Impact Study for Generator Modification (Inverter Change) GEN-2014-033 GEN-2014-034 GEN-2014-035

November 2015
Generator Interconnection

Southwest Power Pool

Revision History

Date	Author	Change Description
11/12/2015	SPP	GEN-2014-033, GEN-2014-034, & GEN-2014-035 Impact Study for Generator Modification (Inverter Change) Report Issued

Executive Summary

This document reports on the findings of an Impact Study under the Southwest Power Pool Open Access Transmission Tariff (OATT) for 170 MW of solar generation to be interconnected with Energy Resource Interconnection Service (ERIS) into the Transmission System of Southwest Public Service (SPS) in Chaves County, New Mexico. GEN-2014-033, GEN-2014-034, & GEN-2014-035 under GIP Section 4.4.2, have requested a modification to their respective Interconnection Requests. This Impact Study determines the impacts of modifying the technical parameters associated with the Generating Facility technology. The Interconnection Customers have requested an evaluation to determine the effects of changing solar inverter generators from the previously studied SMA Sunny Central 0.5MW photovoltaic solar inverter generators to GE LV5 1.0MW photovoltaic solar inverter generators.

GEN-2014-033, GEN-2014-034, & GEN-2014-035 propose to use an aggregate of one-hundred seventy (170) GE LV5 1.0MW photovoltaic solar inverter generators with a maximum aggregate nameplate capacity of 170.0MW. The three projects are located in Chaves County, New Mexico and share the same Point of Interconnection (POI) at Chaves County 115kV. GEN-2014-034 & GEN-2014-035 share a portion of the same 115kV transmission line from the GEN-2014-035 115kV substation to the POI.

The interconnection customers have provided documentation that shows the GE LV5 1.0MW photovoltaic solar inverter generators each have a unity reactive power capability (1.00 power factor) with an active power output at the unit rating. With an active power output below the unit rating, each unit has an apparent power capability of the unit rating. For example if the active power output is at 95% of the unit rating then the reactive power capability is 0.95 lagging (providing VARS) and 0.95 leading (absorbing VARS) power factor.

With the assumptions and requirements described in this report and with all the required network upgrades identified in the DISIS-2014-002-4 Definitive Impact Study in place, study projects GEN-2014-033, GEN-2014-034, & GEN-2014-035 utilizing the GE LV5 1.0MW photovoltaic solar inverter generators should be able to reliably interconnect to the SPP transmission grid. In addition, consistent with Order #661A, the facilities will be required to maintain a 95% lagging (providing vars) and 95% leading (absorbing vars) power factor at the point of interconnection.

A power factor analysis was not performed again in this study, the results from the power factor analysis in DISIS-2014-002-1 remain applicable. The facility will be required to maintain a 95% lagging (providing VARs) and 95% leading (absorbing VARs) power factor at the point of interconnection. The Customer is responsible for maintaining a 95% power factor at the point of interconnection. Additional capacitor banks or other reactive equipment may be required to meet this requirement depending on the design of the Generating Facility and its collector system.
The analysis indicates that the requested modification by the Interconnection Customer is not considered Material and is acceptable to SPP.

I. Introduction

GEN-2014-033, GEN-2014-034, & GEN-2014-035 Impact Study is a generator interconnection study performed to study the impacts of interconnecting the projects shown in Table I-1. The in-service date assumed for the generation addition is December 2016. This study evaluates the modification request by the Customer for a change from SMA Sunny Central 0.5MW photovoltaic solar inverter generators to GE LV5 1.0MW photovoltaic solar inverter generators.

Table I-1: Interconnection Requests

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2014-033	70.0	GE PV LV5 1.0MW	Chaves County 115kV (527482)
GEN-2014-034	70.0	GE PV LV5 1.0MW	Chaves County 115kV (527482)
GEN-2014-035	30.0	GE PV LV5 1.0MW	Chaves County 115kV (527482)

The higher, equally, and lower queued requests shown in Table I-2 were included in this study and the wind and solar farms were dispatched to 100% of rated capacity.

Table I-2: Higher and Equal, Queued Interconnection Requests

Request	Capacity (MW)	Generator Model	Point of Interconnection
ASGI-2010-010	42.2	Wartsila 20V34SG (528331)	Lovington 115kV (528334)
ASGI-2010-020	30.0	Nordex N100 2.5MW (580088)	Tap LE-Tatum - LE-Crossroads 69kV (560360)
ASGI-2010-021	15.0	Mitsubishi MPS-1000A 1.0MW (M1MWG) (580083)	Tap LE-Saunders Tap - LE-Anderson 69kV (560364)
ASGI-2011-001	27.3	Suzlon S97 2.1MW (528332)	Lovington 115kV (528334)
ASGI-2011-003	10.0	Sany 2.0MW (525942)	Hendricks 115kV (525943)
ASGI-2011-004	19.8	Sany 1.8MW (583193 & 583196)	Pleasant Hill 69kV (525915)
ASGI-2012-002	18.2	Vestas V82 1.65MW (583283)	FE-Clovis Interchange 115kV (524808)
ASGI-2013-002	18.4	Siemens VS 2.3MW (583613)	FE Tucumcari 115kV (524509)
ASGI-2013-003	18.4	Siemens VS 2.3MW (583623)	FE Clovis 115kV (524808)
ASGI-2013-006	2.0	Gamesa G114 2.0MW (583813)	SPEC - Erskine 69kV (526483)
ASGI-2013-005	19.8	Vestas V82 1.65MW (583283)	FE-Clovis 115kV (524808)
ASGI-2014-001	2.5	GE 2.5MW (583816)	SPEC - Erskine 69kV (526109)
ASGI-2014-002	49.6	SMA 0.8MW (584314)	Santa Rosa tap - Tucumcari 69kV line (524509)
ASGI-2014-005	10.0	PV Inverter (584333)	Strata 69 kV (528046)
ASGI-2014-008	10.0	PV Inverter (584343)	South Loving 69kV (528218)
ASGI-2014-009	10.0	PV Inverter (584353)	Wood Draw 115kV (528228)
ASGI-2014-010	10.0	PV Inverter (584363)	Ochoa 115kV (528232)
ASGI-2014-012	10.0	PV Inverter (584383)	Cooper Ranch 115kV (528554)
ASGI-2015-002	2.0	GE 2.0MW (584723)	SPEC-Yuma 69kV (526469)
GEN-2001-033	180.0	Mitsubishi MHI 1000A 1.0MW (WT1G1) (524890 & 524896)	San Juan Tap 230kV (524885)

Table I-2: Higher and Equal, Queued Interconnection Requests

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2001-036	80.0	Mitsubishi MHI 1000A 1.0MW (WT1G1) (524485)	Norton 115kV (524502)
GEN-2006-018	170.0	CT (GENSAL) (525841, 525842, & 525843)	TUCO Interchange 230kV (525830)
GEN-2006-026	502.0	Gas (GENROU) (527901, 527902, & 527903)	Hobbs 230kV & Hobbs 115kV (527891/527894)
GEN-2008-022	300.0	Vestas V100 VCSS 2.0MW (577100, 577110, & 577120)	Tap Eddy Co - Tolk (Crossroads) 345kV (560007)
GEN-2010-006	180 Summer 205 Winter	Gas (GENROU) (526333)	Jones 230kV (526337)
GEN-2010-046	56.0	Wartsila (580043)	TUCO Interchange 230kV (525830)
GEN-2011-025	78.76	GE 1.79MW (581140)	Tap LE-Tatum - LE-Crossroads 69kV (562004)
GEN-2011-045	180 Summer 205 Winter	NG CT (GENROU) (526334)	Jones 230kV (526337)
GEN-2011-046	23 Summer 27 Winter	Diesel CT (GENROU) (524471)	Lopez 115kV (524472)
GEN-2011-048	175.0	CT (GENROU) (527166)	Mustang 230kV (527151)
GEN-2012-001	61.2	CCWE 3.6MW (522903)	Tap Grassland - Borden County 230kV (526679)
GEN-2012-020	477.1	GE 1.68MW (583343 & 583346)	TUCO 230kV (525830)
GEN-2012-034	172.0 (7.0 increase)	CT (GENROU) (527164)	Mustang 230kV (527151)
GEN-2012-035	172.0 (7.0 increase)	CT (GENROU) (527165)	Mustang 230kV (527151)
GEN-2012-036	182.0 (7.0 increase)	CT (GENROU) (527166)	Mustang 230kV (527151)
GEN-2012-037	203.0	GE 7FA Gas CT (GENROU) (525844)	TUCO 345kV (525832)
GEN-2013-016	203.0	GE 7FA Gas CT (GENROU) (525845)	TUCO 345kV (525832)
GEN-2013-022	25.0	Solaron 0.5MW (583313)	Norton 115kV (524502)
GEN-2014-012	225.0	CT (GENROU) (528607)	Tap Hobbs Interchange - Andrews 230kV (528611)
GEN-2013-027	150	Siemens VS 2.3MW (583843) & 2.415MW (583846)	Tap Tolk - Yoakum 230kV (562480)
GEN-2014-047	40.0	AE 500NX 0.5MW (584263)	Tap Tolk - Eddy County (Crossroads) 345kV (560007)
GEN-2014-053	80.0	GE 2.0MW (584033)	Carlisle 230kV (526161)
GEN-2014-054	120.0	GE 2.0MW (584043)	Carlisle 230kV (526161)

GEN-2014-033, GEN-2014-034, and GEN-2014-035 were included within the DISIS-2014-002 that was studied in fall 2014 and posted January 31, 2015. The cluster has been restudied since the

original posting. These reports can be located at the following Generation Interconnection Study URL:
http://sppoasis.spp.org/documents/swpp/transmission/GenStudies.cfm?YearType=2014_Impact_Studies

This restudy included a stability analysis of the interconnection request. Contingencies that resulted in a prior-queued project tripping off-line, if any, were re-run with the prior-queued project's voltage and frequency tripping relays disabled. The stability analysis was performed on three seasonal models, the modified version of the 2015 summer, 2015 winter, and 2025 summer peak load cases.

The stability analysis determines the impacts of the interconnecting projects on the stability and voltage recovery of the nearby systems 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 is investigated. The three-phase faults and the single line-to-ground faults listed in Table III-1 were used in the stability analysis.

Nothing in this System Impact Study constitutes a request for transmission service or grants the Interconnection Customer any rights to transmission service.

II. Facilities

GEN-2014-033, GEN-2014-034, & GEN-2014-035 projects propose to use an aggregate of one-hundred seventy (170) GE LV5 1.0MW photovoltaic solar inverter generators with a maximum aggregate nameplate capacity of 170.0MW. The three projects are located in Chaves County, New Mexico and share the same Point of Interconnection (POI) at Chaves County 115kV. Each inverter generator will be connected through a 0.55/34.5kV Generator Step Unit transformer to a 34.5kV collector system that feeds a 34.5/115kV substation transformer. This transformer will connect the Customer's 115kV transmission line to the Point of Interconnection (POI). GEN-2014-034 & GEN-2014-035 share a portion of the same 115kV transmission line from the GEN-2014-035 115kV substation to the POI. A one-line drawing for the GEN-2014-033, GEN-2014-034, & GEN-2014-035 generator interconnection requests are shown in Figure II-1.

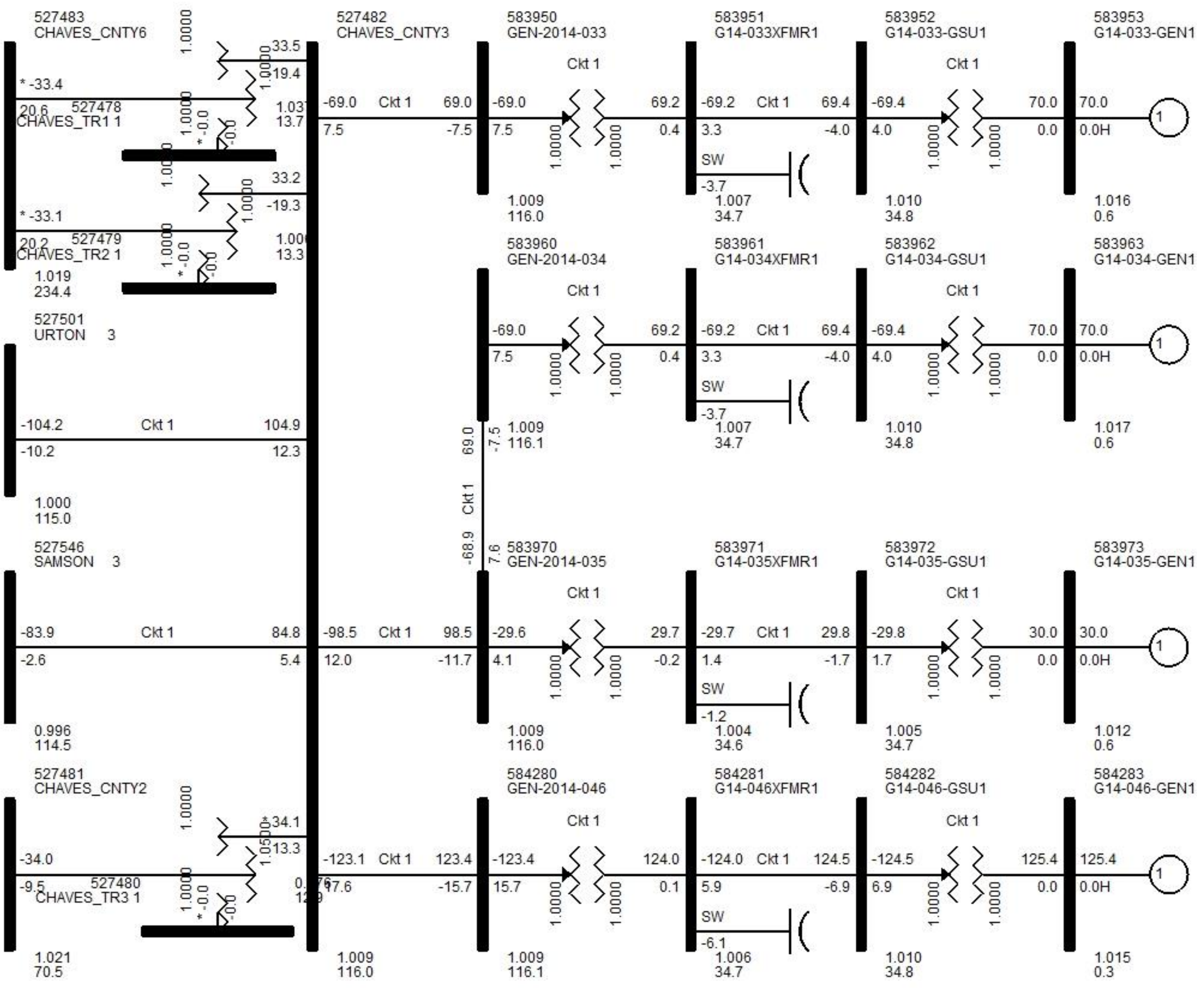

Figure II-1: GEN-2014-033, GEN-2014-034, & GEN-2014-035 One-line Diagram

III. Stability Analysis

Transient stability analysis is used to determine if the transmission system can maintain angular stability and ensure bus voltages stay within planning criteria bandwidth during and after a disturbance while considering the addition of a generator interconnection request.

Model Preparation

Transient stability analysis was performed using a modified version of the 2014 series of Model Development Working Group (MDWG) dynamic study models including the 2015 summer, 2015 winter, and 2025 summer seasonal peak load cases. The cases are then loaded with prior queued interconnection requests and network upgrades assigned to those interconnection requests. Finally the prior queued and study generation are dispatched into the SPP footprint. Initial simulations are then carried out for a no-disturbance run of twenty (20) seconds to verify the numerical stability of the model.

Disturbances

Fifteen (15) contingencies were identified for use in this study and are listed in Table III-1. These contingencies included three-phase faults and single-phase line faults at locations defined by SPP. Single-phase line faults were simulated by applying fault impedance to the positive sequence network at the fault location to represent the effect of the negative and zero sequence networks on the positive sequence network. The fault impedance was computed to give a positive sequence voltage at the specified fault location of approximately 60% of pre-fault voltage. This method is in agreement with SPP current practice.

Except for transformer faults, the typical sequence of events for a three-phase and a single-phase fault is as follows:

1. apply fault at particular location
2. continue fault for five (5) cycles, clear the fault by tripping the faulted facility
3. after an additional twenty (20) cycles, re-close the previous facility back into the fault
4. continue fault for five (5) additional cycles
5. trip the faulted facility and remove the fault

Transformer faults are typically modeled as three-phase faults, unless otherwise noted. The sequence of events for a transformer fault is as follows:

1. apply fault for five (5) cycles
2. clear the fault by tripping the affected transformer facility (unless otherwise noted there will be no re-closing into a transformer fault)

The control areas monitored are 520, 524, 525, 526, 531, 534, and 536.

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
1	FLT01-3PH	3 phase fault on Chaves County 115kV (527482) to Samson 115kV (527546) CKT 1, near Chaves County. a. Apply fault at the Chaves County 115kV bus. b. Clear fault after 5 cycles and trip the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
2	FLT02-3PH	3 phase fault on Chaves County 115kV (527482) to Urton 115kV (527501) CKT 1, near Chaves County. a. Apply fault at the Chaves County 115kV bus. b. Clear fault after 5 cycles and trip the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
3	FLT03-3PH	3 phase fault on the Chaves County 115kV (527482) to Chaves County 230kV (527483) to Chaves County 13.2kV (527478) XFMR CKT 1, near Chaves County 115kV. a. Apply fault at the Chaves County 115kV bus. b. Clear fault after 5 cycles and trip the faulted transformer.
4	FLT04-3PH	3 phase fault on the Eddy North 115kV (527798) to Eddy South 230kV (527800) to Eddy 13.2kV (527797) XFMR CKT 1, near Eddy North 115kV. a. Apply fault at the Eddy North 115kV bus. b. Clear fault after 5 cycles and trip the faulted transformer.
5	FLT05-3PH	3 phase fault on Chaves County 230kV (527483) to San Juan Tap 230kV (524885) CKT 1, near Chaves County. a. Apply fault at the Chaves County 230kV bus. b. Clear fault after 5 cycles and trip the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
6	FLT06-3PH	3 phase fault on Chaves County 230kV (527483) to Eddy North 230kV (527799) CKT 1, near Chaves County. a. Apply fault at the Chaves County 230kV bus. b. Clear fault after 5 cycles and trip the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
7	FLT07-3PH	3 phase fault on the Eddy North 230kV (527799) to Eddy South 115kV (527793) to Eddy 13.2kV (527795) XFMR CKT 2, near Eddy North 230kV. a. Apply fault at the Eddy North 230kV bus. b. Clear fault after 5 cycles and trip the faulted transformer.
8	FLT08-3PH	3 phase fault on the Eddy North 230kV (527799) to Eddy County 345kV (527802) to Eddy 13.2kV (527796) XFMR CKT 1, near Eddy North 230kV. a. Apply fault at the Eddy North 230kV bus. b. Clear fault after 5 cycles and trip the faulted transformer.

Table III-1: Contingencies Evaluated

Cont. No.	Contingency Name	Description
9	FLT09-3PH	3 phase fault on Eddy South 230kV (527800) to Cunningham 230kV (527865) CKT 1, near Eddy South. a. Apply fault at the Eddy South 230kV bus. b. Clear fault after 5 cycles and trip the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
10	FLT10-3PH	3 phase fault on Eddy South 230kV (527800) to 7 Rivers 230kV (528095) CKT 1, near Eddy South. a. Apply fault at the Eddy South 230kV bus. b. Clear fault after 5 cycles and trip the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
11	FLT48-3PH	3 phase fault on G08-022 Tap 345kV (560007) to Eddy County 345kV (527802) CKT 1, near G08-022 Tap. a. Apply fault at the G08-022 Tap 345kV bus. b. Clear fault after 5 cycles and trip the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
12	FLT116-3PH	3 phase fault on the Border (515458) to Woodward (515375) 345kV line circuit 1, near Border. a. Apply fault at the Border 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
13	FLT129-3PH	3 phase fault on the Border (515458) to TUCO Int (525832) 345kV line circuit 1, near Border. a. Apply fault at the Border 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
14	FLT214-3PH	3 phase fault on the TUCO Int (525832) to OKU (511456) 345kV line circuit 1, near TUCO Int. a. Apply fault at the TUCO Int 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
15	FLT215-3PH	3 phase fault on the OKU (511456) to LES (511468) 345kV line circuit 1, near OKU. a. Apply fault at the OKU 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.

Results

The stability analysis for the equipment change was evaluated by SPP Staff in the analysis for the restudy of Group 6 in DISIS-2014-002-4. The results are summarized in Table III-2.

Based on the dynamic results and with all project and network upgrades in service, there were no stability problems found during any of the simulations. No generators tripped or went unstable, and voltages recovered to acceptable levels.

Table III-2: Contingency Results and Summary

Contingency Number and Summary		2015SP	2015WP	2025SP
1	3 phase fault on Chaves County 115kV (527482) to Samson 115kV (527546) CKT 1, near Chaves County.	OK	OK	OK
2	3 phase fault on Chaves County 115kV (527482) to Urton 115kV (527501) CKT 1, near Chaves County.	OK	OK	OK
3	3 phase fault on the Chaves County 115kV (527482) to Chaves County 230kV (527483) to Chaves County 13.2kV (527478) XFMR CKT 1, near Chaves County 115kV.	OK	OK	OK
4	3 phase fault on the Eddy North 115kV (527798) to Eddy South 230kV (527800) to Eddy 13.2kV (527797) XFMR CKT 1, near Eddy North 115kV.	OK	OK	OK
5	3 phase fault on Chaves County 230kV (527483) to San Juan Tap 230kV (524885) CKT 1, near Chaves County.	OK	OK	OK
6	3 phase fault on Chaves County 230kV (527483) to Eddy North 230kV (527799) CKT 1, near Chaves County.	OK	OK	OK
7	3 phase fault on the Eddy North 230kV (527799) to Eddy South 115kV (527793) to Eddy 13.2kV (527795) XFMR CKT 2, near Eddy North 230kV.	OK	OK	OK
8	3 phase fault on the Eddy North 230kV (527799) to Eddy County 345kV (527802) to Eddy 13.2kV (527796) XFMR CKT 1, near Eddy North 230kV.	OK	OK	OK
9	3 phase fault on Eddy South 230kV (527800) to Cunningham 230kV (527865) CKT 1, near Eddy South.	OK	OK	OK
10	3 phase fault on Eddy South 230kV (527800) to 7 Rivers 230kV (528095) CKT 1, near Eddy South.	OK	OK	OK
11	3 phase fault on G08-022 Tap 345kV (560007) to Eddy County 345kV (527802) CKT 1, near G08-022 Tap.	OK	OK	OK
12	3 phase fault on Border 345kV (515458) to Woodward 345kV (515375) CKT 1, near Border.	OK	OK	OK
13	3 phase fault on the Border 345kV (515458) to TUCO Int 345kV (525832) CKT 1, near Border.	OK	OK	OK
14	3 phase fault on the TUCO Int 345kV (525832) to OKU 345kV (511456) CKT 1, near TUCO Int 345kV.	OK	OK	OK
15	3 phase fault on the OKU 345kV (511456) to LES 345kV (511468) CKT 1, near OKU.	OK	OK	OK

FERC LVRT Compliance

FERC Order #661A places specific requirements on wind farms through its Low Voltage Ride Through (LVRT) provisions. For Interconnection Agreements signed after December 31, 2006, wind farms shall stay on line for faults at the POI that draw the voltage down at the POI to 0.0 *pu*.

Contingencies 1, 2, & 3 in Table III-2 simulated the LVRT contingencies. GEN-2014-033, GEN-2014-034, & GEN-2014-035 met the LVRT requirements by staying on-line and the transmission system remained stable.

IV. Conclusion

The SPP GEN-2014-033, GEN-2014-034, & GEN-2014-035 Impact Restudy evaluated the impact of the Customer's requested modification to interconnect the projects shown below.

Table IV-1: Interconnection Requests

Request	Capacity (MW)	Generator Model	Point of Interconnection
GEN-2014-033	70.0	GE PV LV5 1.0MW	Chaves County 115kV (527482)
GEN-2014-034	70.0	GE PV LV5 1.0MW	Chaves County 115kV (527482)
GEN-2014-035	30.0	GE PV LV5 1.0MW	Chaves County 115kV (527482)

With all Base Case Network Upgrades in service and previously assigned Network Upgrades in service, the GEN-2014-033, GEN-2014-034, & GEN-2014-035 projects were found to remain on line, and the transmission system was found to remain stable for all conditions studied.

The GEN-2014-033, GEN-2014-034, & GEN-2014-035 projects are required to maintain a power factor requirement of the pro-forma standard 0.95 leading (absorbing) to 0.95 lagging (supplying) at the Point of Interconnection.

Low Voltage Ride Through (LVRT) analysis showed the study generators did not trip offline due to low voltage when all Network Upgrades are in service.

All generators in the monitored areas remained stable for all of the modeled disturbances.

The analysis indicates that the requested modification by the Interconnection Customer is not considered Material and is acceptable to SPP.

Any changes to the assumptions made in this study, for example, one or more of the previously queued requests withdraw, may require a re-study at the expense of the Customer.

Nothing in this System Impact Study constitutes a request for transmission service or confers upon the Interconnection Customer any right to receive transmission service.

APPENDIX A

PLOTS
(Available upon request)

APPENDIX B

TRANSIENT VOLTAGE DETAILS
(Available upon request)

APPENDIX C

POWER FACTOR ANALYSIS
(Performed in DISIS-2014-002-1)

Access above report via this URL:
http://sppoasis.spp.org/documents/swpp/transmission/studies/files/2014_Generation_Studies/DISIS-2014-002-1_5-27-15_complete.pdf

APPENDIX D

PROJECT MODELS
(Available upon request)

APPENDIX E

TRANSMISSION ONE-LINES
(Available upon request)