Interconnection System Impact Study Report
Request # GI-2007-12

250 MW Wind Farm, Near Calhan, Colorado

Public Service Company of Colorado
Transmission Planning
March 19, 2009

Executive Summary

Public Service Company of Colorado received an interconnection request (GI-2007-12) for a System Impact Study to examine installation of a 250 MW wind turbine generator facility near Calhan, Colorado. The proposed interconnection point is the Jackson Fuller 230 kV Substation near Colorado Springs, Colorado (see Figure 1 below). This substation is jointly owned by Colorado Springs Utilities, Tri-State Generation & Transmission, and PSCo. The wind generating facilities are located approximately 24 miles from the interconnection point and would be connected via a developer owned radial 230 kV line. The requested in service date is December 31, 2010 with a projected backfeed date of June 30, 2010.

The generator output, equipment, and interconnection point did not change from the Feasibility Study. Therefore, the load flow and short circuit study results and associated cost estimates from that analysis are still considered valid. The SIS focused mainly on dynamic and transient stability. Impacts of ratings changes on the CSU system were also addressed. In addition, voltage performance at the POI was included. A project schedule for the work estimated in the Feasibility Study was also developed.

The request was studied as a stand-alone project only, with no evaluations made of other potential new generation requests that may exist in the Large Generator Interconnection Request (LGIR) queue, other than the generation projects that are already approved and planned to be in service by December 2010. The main purpose of this System Impact Study was to evaluate the potential impact on the PSCo transmission infrastructure as well as that of neighboring utilities when injecting the proposed 250 MW of generation at the interconnection point at the Jackson Fuller 230 kV Substation, and delivering the additional generation to native PSCo loads.

Based on the study results, the proposed wind plant with 100 Clipper Liberty 2.5 MW wind turbines will be transiently stable and meet the low voltage ride through requirement. Also, all oscillations were well damped. In addition, all transient voltage swings were within WECC voltage dip criteria. Therefore, the dynamic and transient stability performance of the proposed wind plant is expected to be satisfactory.

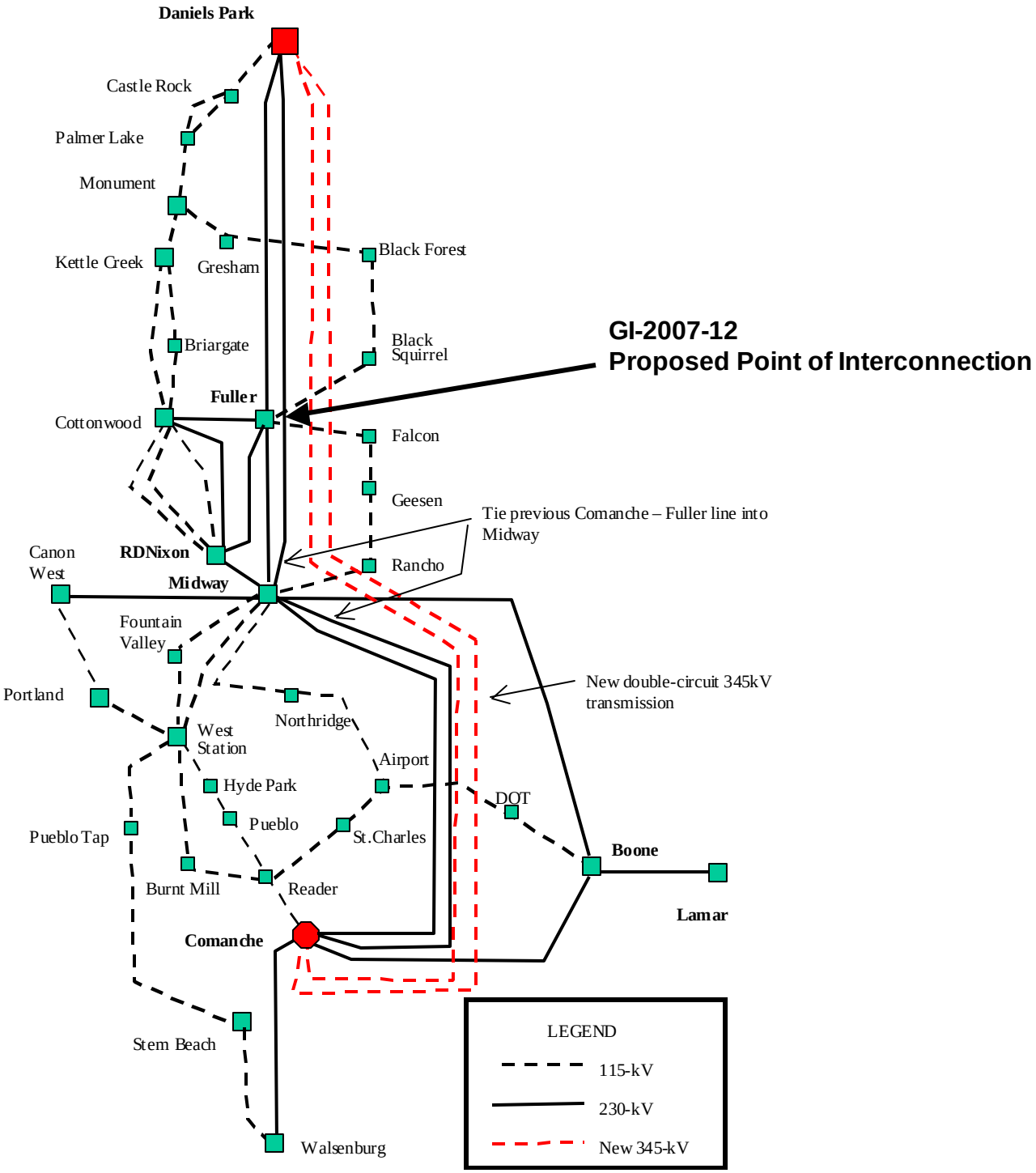
In the GI-2007-12 Feasibility Study, CSU's Cottonwood-Kettle Creek 115 kV circuit was found to be overloaded at 117.1% of the 132 MVA rating with the new generation. On December 17, 2008, PSCo received a communication from CSU indicating that the actual rating of this line is 125 MVA. This is lower than was assumed in the Feasibility Study. However, on February 2, 2009, PSCo received another communication from CSU indicating that upgrades will be made to this line to increase the rating to 168 MVA. The upgrades are planned to be in service in May 2009. Note that the impedance of the line will not change. Therefore, there was no need for revised load flow studies. With the higher 168 MVA rating, the Cottonwood-Kettle Creek 115 kV line is no longer overloaded due to installation of the proposed wind plant.

Voltage Performance at the Point of Interconnection

The Rocky Mountain Area Voltage Guidelines specify the ideal voltage range at 230 kV non-regulating buses in the Northeast Colorado Area (Region 7) should be 1.00 – 1.03 per unit. The proposed generation should be able to conform to this requirement when maintaining the power factor at the Jackson Fuller 230 kV POI near unity during peak system conditions.

Line charging from wind plant facilities is expected to be approximately 18 Mvar injected into the POI when the wind plant is off-line. Shunt reactors should be installed within the wind plant to mitigate the line charging.

Figure 1 Network Diagram with Proposed POI at Jackson Fuller



Introduction

Public Service Company of Colorado received a large generator interconnection request (GI-2007-12) to install a 250 MW generating facility near Calhan, Colorado. The project includes 100 Clipper 2.5 MW wind turbine generators (250 MW total). The proposed interconnection point is the Jackson Fuller 230 kV Substation near Colorado Springs, Colorado (see Figure 1). This substation is jointly owned by Colorado Springs Utilities, Tri-State Generation & Transmission, and PSCo. The wind generating facilities are located approximately 24 miles from the interconnection point and would be connected via a developer owned radial 230 kV line. The requested in service date is December 31, 2010 with a projected backfeed date of June 30, 2010.

The generator output, equipment, and interconnection point did not change from the Feasibility Study. Therefore, the load flow and short circuit study results and associated cost estimates from that analysis are still considered valid. The SIS focused mainly on dynamic and transient stability. Impacts of ratings changes on the CSU system were also addressed. In addition, voltage regulation at the POI was included. A project schedule for the work estimated in the Feasibility Study was also developed. The schedule can be found in Section C of the Appendix.

Study Scope and Analysis

The System Impact Study evaluated the transmission impacts associated with the proposed generating station. It consisted of dynamic & transient stability analysis and some power flow analysis. The dynamic & transient analysis identified any dynamic or transient stability problems associated with the new generation. It also evaluated low voltage ride through. The power flow analysis addressed steady state voltage performance at the POI.

PSCo adheres to NERC and WECC Reliability Criteria, as well as internal Company criteria for planning studies. During system intact conditions, criteria are to maintain transmission system bus voltages between 0.95 and 1.05 per unit of nominal, and steady-state power flows below the thermal ratings of all facilities. Per the Rocky Mountain Area Voltage Coordination Guidelines[1], PSCo tries to maintain a transmission system voltage profile ranging from 1.02 – 1.03 per unit at regulating buses and 1.0 – 1.03 per unit at non-regulating buses. Following a single contingency, transmission system steady state bus voltages must remain within 0.90 per unit to 1.10 per unit, and power flows within 100% of the facilities' continuous thermal ratings.

[1] The Voltage Coordination Guidelines Subcommittee of the Colorado Coordinated Planning Group developed these guidelines. The subcommittee consisted of representatives from major Colorado utilities including Colorado Springs Utilities, Platte River Power Authority, Tri-State Generation and Transmission, Public Service Company of Colorado, and Western Area Power Administration-Rocky Mountain Region. Other major utilities outside of Colorado were involved in the development of these guidelines.

Transient stability criteria require that all generating machines remain in synchronism and all power swings should be well damped. Also, transient voltage performance should meet the following criteria:

- Following fault clearing for single contingencies, voltage may not dip more than 25% of the pre-fault voltage at load buses, more than 30% at non-load buses, or more than 20% for more than 20 cycles at any bus.
- Following fault clearing for double contingencies, voltage may not dip more than 30% of the pre-fault voltage at any bus or more than 20% for more than 40 cycles at any bus.

Wind plants are required to remain in service during a three-phase fault lasting up to 9 cycles. They should also remain in service following single line to ground faults with delayed clearing.

For this project, potential affected parties include Colorado Springs Utilities and Tri-State Generation & Transmission (TSG&T).

Power Flow and Transient Stability Models

The dynamic and power flow studies were based on the WECC approved 11HS1BP base case. Load levels reflect 2011 heavy summer peak system conditions. The case was modified to reflect the delayed in service date of the Midway-Waterton 345 kV line. The case was also modified to include the replacement of the Daniels Park and two Waterton 230/115 kV transformers with 280 MVA units.

For the transient and dynamic studies, the Project's wind turbine generators were modeled as two equivalent machines, sized 122.5 MW and 127.5 MW, and connected to two 690 V buses. The machine sizes were based on the number of wind turbines in each part of the wind farm. The wind plant model includes equivalent 34.5/0.690 kV generator step-up transformers and equivalent collector system impedances. It also includes two main 230/34.5 kV 135 MVA transformers. This model is connected to the interconnection station through a 24-mile 230 kV overhead transmission line. The point of interconnection was the Jackson Fuller 230 kV Substation. The machines were set to operate at a fixed 0.98 pf (lag). This power factor resulted in near unity power factor at the POI.

For the low voltage ride through studies, two strings of 2.5 MW generators were modeled, one each on each side of the wind farm. They were set to operate at 0.98 pf (lag). Each had its own GSU transformer. The strings also included the 34.5 kV collector system cable impedances. The remaining generators were modeled as two equivalent machines, sized 100.0 MW and 102.5 MW and operating at 0.98 pf (lag). They were connected to equivalent GSU transformers and equivalent collector system impedances.

The Squirrel Creek generators in the power flow case were switched off due to their cancellation since the load flow case was developed. This generation was made up by dispatching power from Colorado Green, Twin Butte, and Peetz Logan. The balance of the power flow case models included a generation dispatch that simulated high flows from southern Colorado to the north. Generation that was redispatched to develop these dispatch scenarios included units at Fountain Valley, Comanche, and the DC tie at Lamar. The northern generators that were ramped back included units at Cherokee, Pawnee, Manchief, and Rawhide. The generation dispatch in the power flow case can be found in Table 2 in the Appendix.

PSCo control area (Area 70) wind generation facilities, other than those dispatched to offset the outage of the Squirrel Creek generation, were dispatched to approximately 12% of facility ratings, consistent with other similar planning study models.

Transient Stability Study Process

The transient stability studies were conducted using PTI's PSS/E Version 30.3.2 software. NERC Category B & C contingencies were considered as part of the analysis. The simulations considered three-phase faults with normal clearing, single line to ground faults with breaker failure and clearing by backup breakers, and three-phase faults with prior network outages. The analyses using three-phase faults assumed 5 cycle normal clearing time. The single line to ground breaker failure analyses used a backup clearing time of 17 cycles. The results were assessed for dynamic and transient stability performance, including wind turbine generator low voltage ride through. A listing of the buses that were monitored to evaluate transient voltage dip performance can be found in Table 3.

Transient Stability Study Results

The list of contingencies that were evaluated can be found in Table 4 in the Appendix. The range of contingencies evaluated was limited to that necessary to adequately assess the transient stability performance of the proposed wind turbine generator project. Plots of machine speed, power, terminal voltage, terminal frequency, and system voltages for each contingency were produced to perform the assessment. The study shows that with the turbines specified, Clipper 2.5 MW (100 turbines), the proposed generating plant will be transiently stable and meet the low voltage ride through requirement when the controlled power factor at the 34.5 kV collector bus is 0.99 lagging (turbines supplying VARs).

All transient voltage swings were within WECC voltage dip criteria. The maximum observed voltage dip was 8.2%.

Voltage Performance at the Point of Interconnection

Wind developers are required to conform to Xcel Energy interconnection guidelines and FERC Order 661-A. Specifically:

- The wind plant shall maintain the power factor at the POI within the range of 0.95 leading to 0.95 lagging for the full MW operating range of the facility, if the System Impact Study demonstrates that this power factor requirement is necessary to ensure safety or reliability.
- The voltage at the POI of the wind plant shall be maintained within the ideal voltage range for the Northeast Colorado Area (Region 7) as defined by the Rocky Mountain Area Voltage Coordination Guidelines.
- The wind plant is required to demonstrate to the satisfaction of PSCo System Operations prior to the commercial in-service date that it can safely and reliably operate within required power factor and voltage ranges.
- PSCo System Operations will require the Developer to perform operational tests prior to commercial operation that would verify that the equipment installed by the Developer meets operation requirements.
- It is the responsibility of the project developer to determine what type of equipment (DVAR, added switched capacitors, SVC, reactors, etc.), the ratings (MVAR, voltage--34.5 kV or 230 kV), and the locations of those facilities to meet the power factor and voltage range standards.

This study examined the ability of the proposed wind plant to adhere to the power factor and voltage range requirements of the interconnection guidelines. Based on the results of the studies, the wind plant should be able to deliver the full 250 MW minus losses at the POI within the 0.95 leading to 0.95 lagging power factor criteria. However, per the Rocky Mountain Area Voltage Coordination Guidelines for non-regulated buses, the ideal voltage range at the POI should be from 1.00 – 1.03 per unit. Table 1 below illustrates that this requirement can be met for peak system conditions when maintaining near unity power factor at the Jackson Fuller 230 kV POI.

When the proposed wind plant is off-line, the facilities deliver approximately 18 Mvar at the POI due to line charging from the developer's 230 kV transmission line and 34.5 kV collector system. Reactors located within the wind plant can be used to mitigate the line charging.

Table 1 Voltage & Reactive Power at the Point of Interconnection

	GI 2007-12 @ 0 MW	GI 2007-12 @ 250 MW POI @ Unity pf
Real Power Delivered at POI, MW	0.0	243.4
Reactive Power Delivered at POI, Mvar	18.5	-0.5
Power Factor at POI	0.0	1.00
Voltage at the POI, pu	1.007	1.007
Voltage at the 230 kV wind farm bus, pu	1.011	1.016

Colorado Spring Utilities System Overloads

In the GI-2007-12 Feasibility Study, CSU's Cottonwood-Kettle Creek 115 kV circuit was found to be overloaded at 117.1% of the 132 MVA rating with the new generation. On December 17, 2008, PSCo received a communication from CSU indicating that the actual rating of this line is 125 MVA. This is lower than was assumed in the Feasibility Study. However, on February 2, 2009, PSCo received another communication from CSU indicating that upgrades will be made to this line to increase the rating to 168 MVA. The upgrades are planned to be in service in May 2009. Note that the impedance of the line will not change. Therefore, there was no need for revised load flow studies. With the higher 168 MVA rating, the Cottonwood-Kettle Creek 115 kV line is no longer overloaded due to installation of the proposed wind plant.

Project Schedule

The project schedule for the work estimated in the GI-2007-12 Feasibility Study can be found in Section C of the Appendix.

Appendix

A. Generation Dispatch

Table 2 – Generation Dispatch

GI-2007-12 System Impact Study				
Generation Dispatch				
Bus	Name	ID	Status	Pgen
70034	ARAP3 13.800	G3	1	44.0
70035	ARAP4 13.800	G4	1	115.0
70103	CHEROK1 15.500	G1	1	110.0
70104	CHEROK2 15.500	G2	1	110.0
70105	CHEROK3 20.000	G3	1	105.0
70106	CHEROK4 22.000	G4	1	280.0
70119	COMAN 1 24.000	G1	1	360.0
70120	COMAN 2 24.000	G2	1	365.0
70188	FTLUP1-2 13.800	1	0	0.0
70188	FTLUP1-2 13.800	2	0	0.0
70310	PAWNEE 22.000	G1	1	300.0
70314	MANCHEF1 16.000	G1	1	45.0
70315	MANCHEF2 16.000	G2	1	45.0
70350	RAWHIDE 24.000	1	1	145.0
70351	RAWHIDEA 13.800	1	1	40.0
70406	ST.VR 2 18.000	G2	1	130.0
70407	ST.VR 3 18.000	G3	1	130.0
70408	ST.VR 4 18.000	G4	1	130.0
70409	ST.VRAIN 22.000	G1	1	52.0
70446	VALMONT 20.000	G5	1	188.0
70448	VALMONT6 13.800	G6	1	50.0
70553	ARAP5-6 13.800	G5	1	37.0
70553	ARAP5-6 13.800	G6	1	37.0
70554	ARAP7 13.800	G7	1	45.0
70557	VALMNT7 13.800	G7	1	36.0
70558	VALMNT8 13.800	G8	1	36.0
70560	LAMAR DC 230.00	1	1	100.0
70561	RAWHIDEE 13.800	1	1	55.0
70562	SPRUCE1 18.000	G1	1	140.0
70563	SPRUCE2 18.000	G2	1	140.0

GI-2007-12 System Impact Study				
Generation Dispatch				
Bus	Name	ID	Status	Pgen
70567	RAWHIDED 13.800	1	1	55.0
70568	RAWHIDEB 13.800	1	1	60.0
70569	RAWHIDEC 13.800	1	1	56.0
70577	FTNVL1-2 13.800	G1	1	35.0
70577	FTNVL1-2 13.800	G2	1	35.0
70578	FTNVL3-4 13.800	G3	1	35.0
70578	FTNVL3-4 13.800	G4	1	35.0
70579	FTNVL5-6 13.800	G5	1	35.0
70579	FTNVL5-6 13.800	G6	1	35.0
70588	RMEC1 15.000	G1	1	140.0
70589	RMEC2 15.000	G2	1	140.0
70591	RMEC3 23.000	G3	1	322.0
70593	SPNDLE1 18.000	1	1	134.0
70594	SPNDLE2 18.000	2	1	134.0
70631	SQRRL01 24.000	1	0	0.0
70632	SQRRL02 24.000	1	0	0.0
70633	SQRRL03 24.000	1	0	0.0
70701	CO GRN E 34.500	1	1	78.0
70702	CO GRN W 34.500	1	1	78.0
70703	TWNBUTTE 34.500	1	1	78.0
70710	PTZLOGN1 34.500	1	1	146.6
70712	PTZLOGN2 34.500	1	1	146.6
70713	PTZLOGN3 34.500	1	1	36.6
70777	COMAN 3 24.000	1	1	750.0
70822	CEDARCK1 34.500	1	1	15.0
70823	CEDARCK2 34.500	1	1	15.0
73418	RD_NIXON 20.000	1	1	200.0
73434	NIXONCT2 12.500	1	1	30.0
73435	NIXONCT1 12.500	1	1	30.0
73507	FTRNG1CC 18.000	1	1	0.0
73508	FTRNG2CC 18.000	1	1	150.0
73509	FTRNG3CC 18.000	1	1	0.0
			(1=on)	

B. Dynamic and Transient Stability Study Data & Results

Table 3 – Monitored Buses for Transient Voltage Dip Evaluation

Bus #	Bus Name	Nominal Bus Voltage	Bus #	Bus Name	Nominal Bus Voltage
73477	FULLER	230.0	73419	RD_NIXON	230.0
70139	DANIELPK	230.0	73394	CTTNWD S	230.0
70138	DANIELPK	115.0	73391	CTTNWD N	115.0
70278	MARCY	230.0	73393	CTTNWD S	115.0
70284	SURREYRG	230.0	73410	KETTLECK	115.0
70286	MIDWAYPS	230.0	73576	FLYHORSE	115.0
70311	PAWNEE	230.0	73389	BRIARGAT	115.0
70427	TARRYALL	230.0	73414	MONUMENT	115.0
70527	SANTEFE	230.0	70308	PALMER	115.0
70601	DANIELPK	345.0	73445	GRESHAM	115.0
70464	WATERTON	230.0	73400	EMIL AND	115.0
70038	ARAPAHOE	230.0	73422	TEMPLTON	115.0
70212	GREENWD	230.0	73490	RAMPART	115.0
70533	LEMON	230.0	73384	BIRDSALE	115.0
70524	SULPHUR	230.0	73408	KELKER E	115.0
70061	BOONE	230.0	73420	ROCKISLD	115.0
70122	COMANCHE	230.0	73409	KELKER W	115.0
70654	COMAN 3	345.0	73387	BIRDSALW	115.0
70121	COMANCHE	115.0	73407	KELKER N	230.0
70285	MIDWAYPS	115.0	73446	KELKER S	230.0
73413	MIDWAYBR	230.0	73380	ARIES	230.0
73551	W CANON	230.0	73421	STETSON	230.0
73531	LINCOLNT	230.0	73559	FRTRANGE	230.0
73392	CTTNWD N	230.0			

Table 4 – Summary Listing of Dynamic & Transient Stability Study Contingencies & Results

Case #	Fault Type	Fault Location	Tripped Facility	Additional Tripped Facility	Stability Results	Transient Voltage Dip Criteria	
						Bus	Voltage Deviation (pu) 1st Swing
100	3ph	FULLER 230.0 kV	Jackson Fuller-Midway 230 kV	N/A	Stable	PAWNEE 230.0 kV	-0.005
101	3ph	FULLER 230.0 kV	Jackson Fuller-Daniels Park 230 kV	N/A	Stable	MONUMENT 115.0 kV	-0.017
102	3ph	FULLER 230.0 kV	Jackson Fuller-Cottonwood 230 kV	N/A	Stable	CTTNWD N 230.0 kV CTTNWD S 230.0 kV	-0.005 -0.005
103	3ph	FULLER 230.0 kV	Jackson Fuller-Nixon 230 kV	N/A	Stable	PAWNEE 230.0 kV	-0.005
104	3ph	FULLER 230.0 kV	Jackson Fuller 230/115 kV #1	N/A	Stable	PAWNEE 230.0 kV	-0.004
110	3ph	MIDWAYPS 230.0 kV	Midway-Jackson Fuller 230 kV	N/A	Stable	BOONE 230.0 kV	-0.011
111	3ph	MIDWAYPS 230.0 kV	Midway-Boone 230 kV	N/A	Stable	COMANCHE 115.0 kV	-0.017
112	3ph	MIDWAYPS 230.0 kV	Midway-Comanche 230 kV #1	N/A	Stable	BOONE 230.0 kV	-0.014
113	3ph	MIDWAYPS 230.0 kV	Midway-Comanche 230 kV #2	N/A	Stable	BOONE 230.0 kV	-0.014
114	3ph	MIDWAYPS 230.0 kV	Midway-Daniels Pk 230 kV	N/A	Stable	MONUMENT 115.0 kV	-0.012
115	3ph	MIDWAYBR 230.0 kV	Midway-Lincoln 230 kV	N/A	Stable	PAWNEE 230.0 kV	-0.010
116	3ph	MIDWAYBR 230.0 kV	Midway-Nixon 230 kV	N/A	Stable	BOONE 230.0 kV	-0.016
117	3ph	MIDWAYBR 230.0 kV	Midway-Canon West 230 kV	N/A	Stable	BOONE 230.0 kV	-0.009
118	3ph	MIDWAYPS 230.0 kV	Midway 230/115 kV #1	N/A	Stable	BOONE 230.0 kV	-0.013
119	3ph	MIDWAYBR 230.0 kV	Midway 230/115 kV #2	N/A	Stable	BOONE 230.0 kV	-0.008
11A	3ph	MIDWAYPS 230.0 kV	Midway-Fountain Valley 230 kV	N/A	Stable	BOONE 230.0 kV	-0.022
120	3ph	CTTNWD N 230.0 kV	Cottonwood-Jackson Fuller 230 kV	N/A	Stable	CTTNWD N 230.0 kV CTTNWD S 230.0 kV	-0.006 -0.006
121	3ph	CTTNWD S 230.0 kV	Cottonwood-Nixon 230 kV	N/A	Stable	PAWNEE 230.0 kV	-0.003
122	3ph	CTTNWD N 230.0 kV	Cottonwood N 230/115 kV	N/A	Stable	PAWNEE 230.0 kV	-0.004
123	3ph	CTTNWD S 230.0 kV	Cottonwood S 230/115 kV	N/A	Stable	PAWNEE 230.0 kV	-0.004

Case #	Fault Type	Fault Location	Tripped Facility	Additional Tripped Facility	Stability Results	Transient Voltage Dip Criteria	
						Bus	Voltage Deviation (pu) 1st Swing
130	3ph	RD_NIXON 230.0 kV	Nixon-Kelker S 230 kV	N/A	Stable	PAWNEE 230.0 kV	-0.007
131	3ph	RD_NIXON 230.0 kV	Nixon-Kelker N 230 kV	N/A	Stable	PAWNEE 230.0 kV	-0.007
132	3ph	RD_NIXON 230.0 kV	Nixon 230/115 kV #1	N/A	Stable	PAWNEE 230.0 kV	-0.007
133	3ph	RD_NIXON 230.0 kV	Nixon-Jackson Fuller 230 kV	N/A	Stable	PAWNEE 230.0 kV	-0.007
134	3ph	RD_NIXON 230.0 kV	Nixon-Midway 230 kV	N/A	Stable	PAWNEE 230.0 kV	-0.007
135	3ph	RD_NIXON 230.0 kV	Nixon-Cottonwood 230 kV	N/A	Stable	PAWNEE 230.0 kV	-0.006
136	3ph	RD_NIXON 230.0 kV	Nixon Unit 1	N/A	Stable	PAWNEE 230.0 kV	-0.012
137	3ph	RD_NIXON 230.0 kV	Nixon Unit 2	N/A	Stable	PAWNEE 230.0 kV	-0.007
138	3ph	RD_NIXON 230.0 kV	Nixon Unit 3	N/A	Stable	PAWNEE 230.0 kV	-0.007
139	3ph	RD_NIXON 230.0 kV	Nixon-Front Range 230 kV	N/A	Stable	BOONE 230.0 kV	-0.013
140	3ph	DANIELPK 230.0 kV	Daniels Park-Pawnee 230 kV	N/A	Stable	PAWNEE 230.0 kV	-0.014
141	3ph	DANIELPK 230.0 kV	Daniels Park-Arapahoe 230 kV	N/A	Stable	PAWNEE 230.0 kV	-0.012
142	3ph	DANIELPK 230.0 kV	Daniels Park-Tarryall 230 kV	N/A	Stable	PAWNEE 230.0 kV	-0.012
143	3ph	DANIELPK 230.0 kV	Daniels Park 230/115 kV #1	N/A	Stable	DANIELPK 115.0 kV	-0.082
144	3ph	DANIELPK 230.0 kV	Daniels Park-Jackson Fuller 230 kV	N/A	Stable	MONUMENT 115.0 kV	-0.021
145	3ph	DANIELPK 230.0 kV	Daniels Park-Waterton 230 kV	N/A	Stable	PAWNEE 230.0 kV	-0.008
146	3ph	DANIELPK 230.0 kV	Daniels Park-Greenwood 230 kV #1	N/A	Stable	PAWNEE 230.0 kV	-0.007
147	3ph	DANIELPK 230.0 kV	Daniels Park-Midway 230 kV	N/A	Stable	MONUMENT 115.0 kV	-0.015
148	3ph	DANIELPK 230.0 kV	Daniels Park-Greenwood 230 kV #2	N/A	Stable	PAWNEE 230.0 kV	-0.011
149	3ph	DANIELPK 230.0 kV	Daniels Park-Sulpher 230 kV	N/A	Stable	SULPHER 230.0 kV	-0.013
14A	3ph	DANIELPK 230.0 kV	Daniels Park 345/230 kV #1	N/A	Stable	PAWNEE 230.0 kV	-0.011

Case #	Fault Type	Fault Location	Tripped Facility	Additional Tripped Facility	Stability Results	Transient Voltage Dip Criteria	
						Bus	Voltage Deviation (pu) 1st Swing
200	slg w/ BF	FULLER 230.0 kV	Jackson Fuller-Midway 230 kV	Jackson Fuller-Daniels Park 230 kV	Stable	MONUMENT 115.0 kV	-0.018
201	slg w/ BF	FULLER 230.0 kV	Jackson Fuller-Cottonwood 230 kV	Jackson Fuller-Nixon 230 kV	Stable	CTTNWD N 230.0 kV CTTNWD S 230.0 kV	-0.012 -0.012
210	slg w/ BF	MIDWAYPS 230.0 kV	Midway-Comanche 230 kV	Fountain Valley Generation	Stable	BOONE 230.0 kV	-0.033
211	slg w/ BF	MIDWAYPS 230.0 kV	Midway-Daniels Park 230 kV	Midway-Comanche 230 kV	Stable	MONUMENT 115.0 kV	-0.013
212	slg w/ BF	MIDWAYPS 230.0 kV	Midway-Jackson Fuller 230 kV	Midway PS-Midway WAPA 230 kV	Stable	BOONE 230.0 kV	-0.032
213	slg w/ BF	MIDWAYBR 230.0 kV	Midway-Nixon 230 kV	Midway PS-Midway WAPA 230 kV Midway-Lincoln 230 kV Midway-Canon W 230 kV Midway 230/115 kV #2	Stable	BOONE 230.0 kV	-0.051
220	slg w/ BF	CTTNWD N 230.0 kV	Cottonwood N 230/115 kV	Cottonwood-Jackson Fuller 230 kV	Stable	KETTLECK 115.0 kV	-0.012
221	slg w/ BF	CTTNWD S 230.0 kV	Cottonwood S 230/115 kV	Cottonwood-Nixon 230 kV	Stable	CTTNWD N 230.0 kV CTTNWD S 230.0 kV	-0.006 -0.006
230	slg w/ BF	RD_NIXON 230.0 kV	Nixon-Kelker N 230 kV	Nixon Unit 1	Stable	KELKER N 230.0 kV KELKER S 230.0 kV	-0.014 -0.014
231	slg w/ BF	RD_NIXON 230.0 kV	Nixon-Cottonwood 230 kV	Nixon 230/115 kV #1	Stable	BOONE 230.0 kV	-0.008
232	slg w/ BF	RD_NIXON 230.0 kV	Nixon-Jackson Fuller 230 kV	Nixon Unit 2 Nixon Unit 3	Stable	LINCOLNT 230.0 kV	-0.008
233	slg w/ BF	RD_NIXON 230.0 kV	Nixon-Midway 230 kV	Frontrange Generation	Stable	RD_NIXON 230.0 kV	-0.020
240	slg w/ BF	DANIELPK 230.0 kV	Daniels Park-Arapahoe 230 kV	Daniels Park 345/230 kV #2	Stable	ARAPAHOE 230.0 kV	-0.009
241	slg w/ BF	DANIELPK 230.0 kV	Daniels Park-Tarryall 230 kV	Daniels Park 345/230 kV #3	Stable	PAWNEE 230.0 kV	-0.010
242	slg w/ BF	DANIELPK 230.0 kV	Daniels Park-Waterton 230 kV	Daniels Park-Jackson Fuller 230 kV	Stable	MONUMENT 115.0 kV	-0.020
243	slg w/ BF	DANIELPK 230.0 kV	Daniels Park-Greenwood 230 kV #2	Daniels Park-Midway 230 kV	Stable	MONUMENT 115.0 kV	-0.015
244	slg w/ BF	DANIELPK 230.0 kV	Daniels Park-Greenwood 230 kV #1	Daniels Park-Pawnee 230 kV	Stable	PAWNEE 230.0 kV	-0.008
245	slg w/ BF	DANIELPK 230.0 kV	Daniels Park-Sulpher 230 kV	Daniels Park 345/230 kV #1	Stable	SULPHER 230.0 kV	-0.014

Case #	Fault Type	Fault Location	Tripped Facility	Prior Line Outage	Stability Results	Transient Voltage Dip Criteria	
						Bus	Voltage Deviation (pu) 1st Swing
300	3ph	FULLER 230.0 kV	Jackson Fuller-Daniels Park 230 kV	Jackson Fuller-Midway 230 kV	Stable	MONUMENT 115.0 kV	-0.018
301	3ph	FULLER 230.0 kV	Jackson Fuller-Cottonwood 230 kV	Jackson Fuller-Midway 230 kV	Stable	CTTNWD N 230.0 kV CTTNWD S 230.0 kV	-0.010 -0.010
302	3ph	FULLER 230.0 kV	Jackson Fuller-Nixon 230 kV	Jackson Fuller-Midway 230 kV	Stable	FULLER 230.0 kV	-0.005
303	3ph	FULLER 230.0 kV	Jackson Fuller 230/115 kV	Jackson Fuller-Midway 230 kV	Stable	BOONE 230.0 kV	-0.004
310	3ph	FULLER 230.0 kV	Jackson Fuller-Midway 230 kV	Jackson Fuller-Daniels Park 230 kV	Stable	FULLER 230.0 kV	-0.006
311	3ph	FULLER 230.0 kV	Jackson Fuller-Cottonwood 230 kV	Jackson Fuller-Daniels Park 230 kV	Stable	CTTNWD N 230.0 kV CTTNWD S 230.0 kV	-0.014 -0.014
312	3ph	FULLER 230.0 kV	Jackson Fuller-Nixon 230 kV	Jackson Fuller-Daniels Park 230 kV	Stable	FULLER 230.0 kV	-0.005
313	3ph	FULLER 230.0 kV	Jackson Fuller 230/115 kV	Jackson Fuller-Daniels Park 230 kV	Stable	BOONE 230.0 kV	-0.003
320	3ph	FULLER 230.0 kV	Jackson Fuller-Midway 230 kV	Jackson Fuller-Cottonwood 230 kV	Stable	FULLER 230.0 kV	-0.005
321	3ph	FULLER 230.0 kV	Jackson Fuller-Daniels Park 230 kV	Jackson Fuller-Cottonwood 230 kV	Stable	MONUMENT 115.0 kV	-0.018
322	3ph	FULLER 230.0 kV	Jackson Fuller-Nixon 230 kV	Jackson Fuller-Cottonwood 230 kV	Stable	FULLER 230.0 kV	-0.004
323	3ph	FULLER 230.0 kV	Jackson Fuller 230/115 kV	Jackson Fuller-Cottonwood 230 kV	Stable	BOONE 230.0 kV	-0.003
330	3ph	FULLER 230.0 kV	Jackson Fuller-Midway 230 kV	Jackson Fuller-Nixon 230 kV	Stable	FULLER 230.0 kV	-0.005
331	3ph	FULLER 230.0 kV	Jackson Fuller-Daniels Park 230 kV	Jackson Fuller-Nixon 230 kV	Stable	MONUMENT 115.0 kV	-0.018
332	3ph	FULLER 230.0 kV	Jackson Fuller-Cottonwood 230 kV	Jackson Fuller-Nixon 230 kV	Stable	CTTNWD N 230.0 kV CTTNWD S 230.0 kV	-0.010 -0.010
333	3ph	FULLER 230.0 kV	Jackson Fuller 230/115 kV	Jackson Fuller-Nixon 230 kV	Stable	BOONE 230.0 kV	-0.004
340	3ph	FULLER 230.0 kV	Jackson Fuller-Midway 230 kV	Jackson Fuller 230/115 kV	Stable	FULLER 230.0 kV	-0.005
341	3ph	FULLER 230.0 kV	Jackson Fuller-Daniels Park 230 kV	Jackson Fuller 230/115 kV	Stable	MONUMENT 115.0 kV	-0.020
342	3ph	FULLER 230.0 kV	Jackson Fuller-Cottonwood 230 kV	Jackson Fuller 230/115 kV	Stable	CTTNWD N 230.0 kV CTTNWD S 230.0 kV	-0.014 -0.014
343	3ph	FULLER 230.0 kV	Jackson Fuller-Nixon 230 kV	Jackson Fuller 230/115 kV	Stable	FULLER 230.0 kV	-0.004

C. Project Schedule