcements for the contingencies listed in Table 2-5. Table 3-2 is a summary of the stability results for the 17WP, 18SP, and 26SP conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared,

and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions. Voltage recovery criteria includes ensuring that the transient voltage recovery is between 0.7 p.u. and 1.2 p.u. and ending in a steady-state voltage (for N-1 contingencies) at the pre-contingent level or at least above 0.9 p.u. and below 1.1. p.u.

It was observed that the limiting faults for the normal dispatch scenarios were NERC Category P1 events near Holt 345kV and a NERC Category P4 event at Gentleman 345kV. After examining the results without additional reinforcements, the previously studied R-Plan Network Upgrade was investigated to determine the impacts of the following additional transmission elements:

- SPP R Plan
  - Thedford 345/115/13.8 kV transformer
  - Gerald Gentleman Station to Thedford 345kV circuit #1
  - Holt County to Thedford 345kV circuit #1

Refer to Table 3-3 for a summary of the Stability Analysis results with the R-Plan Network Upgrade in-service for the contingencies listed in Table 2-5 and additional contingencies listed in Table 2-6. Table 3-3 is a summary of the stability results for the 17WP, 18SP, and 26SP conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions.

Table 3-2: Summary of Results for 17WP, 18SP, and 26SP Conditions without Reinforcements

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
1	FLT01-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
3	FLT03-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
4	FLT04-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
5	FLT05-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
6	FLT06-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
7	FLT07-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
8	FLT08-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
9	FLT09-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
10	FLT10-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
11	FLT11-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
12	FLT12-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
13	FLT13-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
14	FLT14-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
15	FLT15-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
16	FLT16-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
17	FLT17-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
18	FLT18-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
19	FLT19-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
20	FLT20-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
21	FLT21-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
22	FLT22-3PH	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable
23	FLT23-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
24	FLT24-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
25	FLT25-3PH	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable
26	FLT26-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-2: Summary of Results for 17WP, 18SP, and 26SP Conditions without Reinforcements (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
53	FLT53-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
54	FLT54-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
55	FLT55-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
56	FLT56-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
57	FLT57-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
58	FLT58-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
59	FLT59-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
61	FLT61-SB	Voltage Collapse				No	No	Compliant	Stable	No	No	Compliant	Stable
63	FLT63-SB	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable
64	FLT64-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
65	FLT65-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
66	FLT66-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
67	FLT67-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
68	FLT68-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
69	FLT69-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
70	FLT70-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
71	FLT71-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
72	FLT72-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
73	FLT73-SB	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable
74	FLT74-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
75	FLT75-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
76	FLT76-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
77	FLT77-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
78	FLT78-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
79	FLT79-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
80	FLT80-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-2: Summary of Results for 17WP, 18SP, and 26SP Conditions without Reinforcements (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
81	FLT81-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
82	FLT82-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
83	FLT83-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
84	FLT84-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
85	FLT85-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
86	FLT86-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
87	FLT87-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
88	FLT88-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
89	FLT89-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
90	FLT90-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
91	FLT91-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
92	FLT92-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
93	FLT93-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
94	FLT94-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
95	FLT95-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
96	FLT96-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
97	FLT97-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
98	FLT98-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
99	FLT99-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
100	FLT100-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
101	FLT101-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
102	FLT102-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
103	FLT103-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
104	FLT104-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-3: Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
1	FLT01-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
3	FLT03-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
4	FLT04-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
5	FLT05-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
6	FLT06-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
7	FLT07-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
8	FLT08-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
9	FLT09-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
10	FLT10-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
11	FLT11-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
12	FLT12-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
13	FLT13-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
14	FLT14-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
15	FLT15-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
16	FLT16-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
17	FLT17-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
18	FLT18-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
19	FLT19-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
20	FLT20-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
21	FLT21-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
22	FLT22-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
23	FLT23-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
24	FLT24-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
25	FLT25-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
26	FLT26-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
27	FLT27-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
28	FLT28-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-3: Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
29	FLT29-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
30	FLT30-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
31	FLT31-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
32	FLT32-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
33	FLT33-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
34	FLT34-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
35	FLT35-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
36	FLT36-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
37	FLT37-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
38	FLT38-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
39	FLT39-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
40	FLT40-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
41	FLT41-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
42	FLT42-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
43	FLT43-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
44	FLT44-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
45	FLT45-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
46	FLT46-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
47	FLT47-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
48	FLT48-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
49	FLT49-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
50	FLT50-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
51	FLT51-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
52	FLT52-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
53	FLT53-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
54	FLT54-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
55	FLT55-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-3: Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
56	FLT56-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
57	FLT57-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
58	FLT58-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
59	FLT59-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
61	FLT61-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
63	FLT63-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
64	FLT64-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
65	FLT65-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
66	FLT66-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
67	FLT67-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
68	FLT68-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
69	FLT69-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
70	FLT70-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
71	FLT71-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
72	FLT72-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
73	FLT73-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
74	FLT74-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
75	FLT75-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
76	FLT76-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
77	FLT77-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
78	FLT78-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
79	FLT79-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
80	FLT80-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
81	FLT81-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
82	FLT82-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
83	FLT83-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
84	FLT84-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-3: Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
85	FLT85-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
86	FLT86-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
87	FLT87-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
88	FLT88-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
89	FLT89-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
90	FLT90-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
91	FLT91-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
92	FLT92-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
93	FLT93-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
94	FLT94-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
95	FLT95-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
96	FLT96-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
97	FLT97-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
98	FLT98-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
99	FLT99-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
100	FLT100-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
101	FLT101-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
102	FLT102-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
103	FLT103-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
104	FLT104-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
105	FLT105-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
106	FLT106-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
107	FLT107-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
108	FLT108-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
109	FLT109-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
110	FLT110-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
111	FLT111-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-3: Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak				2018 Summer Peak				2026 Summer Peak			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
112	FLT112-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
113	FLT113-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
114	FLT114-PO	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable
115	FLT115-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
116	FLT116-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
117	FLT117-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
118	FLT118-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

With the R-Plan Network Upgrade in-service, it was observed that the network upgrade mitigated all P1 and P4 events of concern near Holt County 345kV and Gentleman 345kV. Refer to Figure 3-1 for a representative voltage plot for FLT22-3PH, which is a P1 event at Holt County 345kV, resulting in the loss of the Holt County to Grand Island 345kV circuit. It can be observed that the R-Plan Network Upgrade improves the post-fault voltage response.

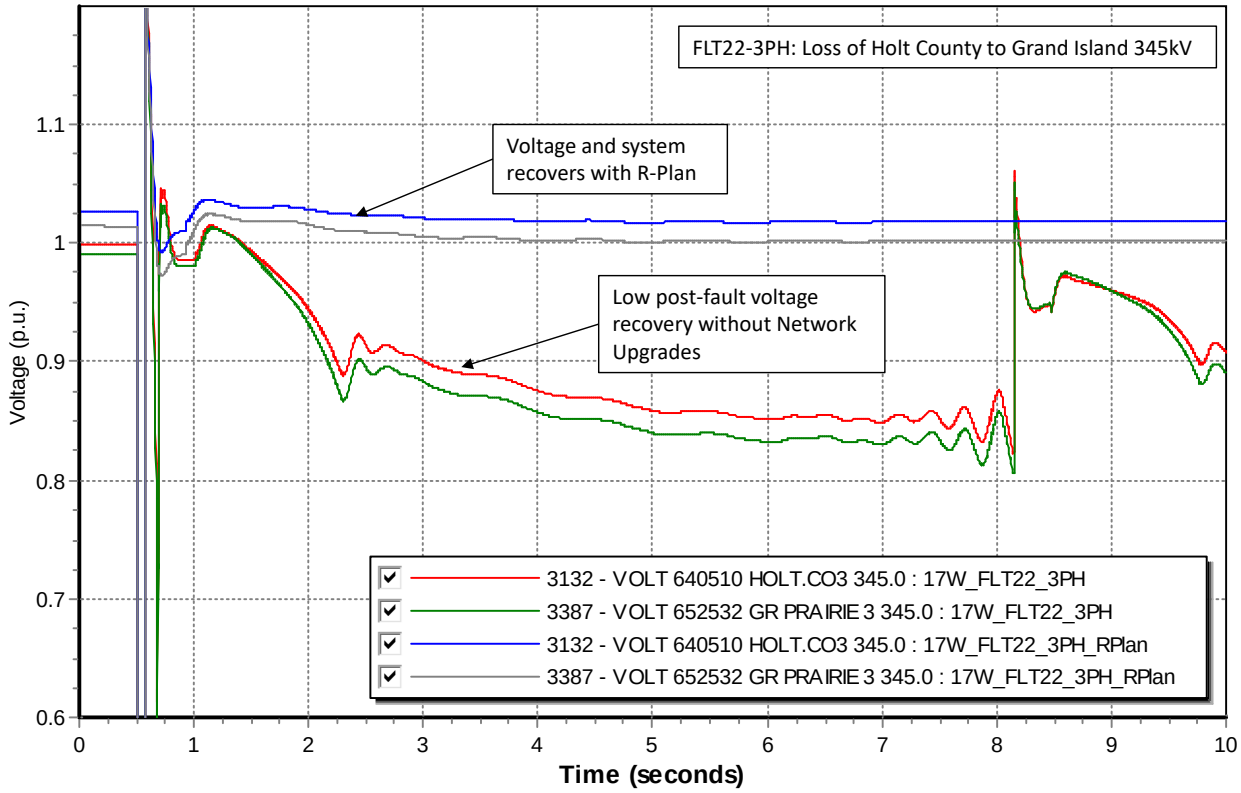

Figure 3-1: Representative voltage plot of local bus voltage for the loss of Holt County to Grand Island 345kV (17WP).

Voltage collapse was observed for a single contingency in the 17WP season conditions which was the P4 event at Gentleman resulting in the loss of Gentleman to Sweetwater 345kV and Gentleman to Red Willow 345kV (FLT61-SB). After the implementation of the R-Plan Network Upgrade, the voltage collapse issue was mitigated due to an extra outlet out of Gentleman 345kV. Refer to Figure 3-2 for a representative voltage plot comparing the results with and without the R-Plan Network Upgrade.

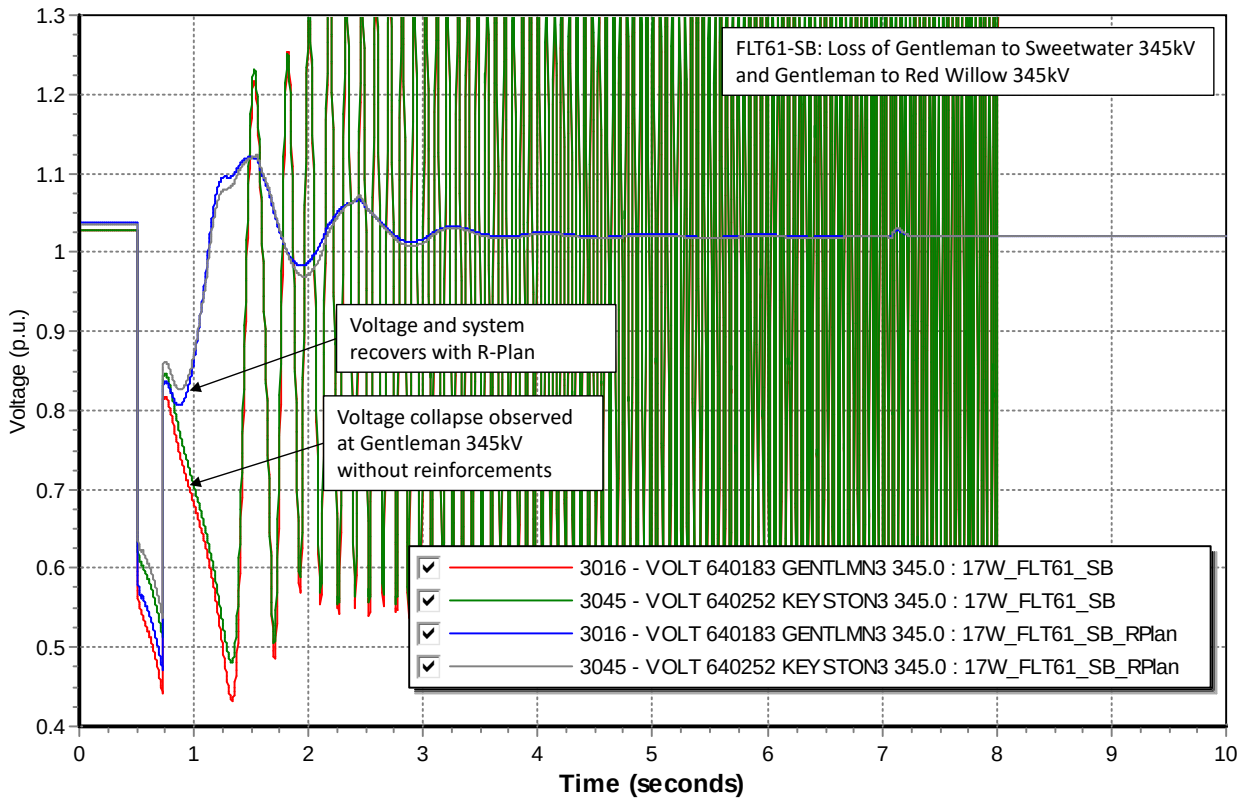

Figure 3-2: Representative voltage plot of local bus voltage for the P4 event at Gentleman 345kV (17WP).

3.2.1 Curtailment for P6 Events for the Normal Dispatch Scenario

The R-Plan Network Upgrade identified in Section 3.2 relieved the voltage collapse and low post-fault voltage recovery issues for all P1 and P4 events studied. However, there were several prior outage conditions near Laramie River Station and Sidney that resulted in a voltage collapse with the R-Plan Network Upgrade in-service. The following prior outage contingencies resulted in voltage collapse with the R-Plan Network Upgrade in-service:

- **FLT74-PO**: Prior outage on the Sidney – Laramie River Station 345kV line circuit 1
  - 3 phase fault on the Stegall to Sidney 345kV line circuit 1, near Stegall.
- **FLT76-PO**: Prior outage on the G16-110-TAP – Stegall 345kV line circuit 1
  - 3 phase fault on the Sidney to Keystone 345kV line circuit 1, near Sidney.
- **FLT78-PO**: Prior outage on the Sidney – Stegall 345kV line circuit 1
  - 3 phase fault on the Sidney to Laramie River Station 345kV line circuit 1, near Sidney.
- **FLT81-PO**: Prior outage on the Sidney – Sidney Transformer 230 kV line circuit 1
  - 3 phase fault on the Sidney to Keystone 345kV line circuit 1, near Sidney.

Additionally, with the R-Plan Network Upgrade in-service and for the prior outage of Thedford to Holt County 345kV, low post-fault voltage conditions exist (FLT114-PO). For prior outage conditions that result in a voltage collapse or are observed to have low post-fault voltage recovery, generation curtailment in the vicinity of the faults was investigated. Refer to Table 3-4 for a summary of the generation curtailment required for each prior outage condition listed above. Approximately 650 MW of generation capacity in the vicinity of Laramie River Station and Sidney and approximately 450 MW of generation capacity in the vicinity of Holt County was evaluated for curtailment as a system adjustment and included the following units:

- GEN-2016-147
- Laramie River Station
- Grand Prairie Wind

Table 3-4: Generation Curtailment for Prior Outage Conditions

Fault Number	Generation Curtailment (%/MW)		
	17WP	18SP	26SP
FLT74-PO	45% 275 MW	35% 250 MW	35% 250 MW
FLT76-PO	15% 90 MW	15% 90 MW	15% 90 MW
FLT78-PO	45% 275 MW	45% 275 MW	45% 275 MW
FLT81-PO	35% 250 MW	35% 250 MW	35% 250 MW
FLT114-PO	10% 50 MW	10% 50 MW	10% 50 MW

The limiting prior outage faults that required the highest amount of generation curtailment were prior outages out of Sidney 345kV. FLT74-PO, prior outage of Sidney to Laramie River Station 345kV, and FLT78-PO, prior outage of Sidney to Stegall 345kV, each resulted in requiring 275 MW of generation curtailment in the Laramie River Station 345kV and Sidney 345kV vicinity to mitigate the voltage collapse/instability observed. Refer to Figure 3-3 for a representative voltage plot of area bus voltages for FLT78-PO for 17WP conditions. Refer to Figure 3-4 for a representative rotor angle plot for the Laramie River Station generation. This fault was observed to result in voltage collapse/instability in the vicinity of Laramie River Station and Sidney 345kV without generation curtailment. Curtailing generation by 275 MW in the vicinity of Laramie River Station and Sidney 345kV mitigates the observed stability issue.

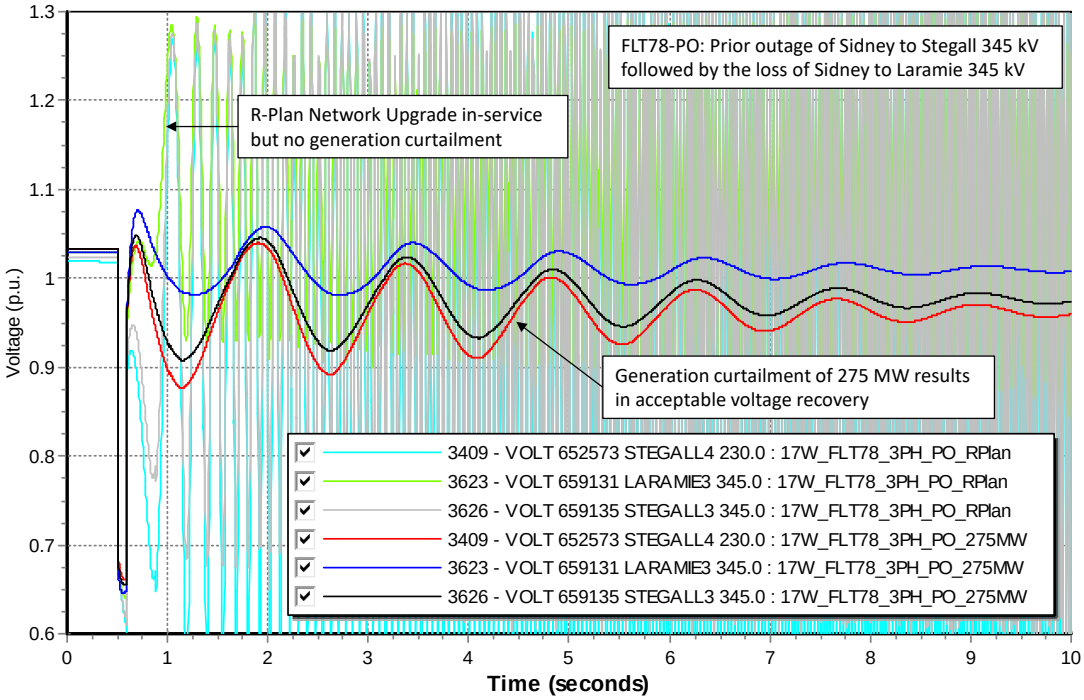

Figure 3-3: Representative voltage plot of FLT78-PO with generation curtailment for 2017 Winter Peak conditions.

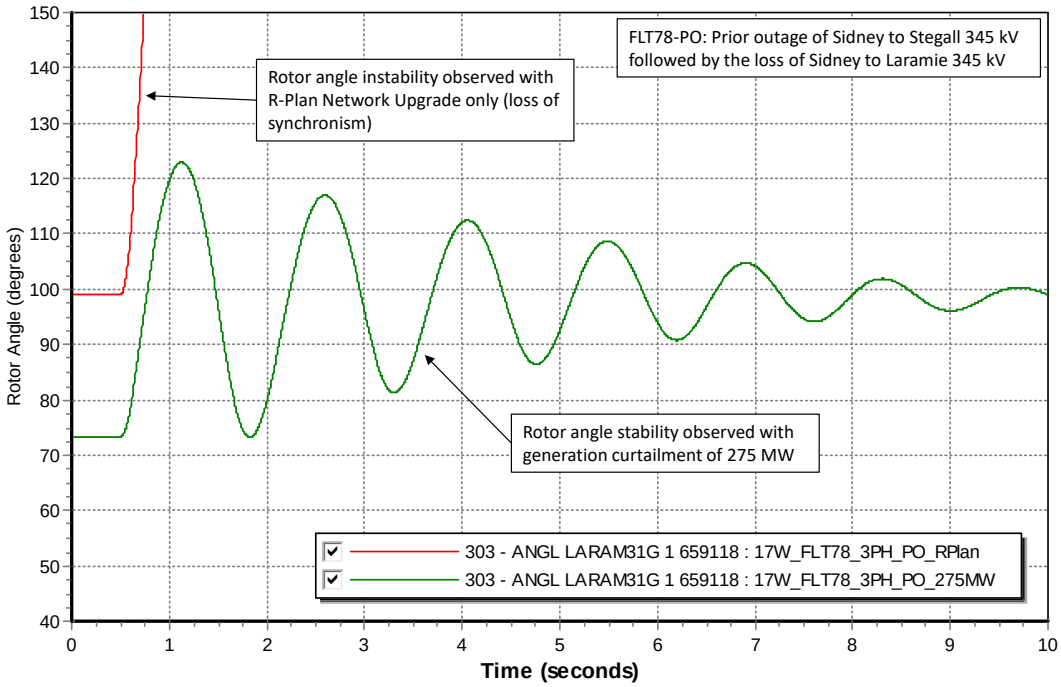

Figure 3-4: Representative rotor angle plot of FLT78-PO with generation curtailment for 2017 Winter Peak conditions.

3.3 Normal Dispatch Scenario Summary of Results

The analysis of the Normal Dispatch Scenario determined mitigation is required to alleviate voltage instability issues in the Gerald Gentleman Station vicinity and the Laramie vicinity for select P1 and P4 events. It was determined that the R-Plan Network Upgrade would alleviate the voltage instability near Gentleman 345kV and low post-fault voltage conditions near Holt County 345kV.

Refer to Appendix B, Appendix C, and Appendix D for a complete set of plots for all contingencies for 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak conditions, respectively. The plots for all three seasons can be provided upon request.

3.4 High GGS Sensitivity Stability Analysis Results

The High GGS Sensitivity Scenario Stability Analysis was performed on the three seasons as identified previously: 17WP, 18SP, and 26SP. The analysis was completed similar to the Normal Dispatch Scenario; the analysis was first completed without any mitigation and then performed with the R-Plan Network Upgrade in-service.

The High GGS Sensitivity Stability Analysis determined that there were multiple contingencies across all seasons that resulted in system/voltage instability, generation tripping offline, and poor post-fault voltage recovery when all generation interconnection requests were at 100% output. The 17WP, 18SP, and 26SP cases were observed to result in voltage collapse and low post-fault voltage recovery in the Gentleman 345kV and Holt County 345kV local area, respectively.

Refer to Table 3-5 for a summary of the High GGS Sensitivity Stability Analysis results without additional reinforcements for the contingencies listed in Table 2-5. Table 3-5 is a summary of the stability results for the 17WP, 18SP, and 26SP conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions. Voltage recovery criteria includes ensuring that the transient voltage recovery is between 0.7 p.u. and 1.2 p.u. and ending in a steady-state voltage (for N-1 contingencies) at the pre-contingent level or at least above 0.9 p.u. and below 1.1. p.u.

It was observed that the limiting faults for the High GGS Sensitivity scenarios were NERC Category P1 events near Holt County 345kV and a NERC Category P4 event at Gentleman 345kV. After examining the results without additional reinforcements, the previously studied R-Plan Network Upgrade was investigated to determine the impacts of the following additional transmission elements:

- SPP R Plan
    - Thedford 345/115/13.8 kV transformer

- Gerald Gentleman Station to Thedford 345kV circuit #1
- Holt County to Thedford 345kV circuit #1

Refer to Table 3-6 for a summary of the High GGS Sensitivity Stability Analysis results with the R-Plan Network Upgrade in-service for the contingencies listed in Table 2-5 and additional contingencies listed in Table 2-6. Table 3-6 is a summary of the stability results for the 17WP, 18SP, and 26SP conditions and states whether the system remained stable or generation tripped offline, if acceptable voltage recovery was observed after the fault was cleared, and if the voltage recovered to above 0.9 p.u. and below 1.1 p.u. post fault steady-state conditions.

Table 3-5: GGS Sensitivity Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
1	FLT01-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
3	FLT03-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
4	FLT04-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
5	FLT05-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
6	FLT06-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
7	FLT07-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
8	FLT08-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
9	FLT09-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
10	FLT10-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
11	FLT11-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
12	FLT12-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
13	FLT13-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
14	FLT14-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
15	FLT15-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
16	FLT16-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
17	FLT17-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
18	FLT18-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
19	FLT19-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
20	FLT20-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
21	FLT21-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
22	FLT22-3PH	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable
23	FLT23-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
24	FLT24-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
25	FLT25-3PH	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable
26	FLT26-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
27	FLT27-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-5: GGS Sensitivity Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
28	FLT28-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
29	FLT29-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
30	FLT30-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
31	FLT31-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
32	FLT32-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
33	FLT33-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
34	FLT34-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
35	FLT35-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
36	FLT36-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
37	FLT37-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
38	FLT38-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
39	FLT39-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
40	FLT40-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
41	FLT41-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
42	FLT42-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
43	FLT43-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
44	FLT44-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
45	FLT45-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
46	FLT46-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
47	FLT47-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
48	FLT48-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
49	FLT49-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
50	FLT50-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
51	FLT51-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
52	FLT52-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
53	FLT53-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
54	FLT54-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-5: GGS Sensitivity Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
55	FLT55-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
56	FLT56-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
57	FLT57-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
58	FLT58-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
59	FLT59-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
61	FLT61-SB	Voltage Collapse				No	No	Compliant	Stable	No	No	Compliant	Stable
63	FLT63-SB	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable
64	FLT64-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
65	FLT65-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
66	FLT66-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
67	FLT67-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
68	FLT68-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
69	FLT69-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
70	FLT70-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
71	FLT71-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
72	FLT72-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
73	FLT73-SB	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable
74	FLT74-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
75	FLT75-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
76	FLT76-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
77	FLT77-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
78	FLT78-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
79	FLT79-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
80	FLT80-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
81	FLT81-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
82	FLT82-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-5: GGS Sensitivity Summary of Results for 2017 Winter, 2018 Summer, and 2026 Summer Peak Conditions (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
83	FLT83-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
84	FLT84-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
85	FLT85-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
86	FLT86-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
87	FLT87-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
88	FLT88-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
89	FLT89-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
90	FLT90-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
91	FLT91-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
92	FLT92-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
93	FLT93-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
94	FLT94-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
95	FLT95-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
96	FLT96-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
97	FLT97-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
98	FLT98-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
99	FLT99-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
100	FLT100-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
101	FLT101-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
102	FLT102-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
103	FLT103-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
104	FLT104-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-6: GGS Sensitivity Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
1	FLT01-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
3	FLT03-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
4	FLT04-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
5	FLT05-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
6	FLT06-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
7	FLT07-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
8	FLT08-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
9	FLT09-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
10	FLT10-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
11	FLT11-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
12	FLT12-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
13	FLT13-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
14	FLT14-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
15	FLT15-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
16	FLT16-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
17	FLT17-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
18	FLT18-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
19	FLT19-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
20	FLT20-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
21	FLT21-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
22	FLT22-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
23	FLT23-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
24	FLT24-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
25	FLT25-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
26	FLT26-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
27	FLT27-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
28	FLT28-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-6: GGS Sensitivity Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
29	FLT29-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
30	FLT30-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
31	FLT31-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
32	FLT32-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
33	FLT33-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
34	FLT34-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
35	FLT35-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
36	FLT36-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
37	FLT37-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
38	FLT38-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
39	FLT39-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
40	FLT40-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
41	FLT41-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
42	FLT42-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
43	FLT43-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
44	FLT44-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
45	FLT45-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
46	FLT46-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
47	FLT47-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
48	FLT48-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
49	FLT49-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
50	FLT50-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
51	FLT51-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
52	FLT52-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
53	FLT53-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
54	FLT54-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
55	FLT55-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-6: GGS Sensitivity Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
56	FLT56-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
57	FLT57-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
58	FLT58-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
59	FLT59-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
61	FLT61-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
63	FLT63-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
64	FLT64-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
65	FLT65-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
66	FLT66-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
67	FLT67-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
68	FLT68-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
69	FLT69-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
70	FLT70-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
71	FLT71-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
72	FLT72-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
73	FLT73-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
74	FLT74-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
75	FLT75-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
76	FLT76-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
77	FLT77-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
78	FLT78-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
79	FLT79-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
80	FLT80-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
81	FLT81-PO	Voltage Collapse				Voltage Collapse				Voltage Collapse			
82	FLT82-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
83	FLT83-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
84	FLT84-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-6: GGS Sensitivity Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
85	FLT85-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
86	FLT86-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
87	FLT87-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
88	FLT88-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
89	FLT89-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
90	FLT90-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
91	FLT91-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
92	FLT92-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
93	FLT93-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
94	FLT94-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
95	FLT95-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
96	FLT96-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
97	FLT97-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
98	FLT98-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
99	FLT99-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
100	FLT100-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
101	FLT101-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
102	FLT102-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
103	FLT103-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
104	FLT104-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
105	FLT105-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
106	FLT106-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
107	FLT107-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
108	FLT108-3PH	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
109	FLT109-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
110	FLT110-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

Table 3-6: GGS Sensitivity Summary of Results for 17WP, 18SP, and 26SP Conditions with R-Plan Network Upgrade (cont.)

Ref. No.	Fault Number	2017 Winter Peak - GGS				2018 Summer Peak - GGS				2026 Summer Peak - GGS			
		Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability	Voltage Recovery		Post Fault Steady-State Voltage	System Stability
		Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.			Less than 0.7 p.u.	Greater than 1.2 p.u.		
111	FLT111-SB	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
112	FLT112-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
113	FLT113-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
114	FLT114-PO	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable	No	No	Low post-fault voltages	Stable
115	FLT115-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
116	FLT116-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
117	FLT117-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable
118	FLT118-PO	No	No	Compliant	Stable	No	No	Compliant	Stable	No	No	Compliant	Stable

With the R-Plan Network Upgrade in-service, it was observed that the network upgrade mitigated all P1 and P4 events of concern near Holt County 345kV and Gentleman 345kV. Refer to Figure 3-5 for a representative voltage plot for FLT22-3PH, which is a P1 event at Holt County 345kV, resulting in the loss of the Holt County to Grand Island 345kV circuit. It can be observed that the R-Plan Network Upgrade improves the post-fault voltage response.

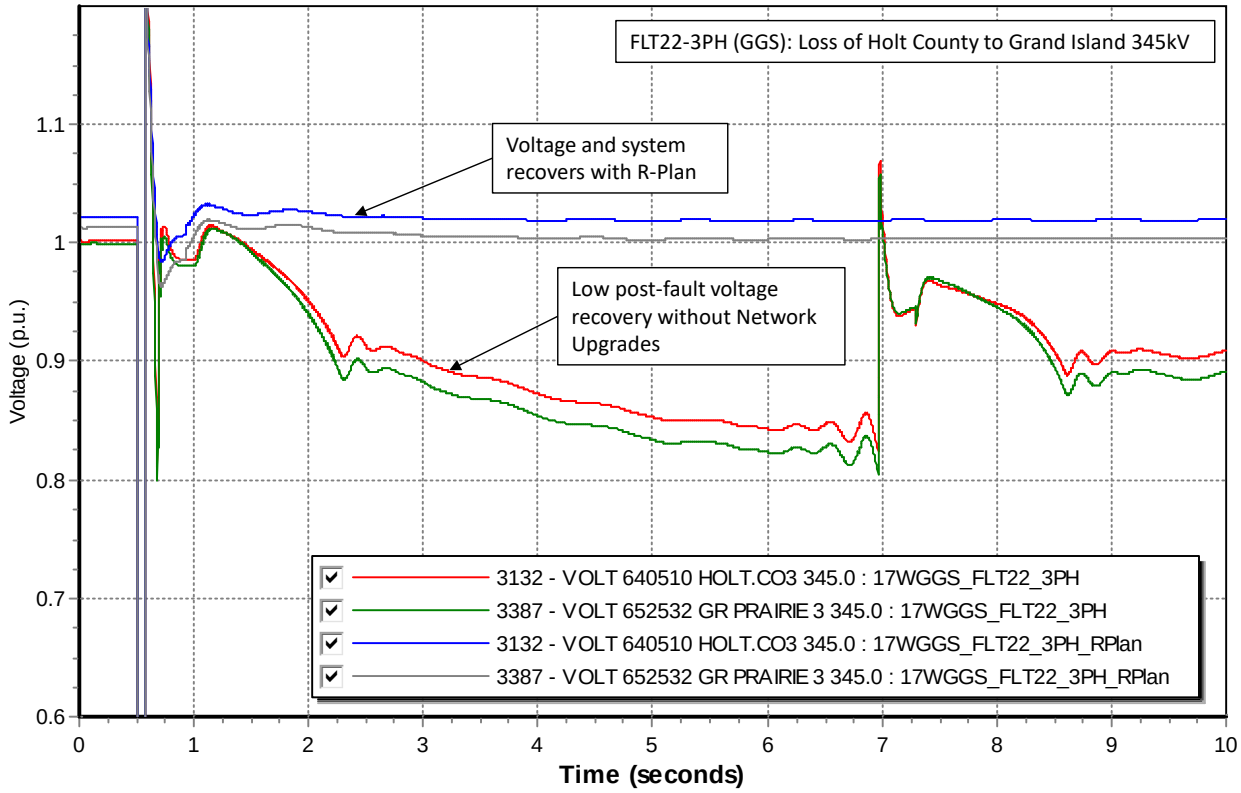

Figure 3-5: Representative voltage plot of local bus voltage for the loss of Holt County to Grand Island 345kV (17WP – GGS).

Voltage collapse was observed for a single contingency in the 17WP season conditions which was the P4 event at Gentleman resulting in the loss of Gentleman to Sweetwater 345kV and Gentleman to Red Willow 345kV (FLT61-SB). After the implementation of the R-Plan Network Upgrade, the voltage collapse issue was mitigated due to an extra outlet out of Gentleman 345kV. Refer to Figure 3-6 for a representative voltage plot comparing the results with and without the R-Plan Network Upgrade for the High GGS Scenario.

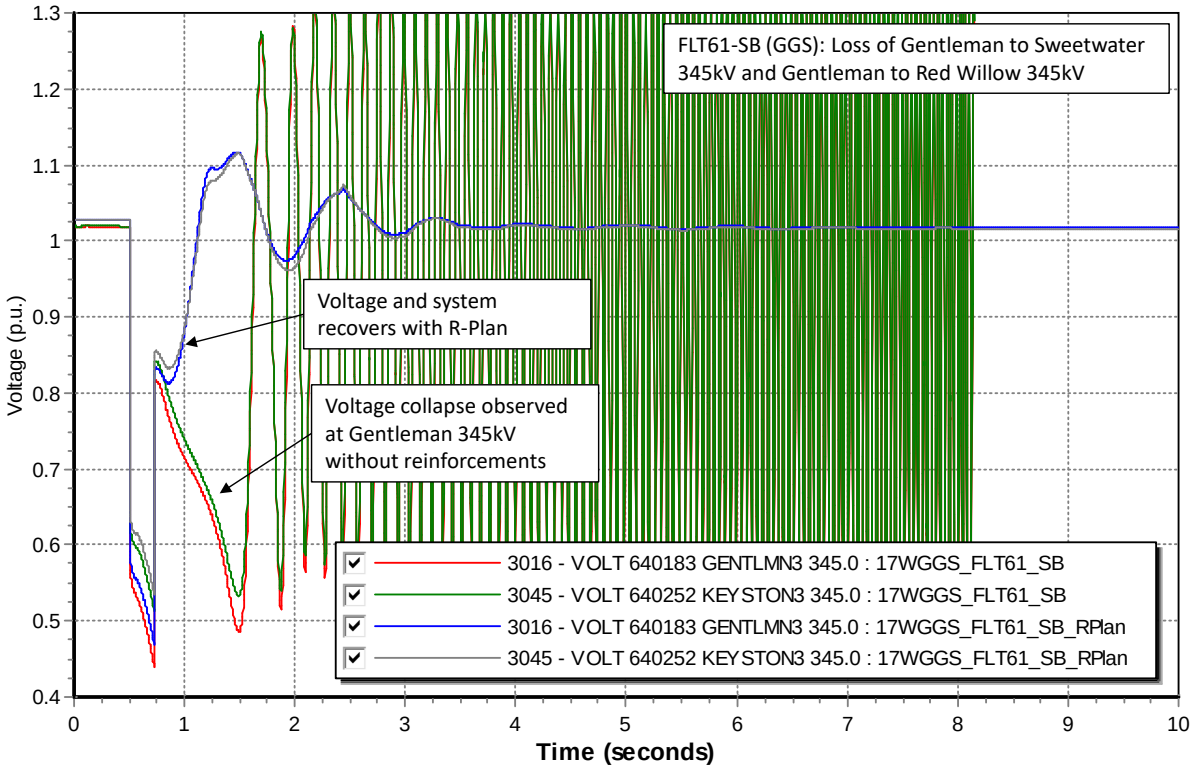

Figure 3-6: Representative voltage plot of local bus voltage for the P4 event at Gentleman 345kV (17WP – GGS).

3.4.1 Curtailment for P6 Events for the High GGS Sensitivity Dispatch Scenario

Similar to the Normal Dispatch Scenario, the R-Plan Network Upgrade, identified in Section 3.4 for the Gerald Gentleman Sensitivity Scenario, relieved the voltage collapse and low post-fault voltage recovery issues for all P1 and P4 events studied. However, there were several prior outage conditions near Laramie River Station and Sidney that resulted in a voltage collapse with the R-Plan Network Upgrade in-service. The following prior outage contingencies resulted in voltage collapse with the R-Plan Network Upgrade in-service:

- **FLT74-PO**: Prior outage on the Sidney – Laramie River Station 345kV line circuit 1
  - 3 phase fault on the Stegall to Sidney 345kV line circuit 1, near Stegall.
- **FLT76-PO**: Prior outage on the G16-110-TAP – Stegall 345kV line circuit 1
  - 3 phase fault on the Sidney to Keystone 345kV line circuit 1, near Sidney.
- **FLT78-PO**: Prior outage on the Sidney – Stegall 345kV line circuit 1
  - 3 phase fault on the Sidney to Laramie River Station 345kV line circuit 1, near Sidney.
- **FLT81-PO**: Prior outage on the Sidney – Sidney Transformer 230 kV line circuit 1
  - 3 phase fault on the Sidney to Keystone 345kV line circuit 1, near Sidney.

Additionally, with the R-Plan Network Upgrade in-service and for the prior outage of Thedford to Holt County 345kV, low post-fault voltage conditions exist (FLT114-PO). For prior outage conditions that result in a voltage collapse or are observed to have low post-fault voltage recovery, generation curtailment in the vicinity of the faults was investigated. Refer to Table 3-7 for a summary of the generation curtailment required for each prior outage condition listed above. Approximately 650 MW of generation capacity in the vicinity of Laramie River Station and Sidney and approximately 450 MW of generation capacity in the vicinity of Holt County was evaluated for curtailment as a system adjustment and included the following units:

- GEN-2016-147
- Laramie River Station
- Grand Prairie Wind

Table 3-7: Generation Curtailment for Prior Outage Conditions for the GGS Sensitivity

Fault Number	Generation Curtailment (%/MW)		
	17WP - GGS	18SP - GGS	26SP - GGS
FLT74-PO	45% 275 MW	45% 275 MW	35% 250 MW
FLT76-PO	15% 90 MW	15% 90 MW	15% 90 MW
FLT78-PO	45% 275 MW	45% 275 MW	45% 275 MW
FLT81-PO	35% 250 MW	35% 250 MW	35% 250 MW
FLT114-PO	10% 50 MW	10% 50 MW	10% 50 MW

The limiting prior outage faults that required the highest amount of generation curtailment were prior outages out of Sidney 345kV. FLT74-PO, prior outage of Sidney to Laramie River Station 345kV, and FLT78-PO, prior outage of Sidney to Stegall 345kV, each resulted in requiring 275 MW of generation curtailment in the Laramie River Station 345kV and Sidney 345kV vicinity to mitigate the voltage collapse/instability observed. Refer to Figure 3-7 for a representative voltage plot of area bus voltages for FLT78-PO for 18SP – GGS conditions. Refer to Figure 3-8 for a representative rotor angle plot for the Laramie River Station generation. This fault was observed to result in voltage collapse/instability in the vicinity of Laramie River Station and Sidney 345kV without generation curtailment. In addition to the R-Plan Network Upgrade, curtailing generation by 275 MW in the vicinity of Laramie River Station and Sidney 345kV mitigates the observed stability issue.

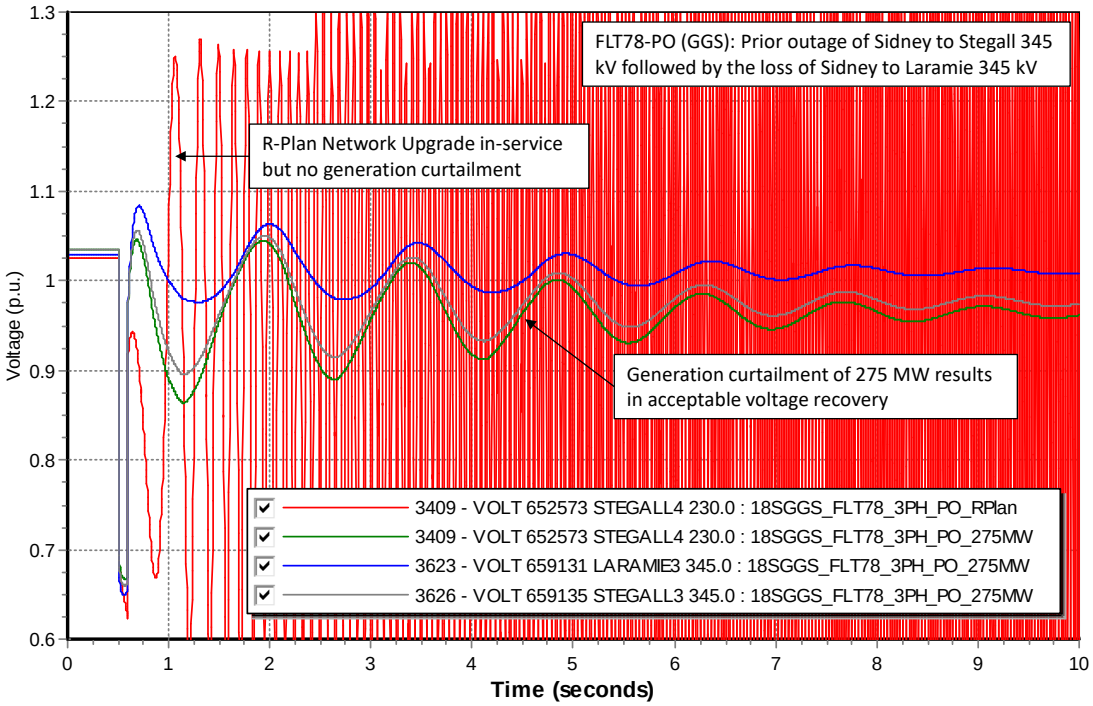

Figure 3-7: Representative voltage plot of FLT78-PO with generation curtailment for 18SP for the High GGS Sensitivity Scenario.

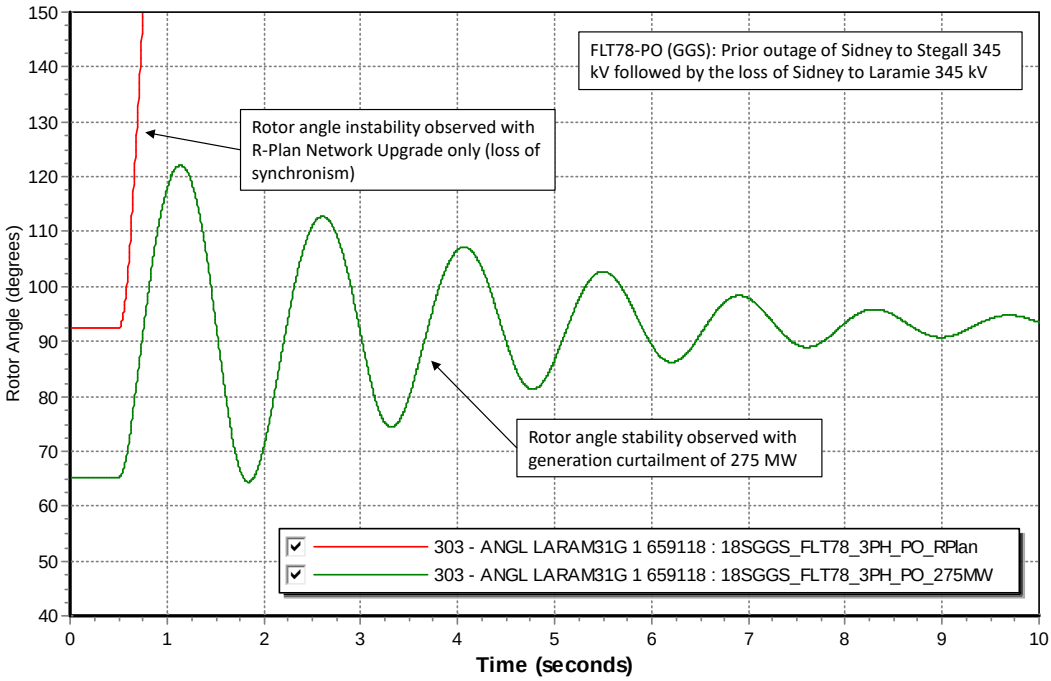

Figure 3-8: Representative rotor angle plot of FLT78-PO with generation curtailment for 18SP for the High GGS Sensitivity Scenario.

Refer to Appendix E, Appendix F, and Appendix G for a complete set of plots for all contingencies for 2017 Winter Peak, 2018 Summer Peak, and 2026 Summer Peak High GGS conditions, respectively. The plots for all three seasons can be provided upon request.

3.5 High GGS Dispatch Scenario Summary of Results

The analysis of the High GGS Dispatch Scenario determined mitigation is required to alleviate voltage instability issues in the Gerald Gentleman Station vicinity and the Laramie vicinity for select P1 and P4 events. It was determined that the R-Plan Network Upgrade would alleviate the voltage instability near Gentleman 345kV and low post-fault voltage conditions near Holt County 345kV

SECTION 4: CONCLUSION

Summary of Stability Analysis

The Stability Analysis determined that there were multiple contingencies across all seasons and dispatch scenarios that resulted in voltage collapse/instability, generation tripping offline, and poor post-fault voltage recovery when all generation interconnection requests were at 100% output. The voltage collapse/instability was observed in the vicinity of Gerald Gentleman Station and Laramie River Station for P4 and P6 fault events.

The P1 events at Holt County and P4 event at Gerald Gentleman Station that resulted in low post-fault voltage recovery and voltage collapse/instability, respectively, could be mitigated by the R-Plan (NTC 200220) Network Upgrade:

- Thedford 345/115/13.8 kV transformer
- Gerald Gentleman Station to Thedford 345kV circuit #1
- Holt County to Thedford 345kV circuit #1

The R-Plan Network Upgrade identified above mitigated the low post-fault voltage and voltage collapse/instability observed for P1 and P4 events evaluated in all seasons and dispatch scenarios. However, with this solution set, generation curtailment is required for several prior outage conditions, P6 events. Prior outage conditions, in anticipation of a subsequent fault events, required additional generation curtailment for the Normal Dispatch Scenario and High GGS Sensitivity Dispatch Scenario for circuits terminated at the following stations:

- Laramie River Station 345kV
- Sidney 345kV
- Sidney 230kV
- Stegall 345kV
- Holt County 345kV

Following the prior outages as described above, to maintain system stability following the three phase faults, the analysis determined that curtailing generation by up to 275 MW in the vicinity of Laramie River Station 345kV and by up to 50 MW at Grand Prairie 345kV resulted in a stable response with no generation tripping or system instability observed.

With the R-Plan Network Upgrade and curtailment above, the Stability Analysis determined that there was no generation tripping or system instability observed as a result of interconnecting all study projects at 100% output.

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APPENDIX A: STEADY STATE AND DYNAMIC MODEL DATA

Base Case Power Flows

Three base case power flows were provided to MEPPI by SPP:

- MDWG16-17W_DIS16021_G09.sav
- MDWG16-18S_DIS16021_G09.sav
- MDWG16-26S_DIS16021_G09.sav

Three GGS Sensitivity base case power flows were provided to MEPPI by SPP:

- MDWG16-17W_DIS16021_G09GGS.sav
- MDWG16-18S_DIS16021_G09GGS.sav
- MDWG16-26S_DIS16021_G09GGS.sav

Three dynamic files were provided to MEPPI by SPP:

- MDWG16-17W_DIS16021_G09.dyr
- MDWG16-18S_DIS16021_G09.dyr
- MDWG16-26S_DIS16021_G09.dyr

Updates Applied to Base Case

Removal of:

- SPP R Plan
  - Thedford 345/115/13.8 kV transformer
  - Gerald Gentleman Station to Thedford 345kV circuit #1
  - Holt County to Thedford 345kV circuit #1
- DISIS-2016-001 withdrawn upgrades:
  - Gerald Gentleman Station to Keystone 345kV circuit #2
  - Keystone to Sidney 345kV circuit #2
  - GEN-2016-023/029 Tap on the Laramie River Station to Sidney 345kV circuit #1
  - GEN-2016-023/029 Tap on the Laramie River Station to Stegall 345kV circuit #1
- DISIS-2016-002 withdrawn upgrades:
  - GEN-2016-110 Tap on the Laramie River Station to Stegall 345kV circuit #1
  - Holt County to Antelope 345kV circuit #1
  - Keystone to Red Willow 345kV circuit #1
  - Red Willow to Post Rock 345kV circuit #1
- SPP Withdrawn requests:
  - GEN-2010-041
  - GEN-2015-053
  - GEN-2015-087
  - GEN-2016-023
  - GEN-2016-029
  - GEN-2016-106
  - GEN-2016-110
  - GEN-2016-165

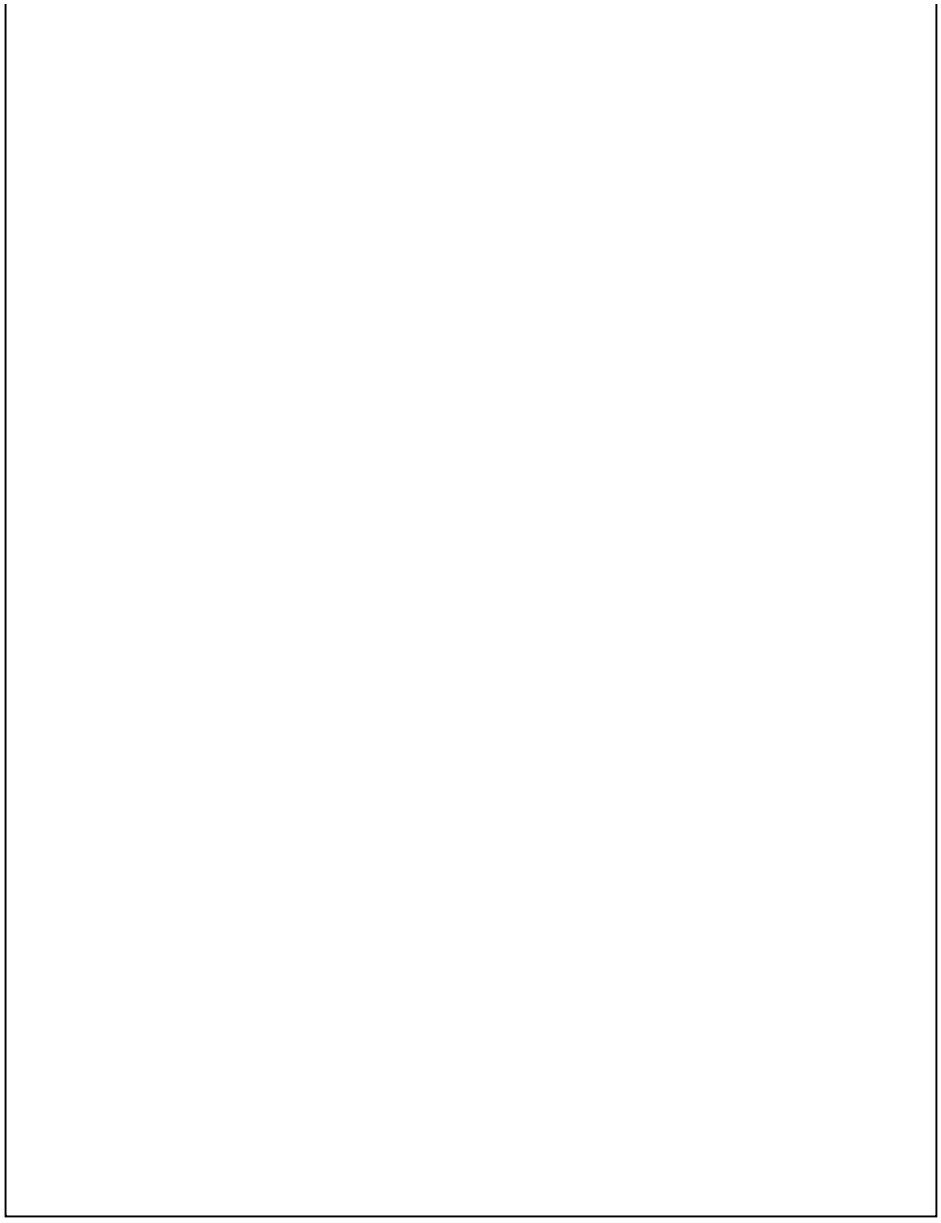
- MISO withdrawn requests:
  - J414
  - J415
  - J439
  - J459
  - J489
  - J511
  - J525
  - J575
  - J577
  - J593
  - J594
  - J596
  - J597
  - J599
  - J637
  - J638

Request Data:

GEN-2016-074

- Wind Farm Size: 200 MW
- Interconnection:
  - Voltage: 345kV
  - POI: Sweetwater 345kV (640374)
  - Transformer: 345/34.5 kV step-up transformer
    - MVA: 156 Winding MVA
    - Z: 11.8%
- Collector System Equivalent Model:
  - Transmission Line:
    - R = 0.00528 p.u.
    - X = 0.00628 p.u.
    - B = 0.0944 p.u.
- Wind Farm Parameters
  - Vestas V110 2.0 MW
  - Machine Terminal Voltage: 0.7 kV
  - Rated Power: 200 MW
  - Number of Wind Turbines: 100
  - Generator Step-Up Transformer:
    - MVA: 210 Winding MVA
    - Z: 7.75%

The following is the dynamic data for GEN-2016-074:



GEN-2016-096

- Wind Farm Size: 227.7 MW
- Interconnection:
  - Voltage: 345kV
  - POI: G15-088-TAP 345kV (560062)
  - Transformer #1: 345/34.5 kV step-up transformer

        - MVA: 100 Winding MVA
        - Z: 12.0%
    - Transformer #2: 345/34.5 kV step-up transformer
        - MVA: 100 Winding MVA
        - Z: 12.0%
- Collector System Equivalent Model:
    - Transmission Line #1:
        - R = 0.014 p.u.
        - X = 0.01826 p.u.
        - B = 0.12261 p.u.
    - Transmission Line #2:
        - R = 0.04197 p.u.
        - X = 0.05936 p.u.
        - B = 0.08998 p.u.
- Wind Farm Parameters
    - Siemens 2.3 MW
    - Machine Terminal Voltage: 0.7 kV
    - Rated Power: 227.7 MW
    - Number of Wind Turbines: 99
    - Generator Step-Up Transformer #1:
        - MVA: 181.5 Winding MVA
        - Z: 5.97%
    - Generator Step-Up Transformer #2:
        - MVA: 90.75 Winding MVA
        - Z: 5.97%

The following is the dynamic data for GEN-2016-096:

GEN-2016-147

- Solar Farm Size: 40 MW
- Interconnection:
  - Voltage: 115 kV
  - POI: Sidney 115 kV
  - Transformer: 115/34.5 kV step-up transformer
    - MVA: 27 Winding MVA
    - Z: 8.5%
- Collector System Equivalent Model:
  - Transmission Line:
    - R = 0.006296 p.u.
    - X = 0.002961 p.u.
    - B = 0.003298 p.u.
- Solar Farm Parameters
  - GE 2.0 MW Solar Inverters
  - Machine Terminal Voltage: 0.6 kV
  - Rated Power: 40 MW
  - Number of Solar Inverters: 20
  - Generator Step-Up Transformer:
    - MVA: 46 Winding MVA
    - Z: 5.9%

The following is the dynamic data for GEN-2016-147:

APPENDIX B: PLOTS FOR 2017 WINTER PEAK CONDITIONS WITH NORMAL DISPATCH

Plots available upon request

APPENDIX C: PLOTS FOR 2018 SUMMER PEAK CONDITIONS WITH NORMAL DISPATCH

Plots available upon request

APPENDIX D: PLOTS FOR 2026 SUMMER PEAK CONDITIONS WITH NORMAL DISPATCH

Plots available upon request

APPENDIX E: PLOTS FOR 2017 WINTER PEAK CONDITIONS WITH HIGH GGS DISPATCH

Plots available upon request

APPENDIX F: PLOTS FOR 2018 SUMMER PEAK CONDITIONS WITH HIGH GGS DISPATCH

Plots available upon request

APPENDIX G: PLOTS FOR 2026 SUMMER PEAK CONDITIONS WITH HIGH GGS DISPATCH

Plots available upon request