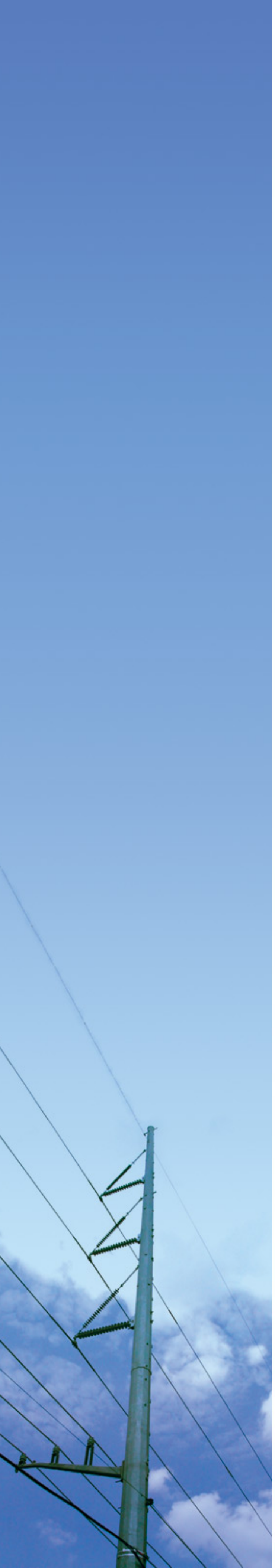

Impact Cluster Study for Generation Interconnection Requests

Southwest Power Pool
Engineering Department
Tariff Studies – Generation Interconnection

(ICS-2008-001-1)
ReStudy #1
January 2010

SPP RESTRICTED

Southwest Power Pool

Executive Summary

As the first stage of the Facility Study for Interconnection Requests being studied under the waiver order in FERC Docket #ER09-262, Southwest Power Pool has conducted this Impact Re-Study for certain generation interconnection requests in the SPP Generation Interconnection Queue to account for interconnection requests that have withdrawn from the interconnection queue since the Impact Cluster Study (ICS-2008-001) was posted on July 1, 2009 and to account for the inclusion of certain transmission projects approved by the SPP Board of Directors as part of the Balanced Portfolio. These interconnection requests have been clustered together for the following Impact Cluster Study. This Impact Cluster Study analyzes the interconnecting of multiple generation interconnection requests associated with new generation totaling 6,322 MW of new generation which would be located within the transmission systems of Mid-Kansas Electric Power LLC (MKEC), Oklahoma Gas and Electric (OKGE), Southwestern Public Service (SPS), Sunflower Electric Power Corporation (SUNC), Westar Energy (WERE) and/or Western Farmers Electric Cooperative (WFEC). The various generation interconnection requests have differing proposed in-service dates[1]. The generation interconnection requests included in this Impact Cluster Study are listed in Appendix A by their queue number, amount, area, requested interconnection point, proposed interconnection point, and the requested in-service date.

Power flow analysis has indicated that for the powerflow cases studied, 6,322 MW of nameplate generation may be interconnected with transmission system reinforcements within the SPP transmission system. Dynamic Stability Analysis has determined the need for reactive compensation in accordance with Order No. 661-A for wind farm interconnection requests and those requirements are listed for each interconnection request within the contents of this report.

Dynamic Stability Analysis has determined that the transmission system will remain stable with the assigned Network Upgrades and Interconnection Facilities to the Impact Cluster Study Generation Interconnection Customers. Q-V analysis determined that additional transmission upgrades were necessary in addition to the upgrades assigned for powerflow analysis. Certain issues will need to be addressed during the Facility Study stage including the following items:

The total estimated minimum cost for interconnecting the studied generation interconnection request is $654,000,000. These costs are shown in Appendix F and G. These costs do not include the Interconnection Customer Interconnection Facilities as defined by the SPP Open Access Transmission Tariff (OATT). This cost does not include additional network constraints in the SPP transmission system that were identified are shown in Appendix I.

Network Constraints listed in Appendix I are in the local area of the new generation when this generation is injected throughout the SPP footprint for the Energy Resource (ER) Interconnection Request. Additional Network constraints will have to be verified with a Transmission Service Request (TSR) and associated studies. With a defined source and sink in a TSR, this list of Network Constraints will be refined and expanded to account for all Network Upgrade requirements.

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[1] The generation interconnection requests in-service dates will need to be deferred based on the required lead time for the Network Upgrades necessary. The Interconnection Customer's that proceed to the Facility Study will be provided a new in-service date based on the completion of the Facility Study.

The required interconnection costs listed in Appendix F and G do not include all costs associated with the deliverability of the energy to final customers. These costs are determined by separate studies if the Customer submits a Transmission Service Request through SPP's Open Access Same Time Information System (OASIS) as required by Attachment Z1 of the SPP OATT.

Based on the SPP Tariff Attachment O, transmission facilities that are part of the SPP Transmission Expansion Plan (STEP) including Sponsored Economic Upgrades or the Balanced Portfolio that may be approved by the SPP Board of Directors will receive notifications to construct. These projects will then be considered construction pending projects and would not be assignable to the Impact Cluster Study Generation Interconnection Requests.

The cost of these facilities is being further refined by the affected Transmission Owners. These facility costs will be presented in the Interconnection Facilities Study to be posted at a later time.

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Introduction

Generation Interconnection Requests in the Southwest Power Pool (SPP) Generation Interconnection Queue have been clustered together for the following Impact Cluster Study. This Impact Cluster Study analyzes multiple generation interconnection requests associated with new generation totaling 6,322 MW which would be located within the transmission systems of Missouri Public Service (MIPU), Mid-Kansas Electric Power LLC (MKEC), Oklahoma Gas and Electric (OKGE), Southwestern Public Service (SPS), Sunflower Electric Power Corporation (SUNC), Westar Energy (WERE) and/or Western Farmers Electric Cooperative (WFEC). The various generation interconnection requests have differing proposed in-service dates. The generation interconnection requests included in this Impact Cluster Study are listed in Appendix A by their queue number, amount, area, requested interconnection point, proposed interconnection point, and the requested in-service date.

The primary objective of this Impact Cluster Study is to identify the system constraints associated with connecting the generation to the area transmission system. The Impact and other subsequent Interconnection Studies are designed to identify attachment facilities, Network Upgrades and other Direct Assignment Facilities needed to accept power into the grid at each specific interconnection receipt point.

Model Development

Interconnection Requests Included in the Cluster

SPP has included the following interconnection requests to be analyzed in this cluster study. The interconnection requests are listed in Appendix A.

All interconnection requests that were included in Impact Cluster Study (ICS-2008-001) posted July 1st, 2009 that later executed a Facility Study Agreement within timeframes given in the FERC Order on July 31st, 2009 and SPP's compliance filing on August 31st, 2009 in Docket #ER09-1254.

Two interconnection requests listed below had executed Facility Study Agreements that were given the option to be studied in the Impact Cluster study and chose to be included Impact Cluster Study (ICS-2008-001) posted July 1, 2009.

- GEN-2006-006
- GEN-2007-008

Previous Queued Projects

The previous queued projects included in this study are listed in Appendix B. In addition to the Base Case Upgrades, the previous queued projects were assumed to be in-service and added to the Base Case models. These projects were dispatched as Energy Resources (ERIS) with equal distribution across the SPP footprint.

Development of Base Cases

Powerflow - The 2009 series Transmission Service Request (TSR) Models 2010 spring and 2014 summer and winter peak scenario 0 peak cases were used for this study. After the 2010 spring and the 2014 summer peak cases were developed, each of the control areas' resources were then re-dispatched using current dispatch orders.

Stability – The 2008 series SPP Model Development Working Group (MDWG) Models 2010 winter and 2010 summer were used for this study.

Base Case Upgrades

The following facilities have been previously assigned or are in construction stages and were assumed to be in-service at the time of dispatch and added to the base case models.

- Woodward – Northwest 345kV line and associated upgrades to be built by OKGE for 2009 in-service[2].
- Hitchland 345/230/115kV upgrades to be built by SPS for 2010/2011 in-service[3].
    - Hitchland – Pringle 230kV line
    - Hitchland – Moore County 230kV line
    - Hitchland – Ochiltree 230kV line
    - Hitchland – Texas County 115kV line
    - Hitchland – Hansford County 115kV line
    - Hitchland – Sherman County Tap 115kV line
- Valliant – Hugo – Sunnyside 345kV – assigned to Aggregate Study AG3-2006 Customers for 2011 in-service
- Wichita – Reno County – Summit 345kV to be built by WERE for 2011 in-service[4].
- Rose Hill – Sooner 345kV to be built by WERE/OKGE for 2010 in-service.
- Finney – Holcomb 345kV Ckt #2 line assigned to GEN-2006-044 interconnection customer for possible 2010 in-service[5].
- Hitchland – Woodward 345kV line assigned to GEN-2006-049 interconnection customer for in service date yet to be determined
- Tuco – Woodward 345kV line approved by the SPP Board of Directors as part of the Balanced Portfolio and issued an NTC in June, 2009
- Spearville – Knoll- Axtell 345kV line approved by the SPP Board of Directors as part of the Balanced Portfolio and issued an NTC in June, 2009

Potential Upgrades Not in the Base Case

Any potential upgrades that do not have a Notification to Construct (NTC) have not been included in the base case. These upgrades include any identified in the SPP Extra-High Voltage (EHV) overlay plan or any other SPP planning study other than the upgrades listed above in the previous section.

[2] Approved based on an order of the Corporation Commission of the State of Oklahoma, Cause No. PUD 200800148 Order No. 55935

[3] Approved 230kV upgrades are based on SPP 2007 STEP. Upgrades may need to be re-evaluated in the system impact study.

[4] Approved based on an order of the Kansas Corporation Commission issued in Docket no. 07-WSEE-715-MIS

[5] Based on Facility Study Posting November 2008

Regional Groupings

The interconnection requests listed in Appendix A were grouped together in eight different regional groups based on geographical and electrical impacts. These groupings are shown in Appendix C.

To determine interconnection impacts, eight different dispatch variations of the spring base case models were developed to accommodate the regional groupings.

Powerflow - For each group, the various wind generating plants were modeled at 80% nameplate of maximum generation. The wind generating plants in the other areas were modeled at 20% nameplate of maximum generation. This process created eight different scenarios with each group being studied at 80% nameplate rating. These projects were dispatched as Energy Resources with equal distribution across the SPP footprint. This method allowed for the identification of network constraints that were common to the regional groupings that could then in turn have the mitigating upgrade cost allocated throughout the entire cluster.

Peaking units were not dispatched in the 2010 spring model. To study peaking units' impacts, the 2014 summer peak model was chosen and peaking units were modeled at 100% of the nameplate rating and wind generating facilities were modeled at 10% of the nameplate rating.

Stability - For each group, all interconnection requests (wind and non-wind) were modeled at 100% nameplate of maximum generation in both winter and summer seasonal models. The wind generation interconnection requests in the other areas were modeled at 20% nameplate of maximum generation while fossil units were modeled at 100% in the other areas. This process created eight different scenarios with each group being studied at 100% nameplate rating. These projects were dispatched as Energy Resources with equal distribution across the SPP footprint.

Identification of Network Constraints

The initial set of network constraints were found by using PTI MUST First Contingency Incremental Transfer Capability (FCITC) analysis on the entire cluster grouping dispatched at the various levels mentioned above. An additional FCITC analysis was conducted for each interconnection request individually at 100% nameplate. These constraints were then screened to determine if any of the generation interconnection requests had at least a 20% Distribution Factor (DF) upon the constraint. Constraints that measured at least a 20% DF from at least one interconnection request were considered for mitigation.

Determination of Cost Allocated Network Upgrades

Cost Allocated Network Upgrades of wind generation interconnection requests were determined using the 2010 spring model. Cost Allocated Network Upgrades of peaking units was determined using the 2014 summer peak model. Once a determination of the required Network Upgrades was made, a powerflow model of the 2010 spring case was developed with all cost allocated Network Upgrades in-service. A MUST FCITC analysis was performed to determine the Power Transfer Distribution Factors (PTDF), defined as a distribution factor with system intact conditions that each generation interconnection request had on each new upgrade. The impact each generation interconnection request had on each upgrade project was weighted by the size of each request. Finally the costs due by each request for a particular project were then determined by allocating the portion of each request's impact over the impact of all affecting requests.

For example, assume that there are three Generation Interconnection requests, X, Y, and Z that are responsible for the costs of Upgrade Project '1'. Given that their respective PTDF for the project have been determined, the cost allocation for Generation Interconnection request 'X' for Upgrade Project 1 is found by the following set of steps and formulas:

- Determine an Impact Factor on a given project for all responsible GI requests:

  Request X Impact Factor on Upgrade Project 1 = PTDF(%)(X) * MW(X) = X1

  Request Y Impact Factor on Upgrade Project 1 = PTDF(%)(Y) * MW(Y) = Y1

  Request Z Impact Factor on Upgrade Project 1 = PTDF(%)(Z) * MW(Z) = Z1

- Determine each request's Allocation of Cost for that particular project:

  $$\text{Request X's Project 1 Cost Allocation (\$)} = \frac{\text{Network Upgrade Project 1 Cost(\$)} * \text{X1}}{\text{X1} + \text{Y1} + \text{Z1}}$$

- Repeat previous for each responsible GI request for each Project

The cost allocation of each needed Network Upgrade is determined by the size of each request and its impact on the given project. This allows for the most efficient and reasonable mechanism for sharing the costs of upgrades.

Credits for Amounts Advanced for Network Upgrades

Interconnection Customer shall be entitled to credits in accordance with Attachment Z1 of the SPP Tariff for any Network Upgrades including any tax gross-up or any other tax-related payments associated with the Network Upgrades, and not refunded to the Interconnection Customer.

Interconnection Facilities

The requirement to interconnect the 6,322 MW of generation into the existing and proposed transmission systems in the affected areas of the SPP transmission footprint consist of the necessary cost allocated shared facilities listed in Appendix G. Interconnection Facilities specific to each generation interconnection request are listed in Appendix F. Appendix G lists the costs by upgrade.

Other Network Constraints in the AEPW, MIDW, OKGE, SPS, SUNC, SWPA, MKEC, WERE, AND WFEC transmission systems that were identified are shown in Appendix I. With a defined source and sink in a TSR, this list of Network Constraints will be refined and expanded to account for all Network Upgrade requirements.

A preliminary one-line drawing for each generation interconnection request are listed in Appendix D. Figure 1 depicts the major transmission line Network Upgrades needed to support the interconnection of the generation amounts requested in this study.

Powerflow

Powerflow Analysis Methodology

The Southwest Power Pool (SPP) Criteria states that:

"The transmission system of the SPP region shall be planned and constructed so that the contingencies as set forth in the Criteria will meet the applicable NERC Reliability Standards for transmission planning. All MDWG power flow models shall be tested to verify compliance with the System Performance Standards from NERC Table 1 – Category A."

The ACCC function of PSS/E was used to simulate single contingencies in portions or all of the modeled control areas of AEPW, EMDE, Grand River Dam Authority (GRDA), Kansas City Power & Light (KCPL), MIDW, MIPU, OKGE, SPS, SUNC, WERE, WFEC and other control areas were applied and the resulting scenarios analyzed. This satisfies the "more probable" contingency testing criteria mandated by NERC and the SPP criteria.

Powerflow Analysis

A powerflow analysis was conducted for each Interconnection Customer's facility using modified versions of the 2010 spring peak and the 2014 summer peak models. The output of the Interconnection Customer's facility was offset in each model by a reduction in output of existing online SPP generation. This method allows the request to be studied as an Energy Resource (ERIS) Interconnection Request. The available seasonal models used were through the 2014 Summer Peak.

This analysis was conducted assuming that previous queued requests in the immediate area of these interconnect requests were in-service. The analysis of the each Customer's project indicates that additional criteria violations will occur on the AEPW, MIDW, OKGE, SPS, SUNC, SWPA, MKEC, WERE, AND WFEC transmission systems under steady state and contingency conditions in the peak seasons.

Cluster Group 1 (Woodward Area)

The Woodward area contained approximately 2,338 MW of new interconnection requests in addition to the 739MW of prior queued interconnection requests   The Woodward – Hitchland 345kV and Woodward-Tuco 345kV lines were added to the model to study this area. West to east flows showed constraints in the area as the proposed Woodward – Northwest 345kV line, and the 138kV line from Woodward to Mooreland. To mitigate these constraints, a 345kV line north to Wichita via Comanche was modeled. In addition, the 138kV line from Woodward to Mooreland was modeled as being reconductored to alleviate constraints that were impacted by the Woodward group.

Cluster Group 2 (Hitchland Area)

The Hitchland area contained 435 MW of interconnection request in addition to the 1,958 MW of previous queued generation interconnection requests. The Hitchland – Woodward 345kV line was added to the models to study this area as it has been assigned to GEN-2006-049 Interconnection Customer. However, as discussed in the stability section, even with the addition of Hitchland-Woodward 345kV, the loss of the Stevens County – Finney 345kV transmission line may cause voltage collapse at the Hitchland 345kV bus. The mitigation for this issue is a new 345kV line identified in the initial Impact Study as a Gray County – Stevens County 345kV line.

Cluster Group 3 (Spearville Area)

The Spearville area contained 1,110 MW of interconnection requests and 660 MW of previous queued interconnection requests. The Spearville–Knoll-Axtell 345kV line was modeled for this area. The major constraints caused by the Spearville area cluster included the Spearville – Mullergren 230kV line, the Circle – Mullergren 230kV line, and the Spearville 345/230kV transformer. To mitigate these constraints, a line to Wichita via Comanche substation was modeled at 345kV. Also, the Spearville 345/230kV autotransformer was shown as overloading due to too much requested generation at the Spearville 230kV bus and a second autotransformer was modeled.

Cluster Group 4 (Mingo/NW Kansas Group)

The Mingo/NW Kansas group had 300 MW in addition to the 715 MW of previously queued generation in the area. This interconnection request also impacted the Spearville – Mullergren 230kV line as well as the Spearville 345/230kV autotransformer. As such, the Spearville – Comanche – Wichita 345kV line was modeled.

Cluster Group 5 (Amarillo Area)
The Amarillo group had 871 MW of interconnection requests in addition to the 1,606 MW of previously queued interconnection requests in this area. The major constraint was the 230kV transmission path from Grapevine – Elk City. A 345kV path from Conway to Wheeler County to Anadarko was needed to alleviate the constraints caused by this group as well as upgrading terminal limits on the existing 230kV transmission system. This line was also needed to alleviate voltage collapse concerns for the Hitchland area requests.

Cluster Group 6 (South Panhandle/New Mexico)
This group had 668 MW of interconnection requests in addition to the 570 MW of previously queued interconnection requests. The Tuco-Woodward 345kV line was modeled for this area. However, this group was still shown to impact overloaded facilities such as the Woodward-Northwest 345kV line and the Grapevine – Elk City 230kV corridor. To alleviate these impacts, the Wheeler County – Anadarko 345kV line was assigned to these interconnection requests.

Cluster Group 7 (Southwestern Oklahoma)
This group had 600 MW of interconnection requests in addition to the 947 MW of previous queued generation in the area. With the reduction of queued generation to the west of this area, no constraints were found in this area with the exception of some local issues.

Cluster Group 8 (South Central Kansas)
GEN-2007-025 had been grouped in the Spearville group in the Facility Study. For the Impact Study, GEN-2007-025 was broken out of Group 3 due to its geographical distance from the Kansas – The GEN-2007-025 Customer initially chose to interconnect to the Wichita – Woodring 345kV line. SPP changed the point of interconnection to the Comanche-Wichita 345kV line as this line routing was closer to the generating facility. Going into the restudy, the Customer again requested to be interconnected to the Wichita-Woodring 345kV line. No constraints were found with this configuration.

Stability Analysis

A stability analysis was conducted for each Interconnection Customer's facility using modified versions of the 2010 winter peak and the 2010 summer peak models. The stability analysis was conducted with all upgrades in service that were identified in the powerflow analysis. For each group, the interconnection requests were studied at 100% nameplate output while the other groups were dispatched at 20% output for wind requests and 100% output for fossil requests. The output of the Interconnection Customer's facility was offset in each model by a reduction in output of existing online SPP generation. The following synopsis is included for each group. The entire stability study for each group can be found in the Appendices.

Cluster Group 1 (Woodward Area)
The Group 1 stability study was conducted by S&C Consulting Services (S&C). It was determined that all interconnection requests in the Woodward area will have a power factor requirement as listed in the study for Group 1 at the point of interconnection in accordance with FERC Order #661A in order to maintain a reliable and stable system. Also, those interconnection requests that were studied with Siemens wind turbines (GEN-2008-003 and GEN-2007-050) may need capacitor banks in addition to

the wind turbine reactive capability due to the reduced capability of the Siemens wind turbines at voltages other than 1.0 per unit. With the power factor requirements and all network upgrades in service, all interconnection request in Group 1 will meet FERC Order #661A low voltage ride through (LVRT) requirements.

Cluster Group 2 (Hitchland Area)

The Group 2 stability study was conducted by Power Technologies Inc (PTI). As discussed earlier, voltage collapse was observed at Hichland for the loss of the Stevens County – Finney 345kV transmission line. A new line was modeled from Stevens County to Gray County Kansas to a point on the Spearville – Holcomb 345kV line.

It was determined that all interconnection requests in the Hitchland area will have a power factor requirement as listed in the study for Group 2 at the point of interconnection in accordance with FERC Order #661A in order to maintain a reliable and stable system.

With the power factor requirements and all network upgrades in service, all interconnection request in Group 2 will meet FERC Order #661A low voltage ride through (LVRT) requirements.

Cluster Group 3 (Spearville Area)

The Group 3 stability study was conducted by Pterra Consulting (Pterra). It was determined that all interconnection requests in the Spearville area will have a power factor requirement as listed in the study for Group 3 at the point of interconnection in accordance with FERC Order #661A.

With the power factor requirements and all network upgrades in service, all interconnection request in Group 3 will meet FERC Order #661A low voltage ride through (LVRT) requirements.

Cluster Group 4 (Mingo Area)

The Group 4 stability study was conducted by ABB Consulting Inc. (ABB). It was determined that all interconnection requests in the Mingo area required to provide varying power factors that depending on the wind turbines used by the requests could results in the need for additional capacitor banks in accordance with FERC Order #661A. During the study, possible instability was observed in NPPD. Closer coordination with NPPD determined NPPD loads were not modeled correctly in the SPP stability model. Those loads were corrected and the faults were run again without reclosing on the transmission line. The results were a stable system

With the power factor requirements and all network upgrades in service, all interconnection request in Group 4 will meet FERC Order #661A low voltage ride through (LVRT) requirements.

Cluster Group 5 (Amarillo Area)

The Group 5 stability study was conducted by Excel Engineering Inc. (Excel) The Amarillo area stability analysis determined that prolonged oscillations of Suzlon S88 wind turbines were prevalent in this area. However, the system was stable and the oscillations died out within 20-30 seconds. It was determined that all interconnection requests in the Amarillo area are required to provide 95% leading/lagging power factor at the point of interconnection in accordance with FERC Order #661A.

With the power factor requirements and all network upgrades in service, all interconnection request in Group 5 will meet FERC Order #661A low voltage ride through (LVRT) requirements.

Cluster Group 6 (South Panhandle Area)

The Group 6 stability study was conducted by Power Technologies Inc. (PTI). It was determined that all interconnection requests in the New Mexico / south panhandle area are required to provide 95% leading/lagging power factor at the point of interconnection in accordance with FERC Order #661A.

With the power factor requirements and all network upgrades in service, all interconnection request in Group 6 will meet FERC Order #661A low voltage ride through (LVRT) requirements.

Cluster Group 7 (Southwest Oklahoma)

The Group 7 stability analysis was conducted by Excel Engineering. The Southwest Oklahoma stability analysis revealed no stability issues with the study requests. It was determined that all interconnection requests in the southwest Oklahoma area will have power factor requirements as denoted in the study.

With the power factor requirements and all network upgrades in service, all interconnection request in Group 7 will meet FERC Order #661A low voltage ride through (LVRT) requirements.

Cluster Group 8 (South Central Kansas)

The Group 8 stability analysis was conducted by Pterra Consulting (Pterra). The GEN-2007-025 stability analysis revealed no stability issues with the study requests. It was determined that GEN-2007-025 will need to meet a +/-95% power factor at the point of interconnection. With the power factor requirements and all network upgrades in service, GEN-2007-025 will meet FERC Order #661A low voltage ride through (LVRT) requirements.

Regional Map with Proposed Upgrades

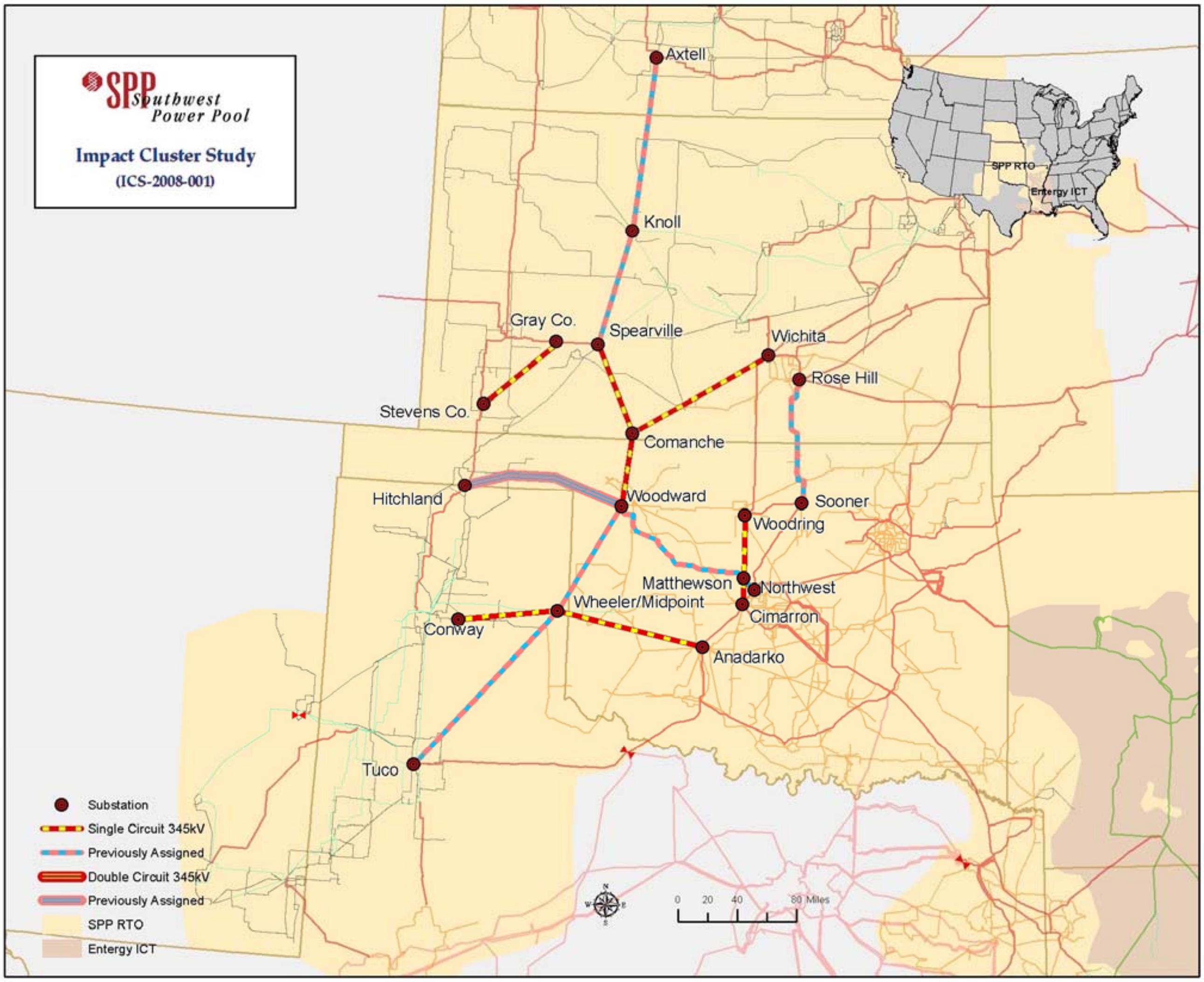


Figure 1 - Proposed Major Line Upgrades

Conclusion

The minimum cost of interconnecting all of the interconnection requests included in this Impact Cluster Study is estimated at $654,000,000 for the Allocated Network Upgrades and Transmission Owner Interconnection Facilities are listed in Appendix E and F. These costs do not include the cost of upgrades of other transmission facilities listed in Appendix I which are Network Constraints.

These interconnection costs do not include any cost of Network Upgrades determined to be required by short circuit analysis. These studies are being performed as part of the Interconnection System Facility Study that each customer has already executed.

The required interconnection costs listed in Appendices E, and F, and other upgrades associated with Network Constraints do not include all costs associated with the deliverability of the energy to final customers. These costs are determined by separate studies if the Customer submits a Transmission Service Request (TSR) through SPP's Open Access Same Time Information System (OASIS) as required by Attachment Z1 of the SPP Open Access Transmission Tariff (OATT).

Appendix

A: Generation Interconnection Requests Considered for Impact Study

Request	Amount	Area	Requested Point of Interconnection	Proposed Point of Interconnection	Requested In-Service Date
GEN-2006-006	205	MKEC	Spearville 230kV	Spearville 230kV	12/31/2010
GEN-2007-005	200	SPS	Pringle 115kV	Pringle 115kV	12/1/2008
GEN-2007-008	300	SPS	Grapevine 230kV	Grapevine 230kV	12/1/2009
GEN-2007-021	201	OKGE	Dewey 138kV	*Tatonga 345kV	8/1/2009
GEN-2007-025	300	WERE	Wichita – Woodring 345kV	* Wichita – Woodring 345kV	10/1/2009
GEN-2007-032	150	WFEC	Clinton Junction - Clinton 138kV	Clinton Junction - Clinton 138kV	12/31/2010
GEN-2007-034	150	SPS	Tolk - Eddy County 345kV	Tolk - Eddy County 345kV	8/15/2010
GEN-2007-038	200	SUNC	Spearville 345kV	Spearville 345kV	12/31/2012
GEN-2007-043	300	AEPW	Lawton Eastside - Cimarron 345kV	Lawton Eastside - Cimarron 345kV	12/1/2009
GEN-2007-044	300	OKGE	Roman Nose 138kV	*Tatonga 345kV	12/1/2009
GEN-2007-045	171	SPS	Conway 115kV	Conway 115kV	12/31/2011
GEN-2007-046	200	SPS	Texas County - *Hitchland 115kV	*Hitchland 115kV	12/31/2011
GEN-2007-048	400	SPS	Amarillo South - Swisher County 230kV	Amarillo South - Swisher County 230kV	11/1/2009
GEN-2007-050	171	OKGE	Woodward 138kV	Woodward EHV 138kV	10/1/2009
GEN-2007-051	200	WFEC	Mooreland 138kV	Mooreland 138kV	11/7/2007
GEN-2007-052	150	WFEC	Anadarko 138kV	Anadarko 138kV	5/1/2008
GEN-2007-057	35	SPS	Valero 115kV	Moore County East 115kV	5/1/2009
GEN-2007-062	765	OKGE	*Woodward 345kV	*Woodward 345kV	12/31/2011
GEN-2008-003	101	OKGE	Woodward 138kV	*Woodward EHV 138kV	8/31/2009
GEN-2008-008	60	SPS	Graham 69kV	Graham 69kV	12/31/2010
GEN-2008-009	60	SPS	San Juan Mesa 230kV	San Juan Mesa 230kV	3/1/2012
GEN-2008-013	300	OKGE	Wichita – Woodring 345kV	Wichita - Woodring 345kV	10/1/2010
GEN-2008-014	150	SPS	TUCO - Oklaunion 345kV	TUCO - Oklaunion 345kV	12/1/2010
GEN-2008-016	248	SPS	Grassland 230kV	Grassland 230kV	12/1/2009
GEN-2008-017	300	SUNC	Setab 345kV	Setab 345kV	3/1/2012
GEN-2008-018	405	SUNC	Holcomb - Spearville 345kV	Finney 345kV	12/31/2012
GEN-2008-019	300	OKGE	Dewey 138kV	*Tatonga 345kV	12/31/2012
GROUPED TOTAL	**6,322**				

***** Planned Facility
^ Proposed Facility
******* Electrically Remote Interconnection Requests

B: Prior Queued Interconnection Requests

Request	Amount	Area	Requested/Proposed Point of Interconnection	Status or In-Service Date
GEN-2001-014	96	WFEC	Fort Supply 138kV	On-Line
GEN-2001-026	74	WFEC	Washita 138kV	On-Line
GEN-2001-033	180	SPS	San Juan Mesa Tap 230kV	On-Line
GEN-2001-036	80	SPS	Caprock Tap 115kV	On-Line
GEN-2001-037	103	OKGE	Windfarm Switching 138kV	On-Line
GEN-2001-039A	105	MKEC	Greensburg - Judson-Large 115kV	On Schedule for 2011
GEN-2001-039M	100	SUNC	Leoti – City Services 115kV	On-Line
GEN-2002-005	120	WFEC	Morewood - Elk City 138kV	On-Line
GEN-2002-006	150	SPS	Texas County 115kV	IA Executed/On Schedule 12/31/2010
GEN-2002-008	240	SPS	*****Hitchland 345kV	On-Line at 120MW
GEN-2002-009	80	SPS	Hansford County 115kV	On-Line
GEN-2002-022	240	SPS	Bushland 230kV	On-Line at 160MW
GEN-2002-025A	150	MKEC	Spearville 230kV	On-Line at 100MW
GEN-2003-004	100	WFEC	Washita 138kV	On-Line
GEN-2003-005	100	WFEC	Anadarko - Paradise 138kV	On Line
GEN-2003-013**	198	SPS	*****Hitchland - Finney 345kV	On Schedule for 2012
GEN-2003-020	160	SPS	Carson County 115kV	On-Line at 80MW
GEN-2003-022	120	AEPW	Washita 138kV	On-Line
GEN-2004-003	240	SPS	Conway 115kV	On Suspension
GEN-2004-014	155	MKEC	Spearville 230kV	On Schedule for 2011
GEN-2004-020	27	AEPW	Washita 138kV	On-Line
GEN-2004-023	21	WFEC	Washita 138kV	On-Line
GEN-2005-003	31	WFEC	Washita 138kV	On-Line
GEN-2005-008	120	OKGE	Woodward 138kV	On-Line
GEN-2005-010	160	SPS	Roosevelt County - Tolk West 230kV (Single Ckt Tap)	On Suspension
GEN-2005-012	250	SUNC	Spearville 345kV	IA Executed/On Schedule 10/1/2011
GEN-2005-015	150	SPS	Tuco - Oklaunion 345kV	On Suspension
GEN-2005-017	340	SPS	*****Hitchland - Potter County 345kV	On Suspension
GEN-2005-021	86	SPS	Kirby 115kV	On Suspension
GEN-2006-002	150	AEPW	Grapevine - Elk City 230kV	On Suspension
GEN-2006-020	20	SPS	*****Hitchland - Sherman County Tap	IA Executed/On Schedule 12/31/2009
GEN-2006-032	200	MIDW	South Hays 230kV	On Schedule for 2012
GEN-2006-034	81	SUNC	Kanarado - Sharon Springs 115kV	On Suspension
GEN-2006-035	225	AEPW	Grapevine - Elk City 230kV	On Suspension
GEN-2006-039	400	SPS	Tap and Tie both Potter County - Plant X 230kV and Bushland - Deaf Smith 230kV	On Suspension
GEN-2006-040	100	SUNC	Mingo 115kV	On Suspension
GEN-2006-043	99	AEPW	Grapevine - Elk City 230kV	On schedule for 2009
GEN-2006-044	370	SPS	*****Hitchland 345kV	On Suspension
GEN-2006-045	240	SPS	Tap and Tie both Potter County - Plant X 230kV and Bushland - Deaf Smith 230kV	On Suspension
GEN-2006-046	130	OKGE	Dewey 138kV	On Schedule for 2010
GEN-2006-047	240	SPS	Tap and Tie both Potter County - Plant X 230kV and Bushland - Deaf Smith 230kV	On Schedule for 2013
GEN-2006-049	400	SPS	*****Hitchland - Finney 345kV	IA Pending
GEN-2007-002	160	SPS	Grapevine 115kV	10/1/2011

Request	Amount	Area	Requested/Proposed Point of Interconnection	Status or In-Service Date
GEN-2007-006	160	OKGE	Roman Nose 138kV	On Suspension
GEN-2007-011	135	SUNC	Syracuse 115kV	On Schedule
GEN-2007-013	99	SUNC	Selkirk 115kV	IA Pending
GROUPED TOTAL	**7,185**			

***** Planned Facility

C: Study Groupings

Cluster	Request	Amount	Area	Proposed Point of Interconnection
Prior Queued	GEN-2001-014	96	WFEC	Fort Supply 138kV
	GEN-2001-037	103	OKGE	Windfarm Switching 138kV
	GEN-2002-005	120	WFEC	Morewood - Elk City 138kV
	GEN-2005-008	130	OKGE	Woodward 138kV
	GEN-2006-046	130	OKGE	Dewey 138kV
	GEN-2007-006	160	OKGE	Roman Nose 138kV
	PRIOR QUEUED SUBTOTAL	**739**		
Cluster	**Request**	**Amount**	**Area**	**Proposed Point of Interconnection**
Woodward	GEN-2007-021	201	OKGE	*Tatonga 345kV
	GEN-2007-044	300	OKGE	*Tatonga 345kV
	GEN-2007-050	200	OKGE	*Woodward 138kV
	GEN-2007-051	171	WFEC	Mooreland 138kV
	GEN-2007-062	765	OKGE	*Woodward 345kV
	GEN-2008-003	101	OKGE	*Woodward EHV 138kV
	GEN-2008-013	300	OKGE	Wichita - Woodring 345kV
	GEN-2008-019	300	OKGE	*Tatonga 345kV
	WOODWARD SUBTOTAL	**2,338**		
	AREA SUBTOTAL	**3,077**		

Cluster	Request	Amount	Area	Proposed Point of Interconnection
Prior Queued	GEN-2002-006	150	SPS	Texas County 115kV
	GEN-2002-008	240	SPS	*Hitchland 345kV
	GEN-2002-009	80	SPS	Hansford County 115kV
	GEN-2003-013	198	SPS	*Hitchland - Finney 345kV
	GEN-2003-020	160	SPS	Carson County 115kV
	GEN-2005-017	340	SPS	*Hitchland - Potter County 345kV
	GEN-2006-020	20	SPS	*Hitchland - Sherman County Tap
	GEN-2006-044	370	SPS	*Hitchland 345kV
	GEN-2006-049	400	SPS	*Hitchland - Finney 345kV
	PRIOR QUEUED SUBTOTAL	**1,958**		
Cluster	**Request**	**Amount**	**Area**	**Proposed Point of Interconnection**
Hitchland	GEN-2007-005	200	SPS	Pringle 115kV
	GEN-2007-046	200	SPS	*Hitchland 115kV
	GEN-2007-057	35	SPS	Moore County East 115kV
	HITCHLAND SUBTOTAL	**435**		
	AREA SUBTOTAL	**2,393**		

Cluster	Request	Amount	Area	Proposed Point of Interconnection
Prior Queued	GEN-2001-039A	105	MKEC	Greensburg - Judson-Large 115kV
	GEN-2002-025A	150	MKEC	Spearville 230kV
	GEN-2004-014	155	MKEC	Spearville 230kV
	GEN-2005-012	250	SUNC	Spearville 345kV
	PRIOR QUEUED SUBTOTAL	**660**		
Cluster	**Request**	**Amount**	**Area**	**Proposed Point of Interconnection**
Spearville	GEN-2006-006	205	MKEC	Spearville 230kV
	GEN-2007-025	300	WERE	Wichita-Woodring 345kV
	GEN-2007-038	200	SUNC	Spearville 345kV
	GEN-2008-018	405	SUNC	Finney 345kV
	SPEARVILLE SUBTOTAL	**1110**		
	AREA SUBTOTAL	**1,770**		

Cluster	Request	Amount	Area	Proposed Point of Interconnection
Prior Queued	GEN-2001-039M	100	SUNC	Leoti - City Services 115kV
	GEN-2006-032	200	MIDW	South Hays 230kV
	GEN-2006-034	81	SUNC	Kanarado - Sharon Springs 115kV
	GEN-2006-040	100	SUNC	Mingo 115kV
	GEN-2007-011	135	SUNC	Syracuse 115kV
	GEN-2007-013	99	SUNC	Selkirk 115kV
	PRIOR QUEUED SUBTOTAL	**715**		
Cluster	**Request**	**Amount**	**Area**	**Proposed Point of Interconnection**
	GEN-2008-017	300	SUNC	Setab 345kV
	MINGO/NW KANSAS SUBTOTAL	**300**		
	AREA SUBTOTAL	**1,015**		

Cluster	Request	Amount	Area	Proposed Point of Interconnection
Prior Queued	GEN-2002-022	240	SPS	Bushland 230kV
	GEN-2004-003	240	SPS	Conway 115kV
	GEN-2005-021	86	SPS	Kirby 115kV
	GEN-2006-039	400	SPS	Tap and Tie both Potter County - Plant X 230kV and Bushland - Deaf Smith 230kV
	GEN-2006-045	240	SPS	Dewey 138kV
	GEN-2006-047	240	SPS	Tap and Tie both Potter County - Plant X 230kV and Bushland - Deaf Smith 230kV
	GEN-2007-002	160	SPS	Grapevine 115kV
	PRIOR QUEUED SUBTOTAL	**1,606**		
Cluster	**Request**	**Amount**	**Area**	**Proposed Point of Interconnection**
Amarillo	GEN-2007-008	300	SPS	^Grapevine 345kV
	GEN-2007-045	171	SPS	^Grapevine 345kV
	GEN-2007-048	400	SPS	Amarillo South - Swisher County 230kV
	AMARILLO SUBTOTAL	**871**		
	AREA SUBTOTAL	**2,477**		

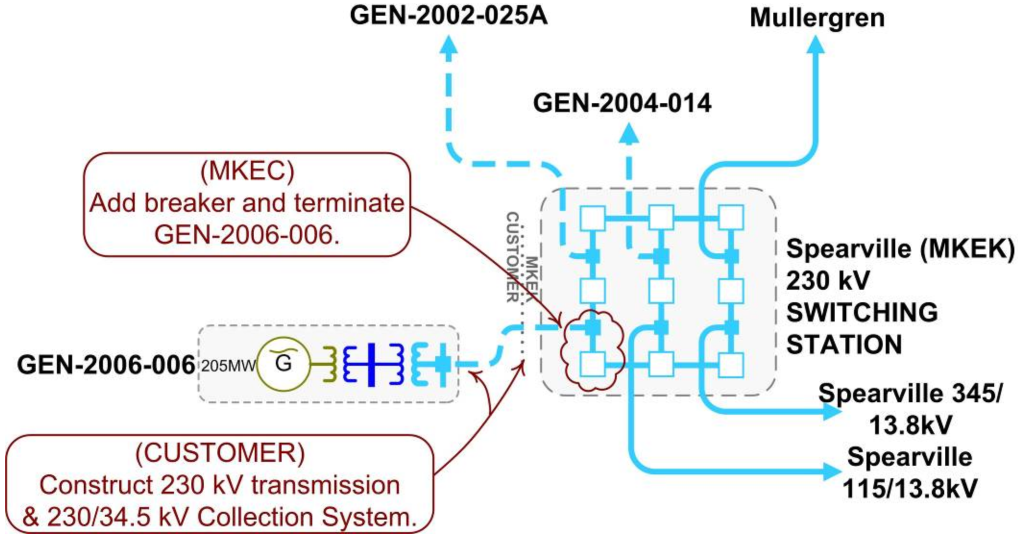
Cluster	Request	Amount	Area	Proposed Point of Interconnection
Prior Queued	GEN-2001-033	180	SPS	San Juan Mesa Tap 230kV
	GEN-2001-036	80	SPS	Caprock Tap 115kV
	GEN-2005-010	160	SPS	Roosevelt County - Tolk West 230kV (Single Ckt Tap)
	GEN-2005-015	150	SPS	TUCO - Oklaunion 345kV
	PRIOR QUEUED SUBTOTAL	**570**		
Cluster	**Request**	**Amount**	**Area**	**Proposed Point of Interconnection**
	GEN-2007-034	150	SPS	Tolk - Eddy County 345kV
	GEN-2008-008	60	SPS	Graham 115kV
	GEN-2008-009	60	SPS	San Juan Mesa 230kV
	GEN-2008-014	150	SPS	TUCO - Oklaunion 345kV
	GEN-2008-016	248	SPS	Grassland 230kV
	SOUTH PANHANDLE/NM SUBTOTAL	**668**		
	AREA SUBTOTAL	**1,238**		

Cluster	Request	Amount	Area	Proposed Point of Interconnection
Prior Queued	GEN-2001-026	74	WFEC	Fort Supply 138kV
	GEN-2003-004	101	WFEC	Washita 138kV
	GEN-2003-005	100	WFEC	Anadarko - Paradise 138kV
	GEN-2003-022	120	AEPW	Washita 138kV
	GEN-2004-020	27	AEPW	Washita 138kV
	GEN-2004-023	21	WFEC	Washita 138kV
	GEN-2005-003	31	WFEC	Washita 138kV
	GEN-2006-002	150	AEPW	Grapevine - Elk City 230kV
	GEN-2006-035	225	AEPW	Grapevine - Elk City 230kV
	GEN-2006-043	99	AEPW	Grapevine - Elk City 230kV
	PRIOR QUEUED SUBTOTAL	**948**		
Cluster	**Request**	**Amount**	**Area**	**Proposed Point of Interconnection**
SW Oklahom a	GEN-2007-032	150	WFEC	Clinton Junction - Clinton 138kV
	GEN-2007-043	300	AEPW	Lawton Eastside - Cimarron 345kV
	GEN-2007-052	150	WFEC	Anadarko 138kV
	SW OKLAHOMA SUBTOTAL	**600**		
	AREA SUBTOTAL	**1,548**		
	*****CLUSTERED TOTAL (w/o PRIOR QUEUED)**	**6.322**		
	*****CLUSTERED TOTAL (w/PRIOR QUEUED)**	**13,518**		

***** Planned Facility
^ Proposed Facility
****** Alternate requests - counted as one request for study purpose
*** Electrically Remote Interconnection Requests included in total

D: Proposed Point of Interconnection One line Diagrams

GEN-2006-006



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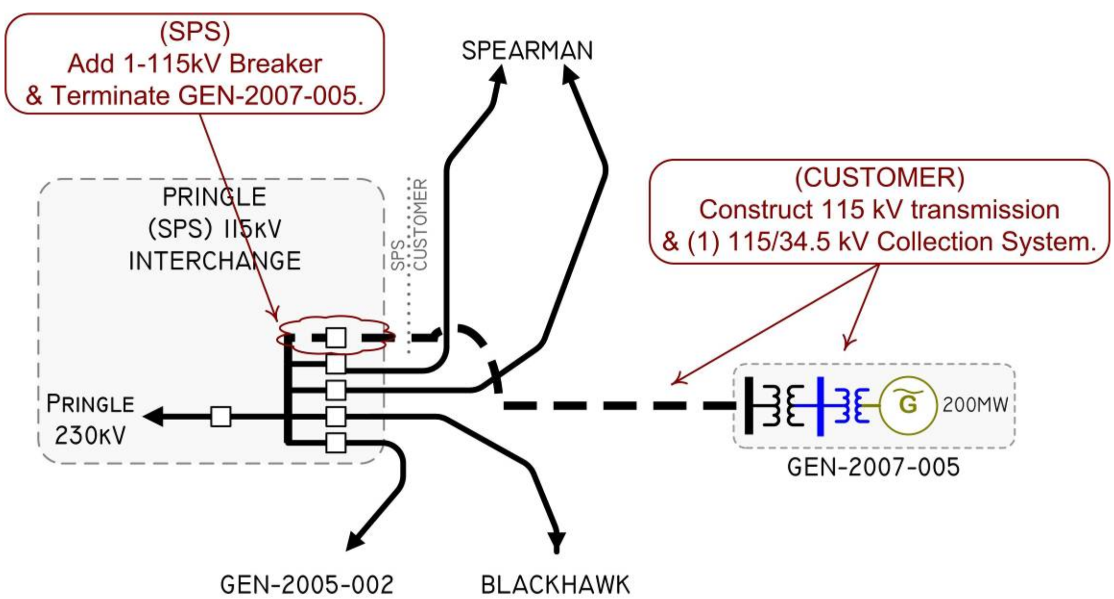
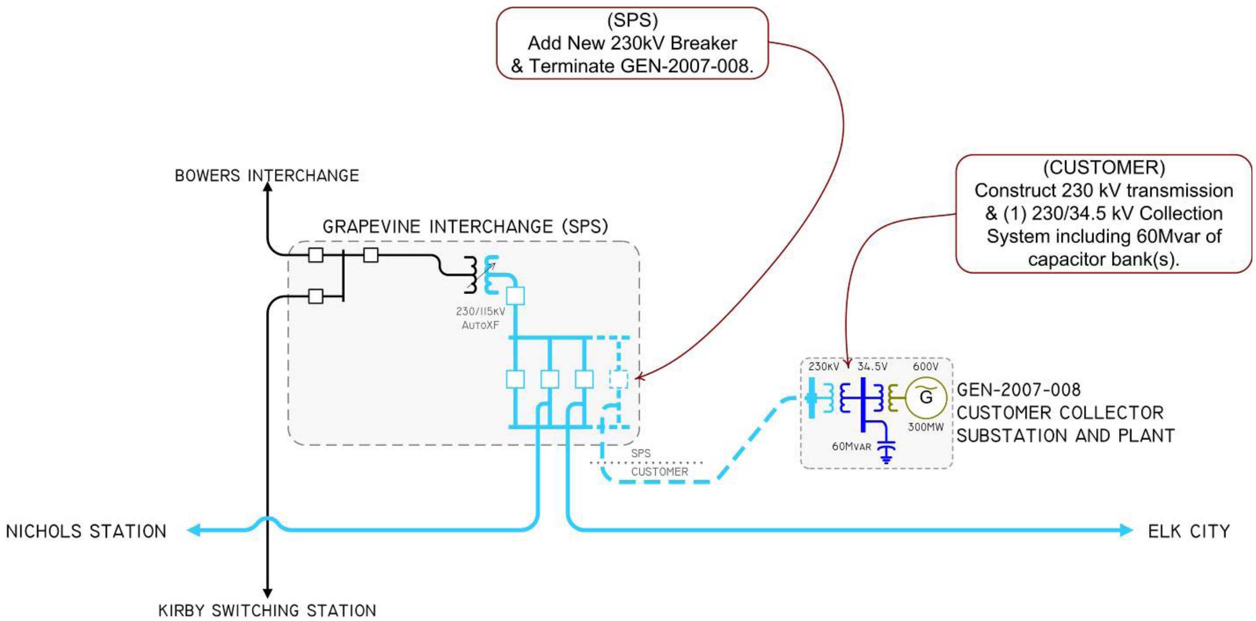
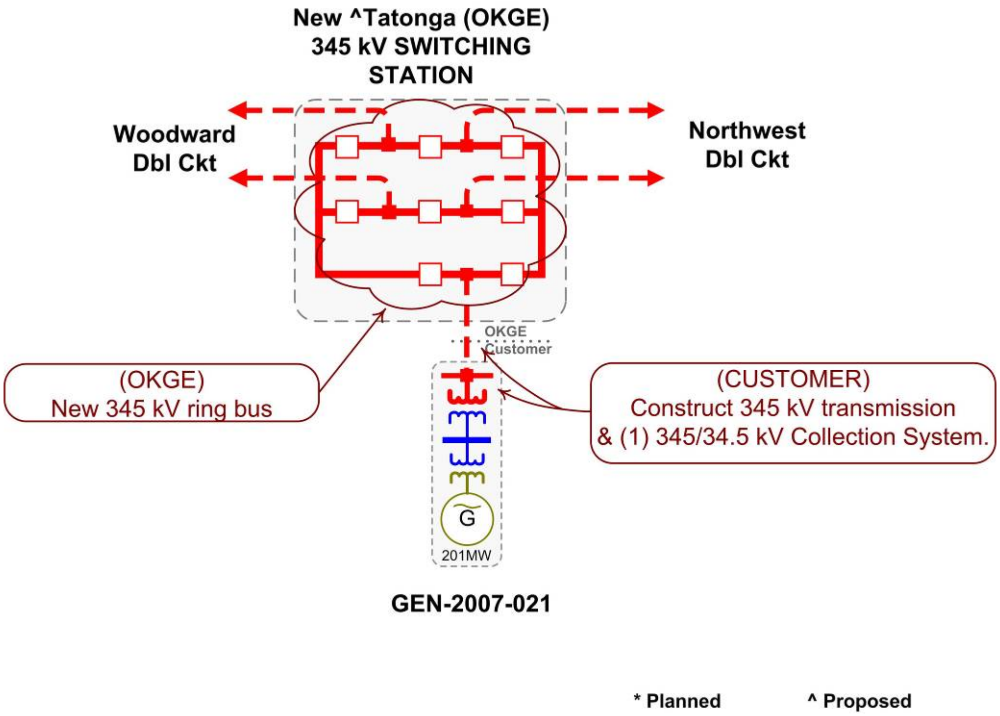


GEN-2007-008



GEN-2007-021



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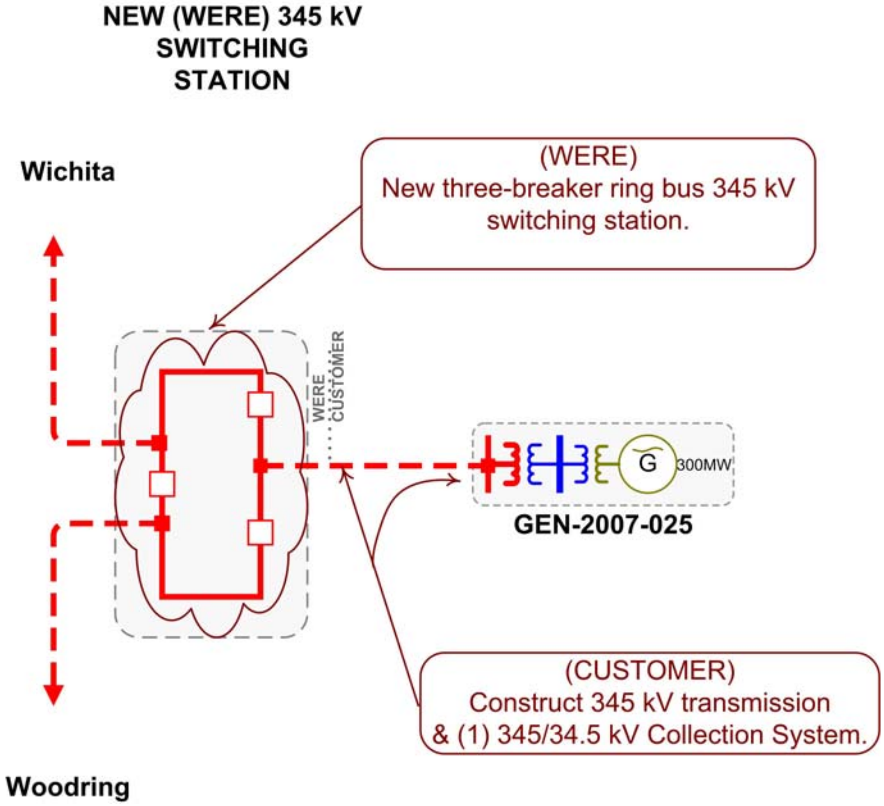

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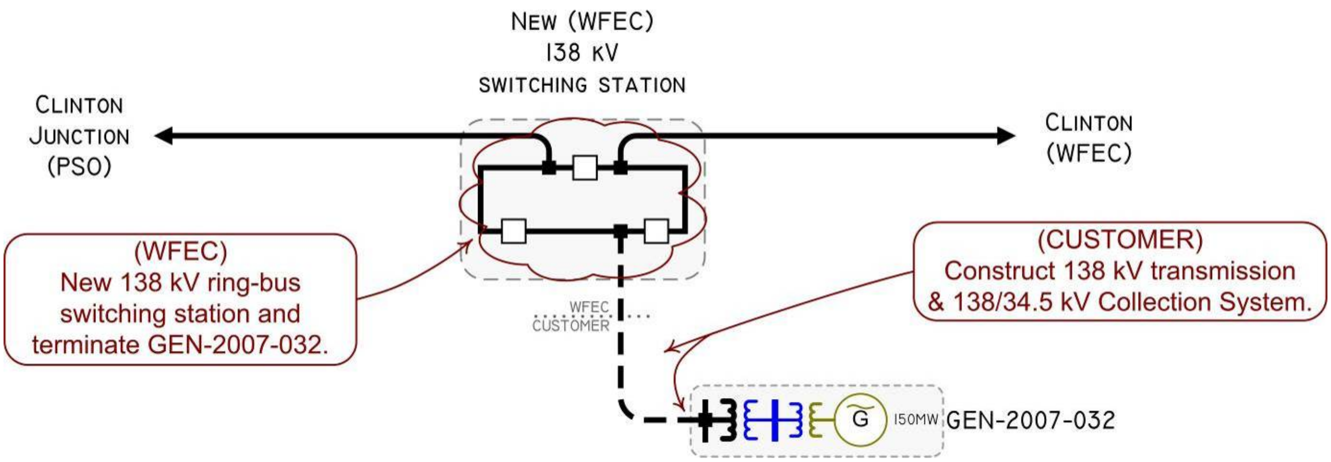
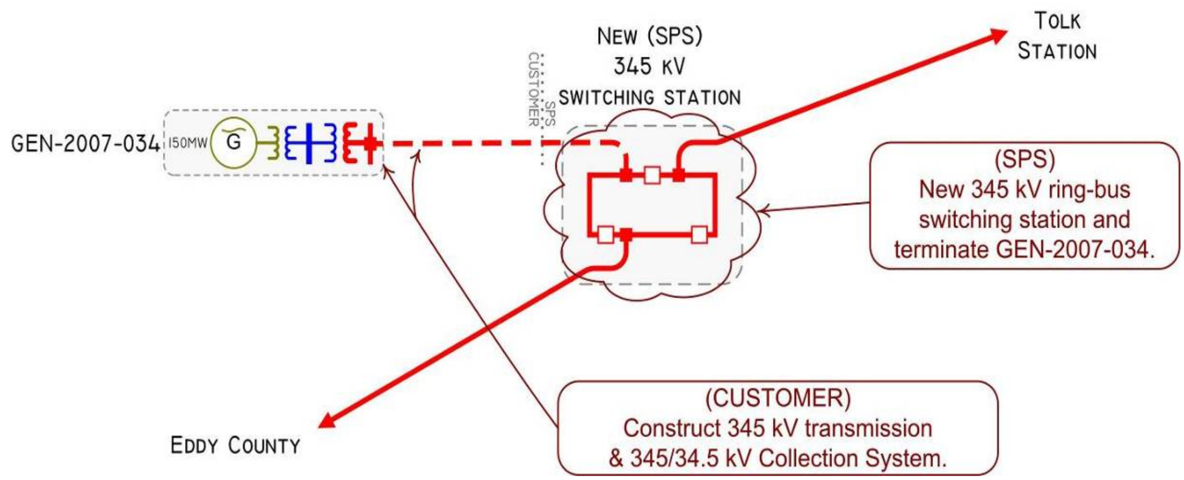


GEN-2007-034



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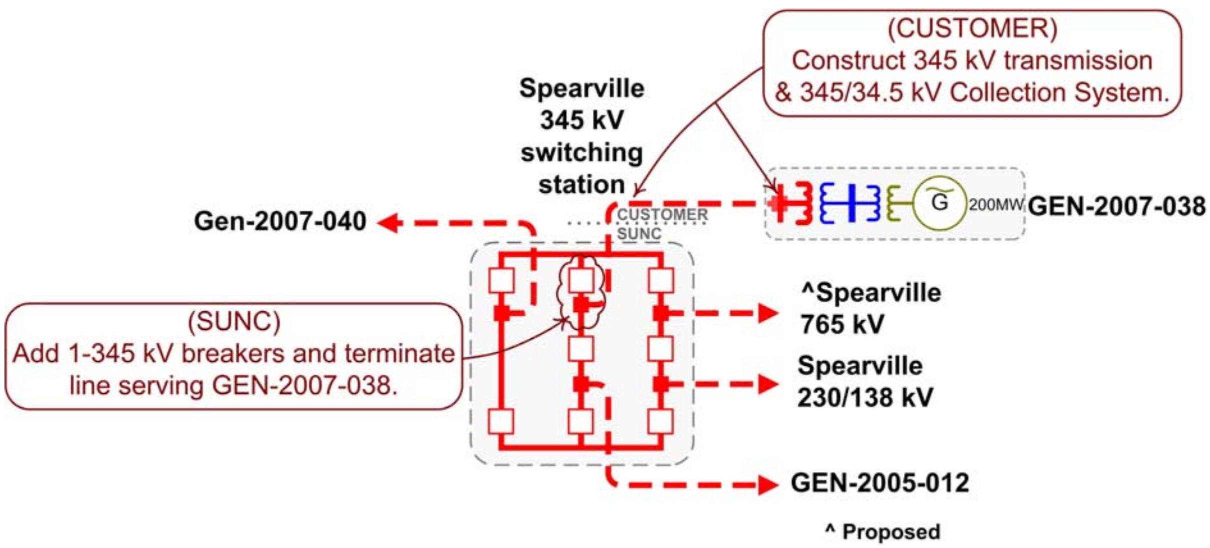
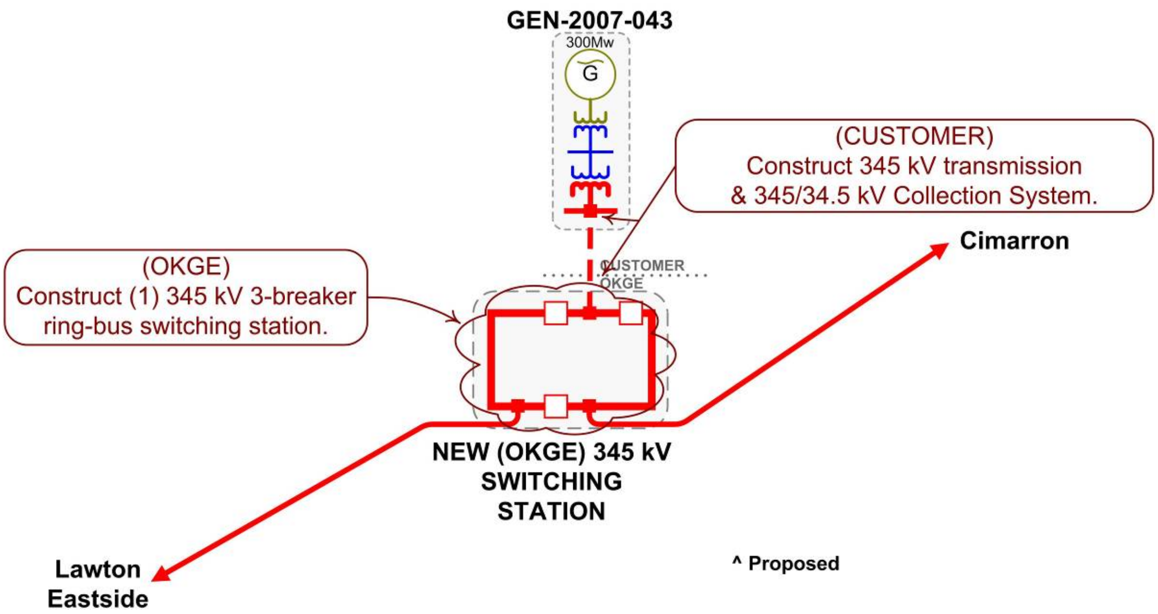


GEN-2007-043



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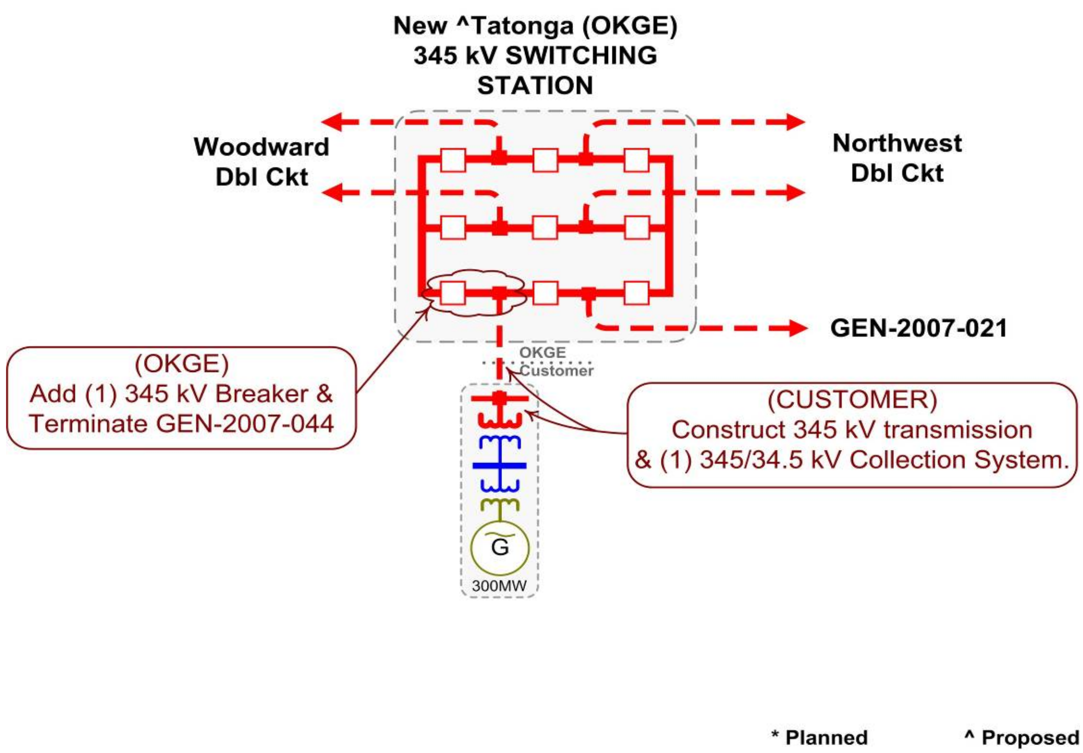
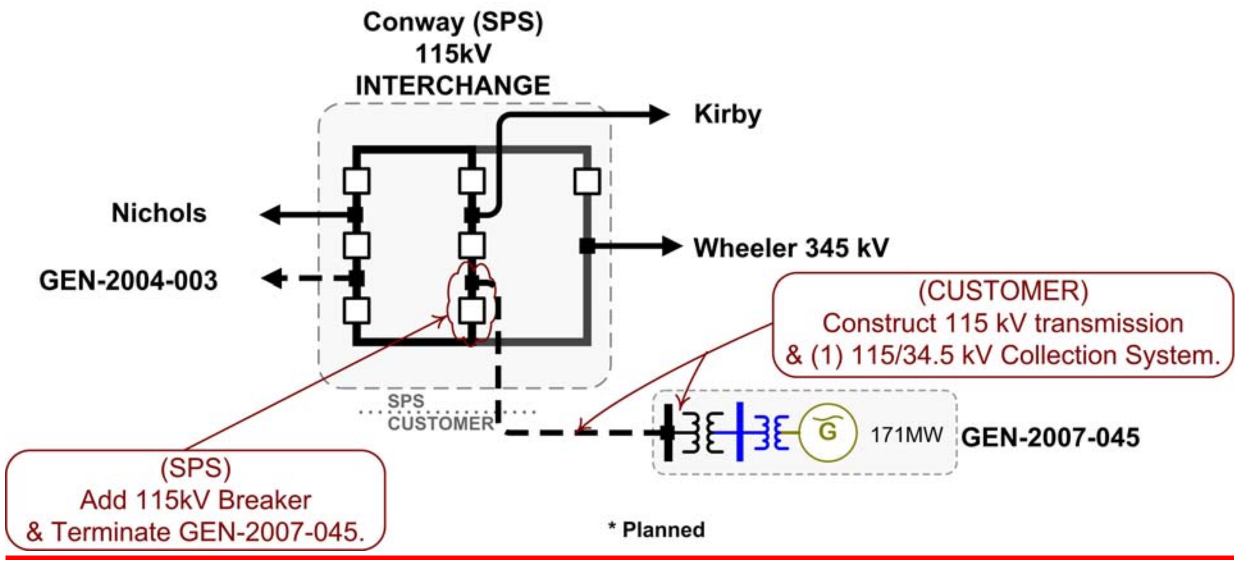


GEN-2007-045



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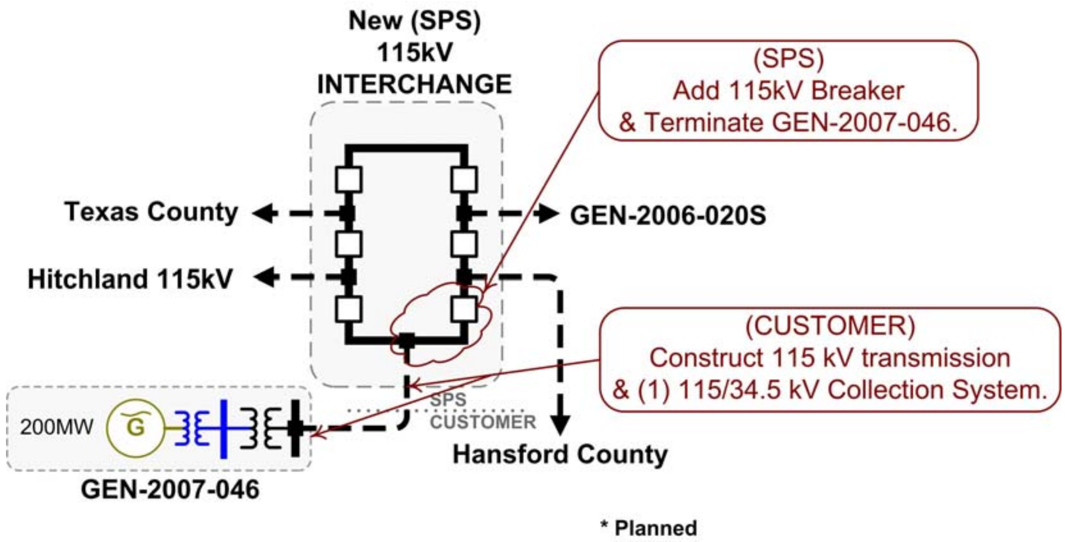

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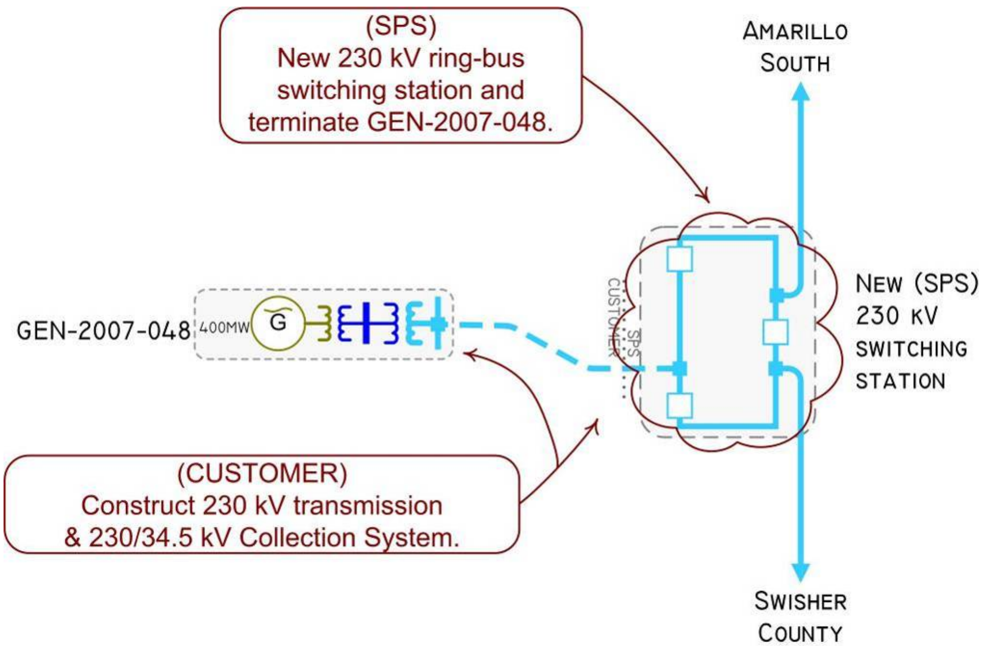
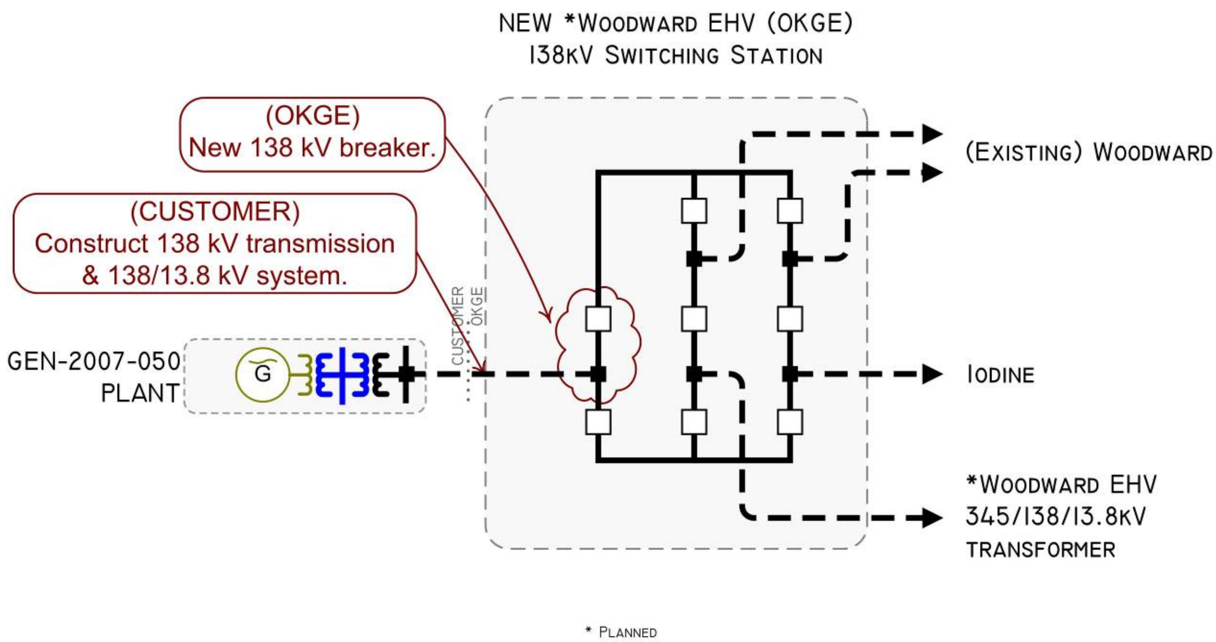
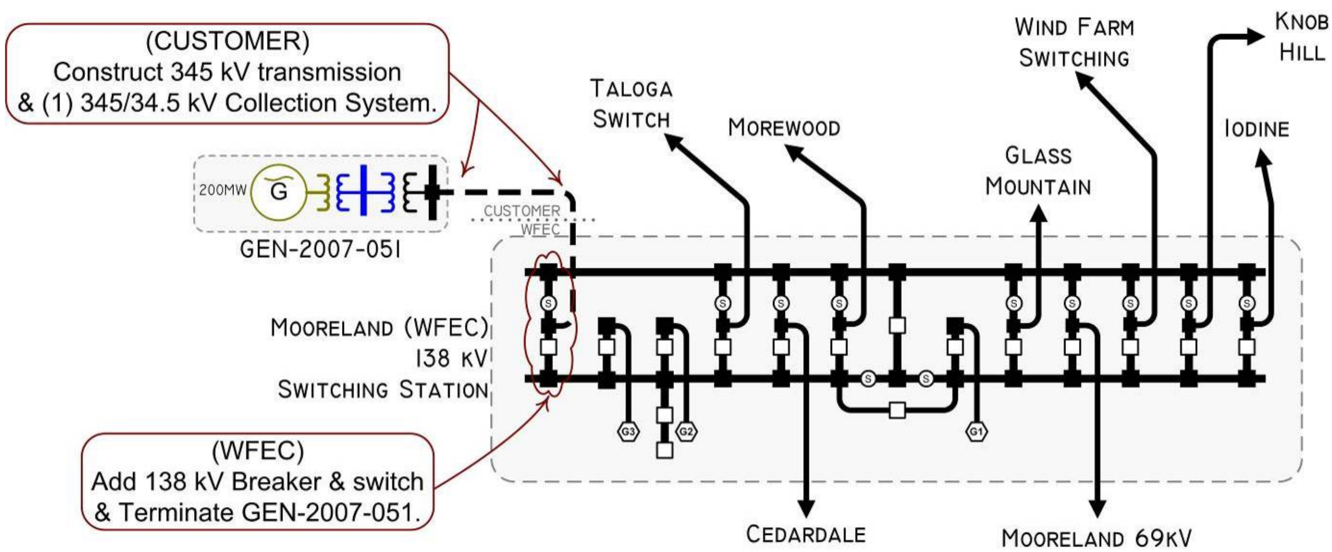


GEN-2007-050



GEN-2007-051



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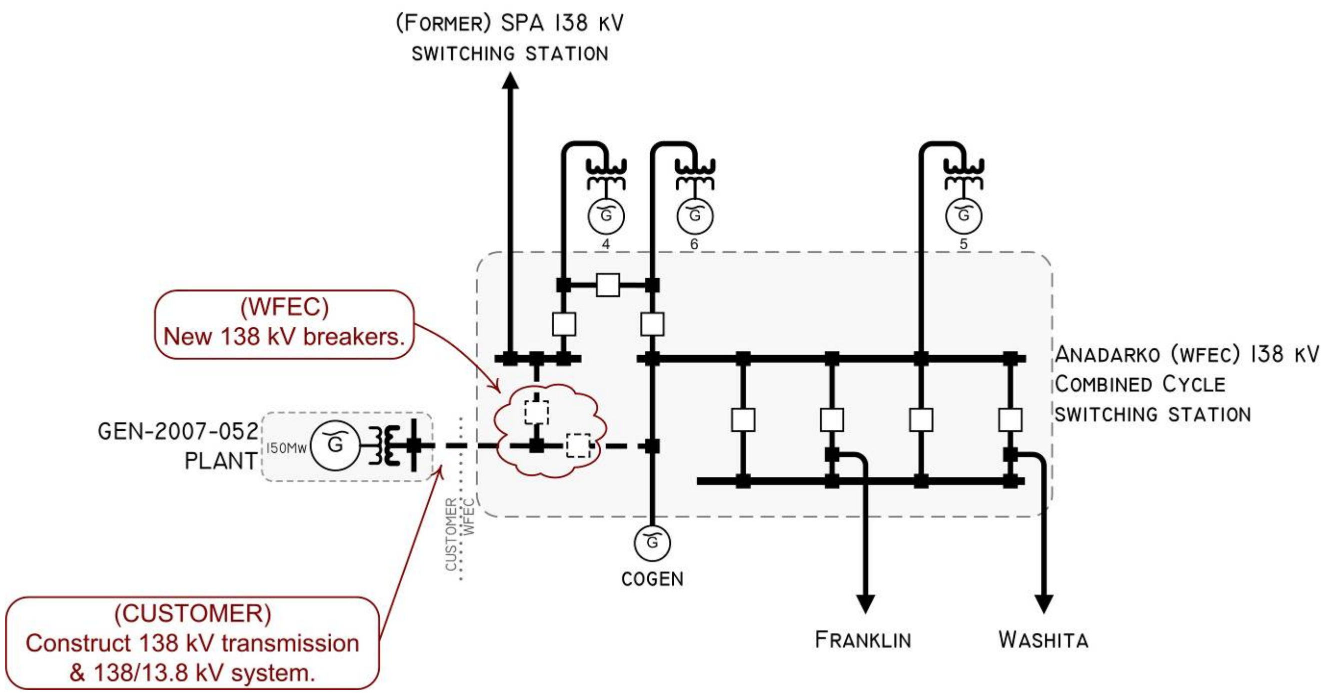
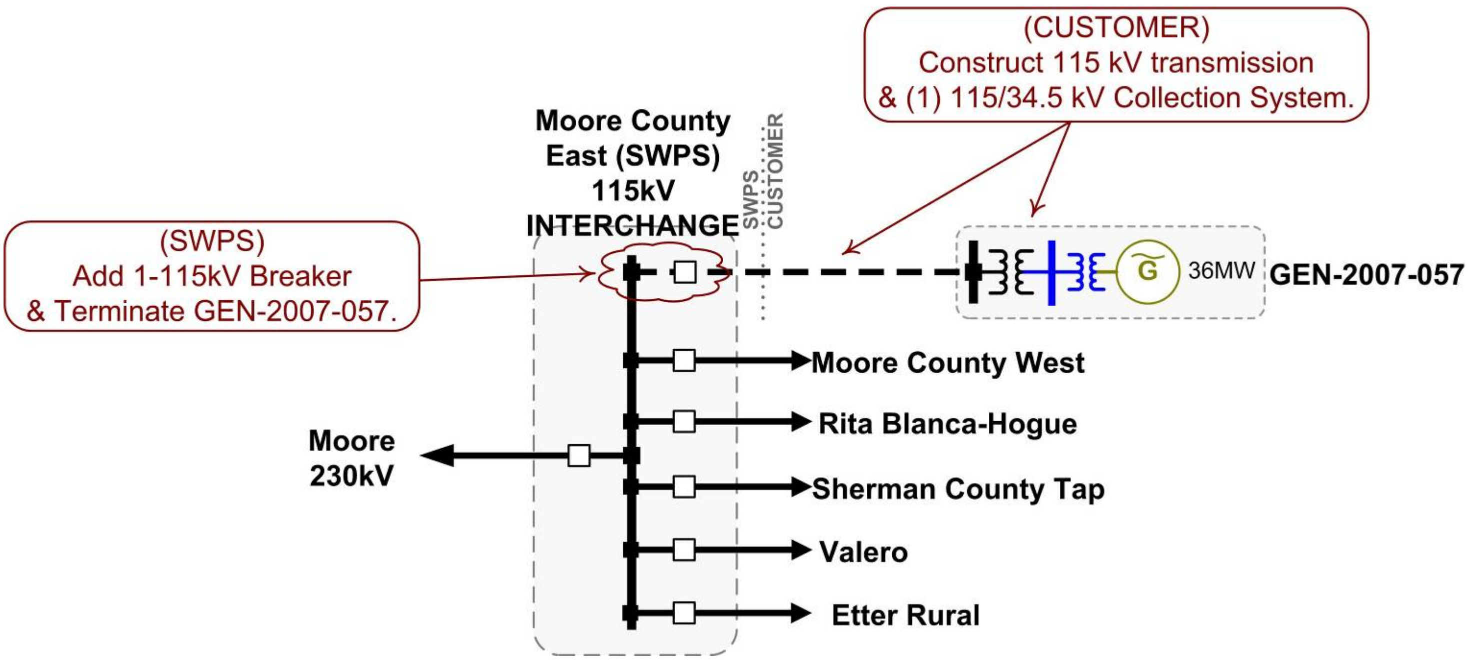
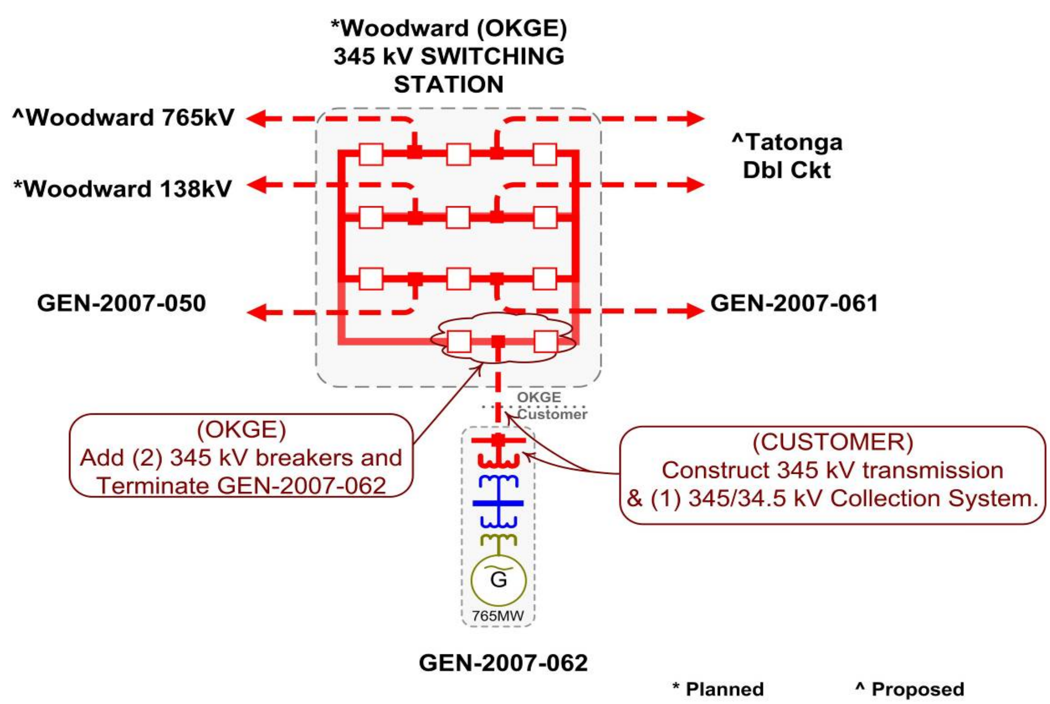


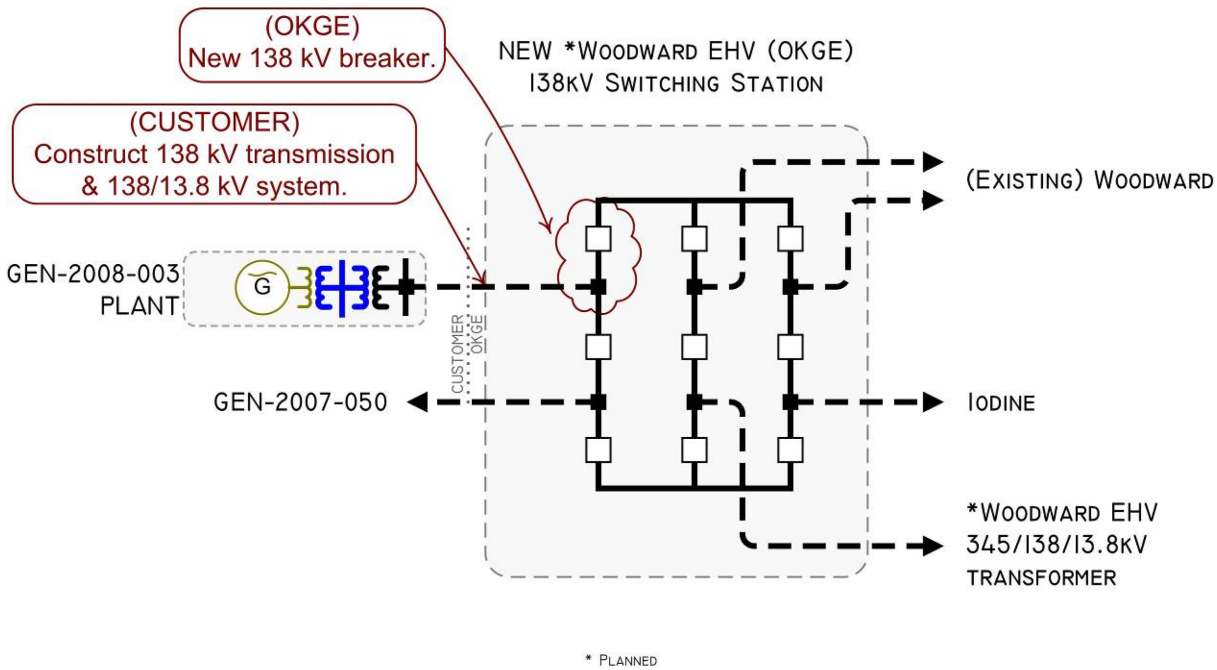
GEN-2007-057



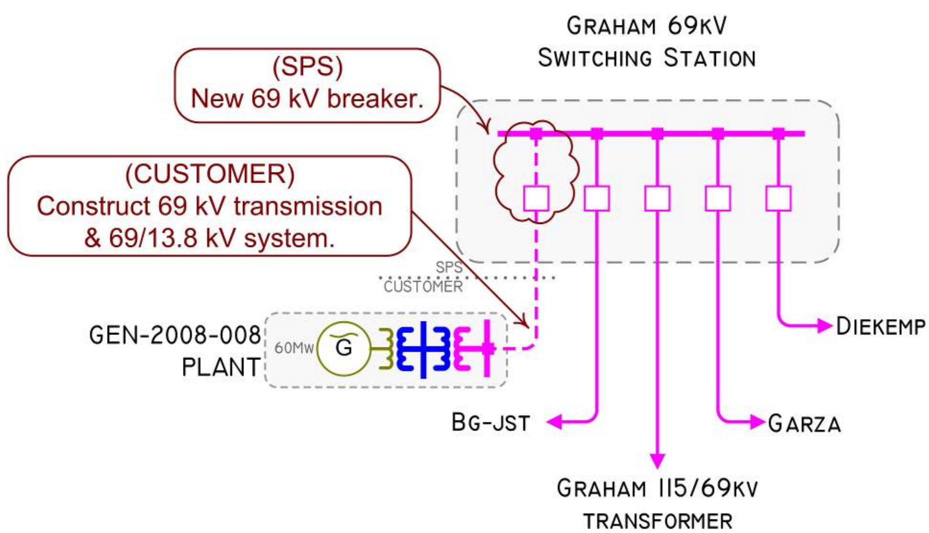
GEN-2007-062



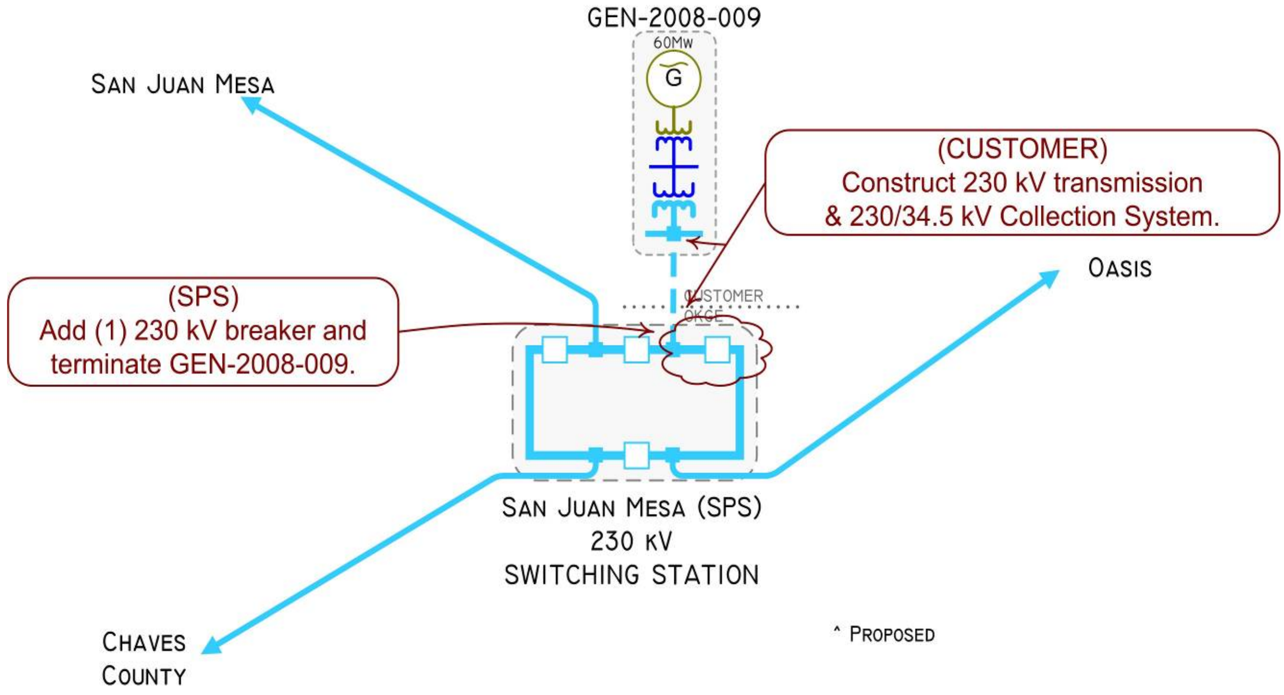
GEN-2008-003



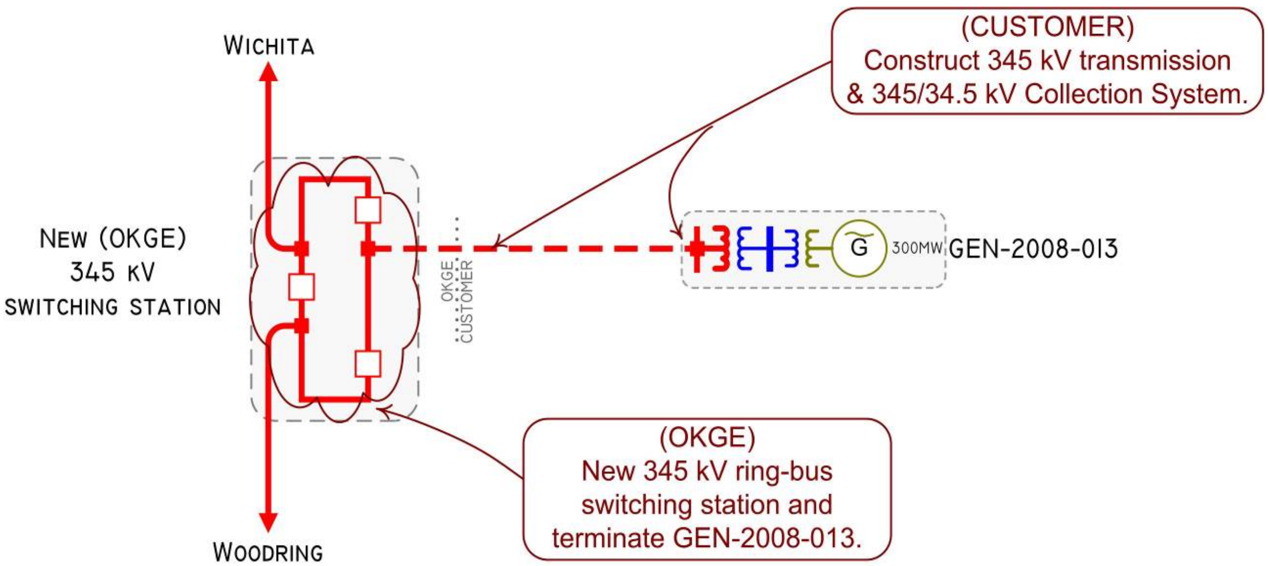
GEN-2008-008



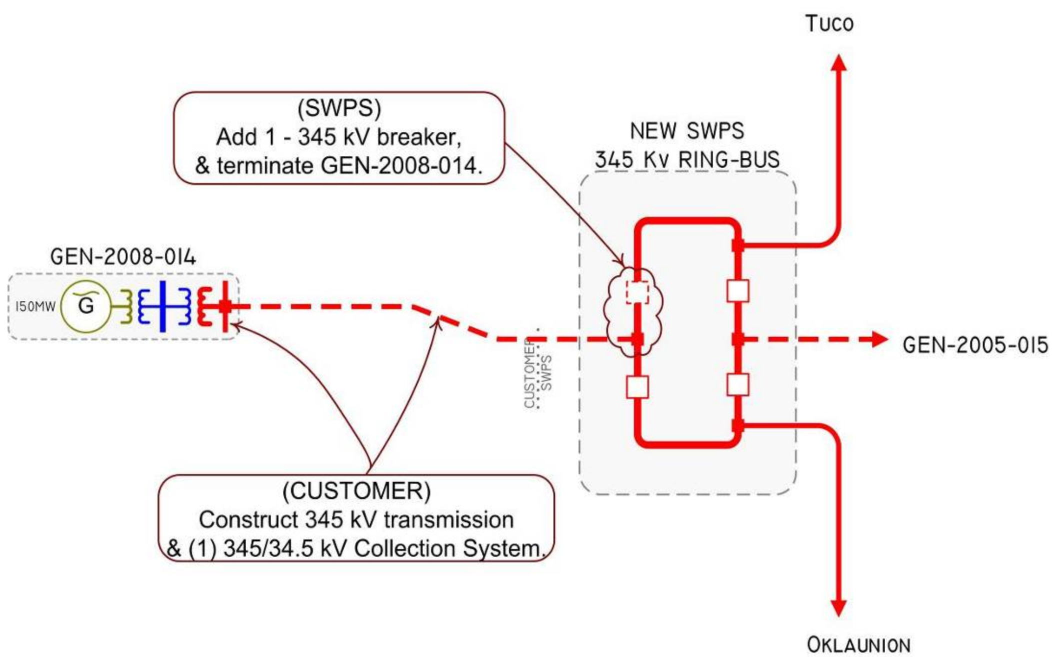
GEN-2008-009


GEN-2008-009
60MW
G
SAN JUAN MESA
(CUSTOMER)
Construct 230 kV transmission
& 230/34.5 kV Collection System.
OASIS
(SPS)
Add (1) 230 kV breaker and
terminate GEN-2008-009.
CUSTOMER
SAN JUAN MESA (SPS)
230 KV
SWITCHING STATION
CHAVES
COUNTY
* PROPOSED

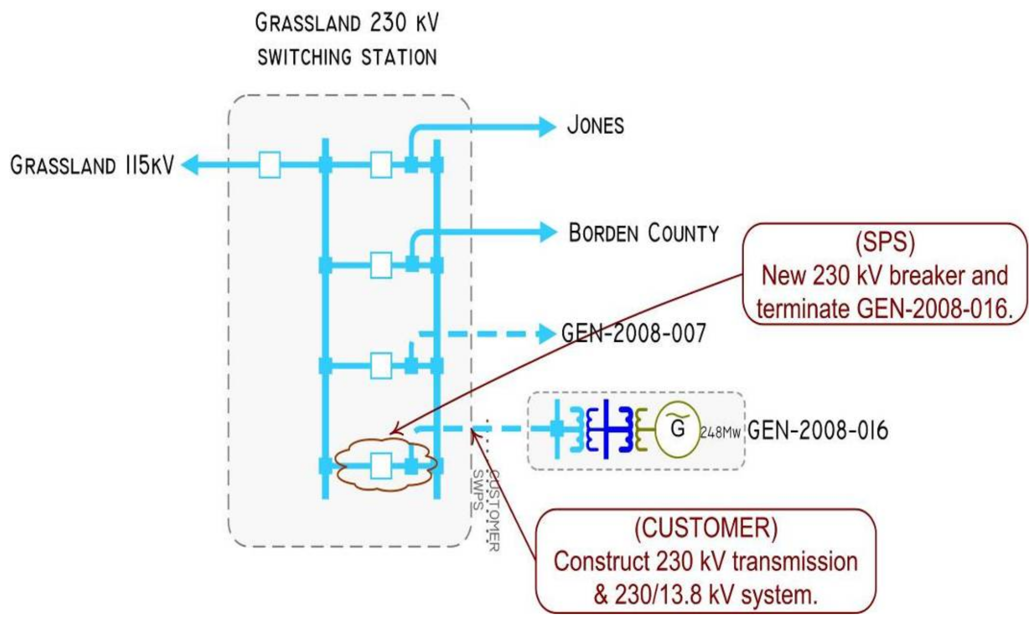
GEN-2008-013



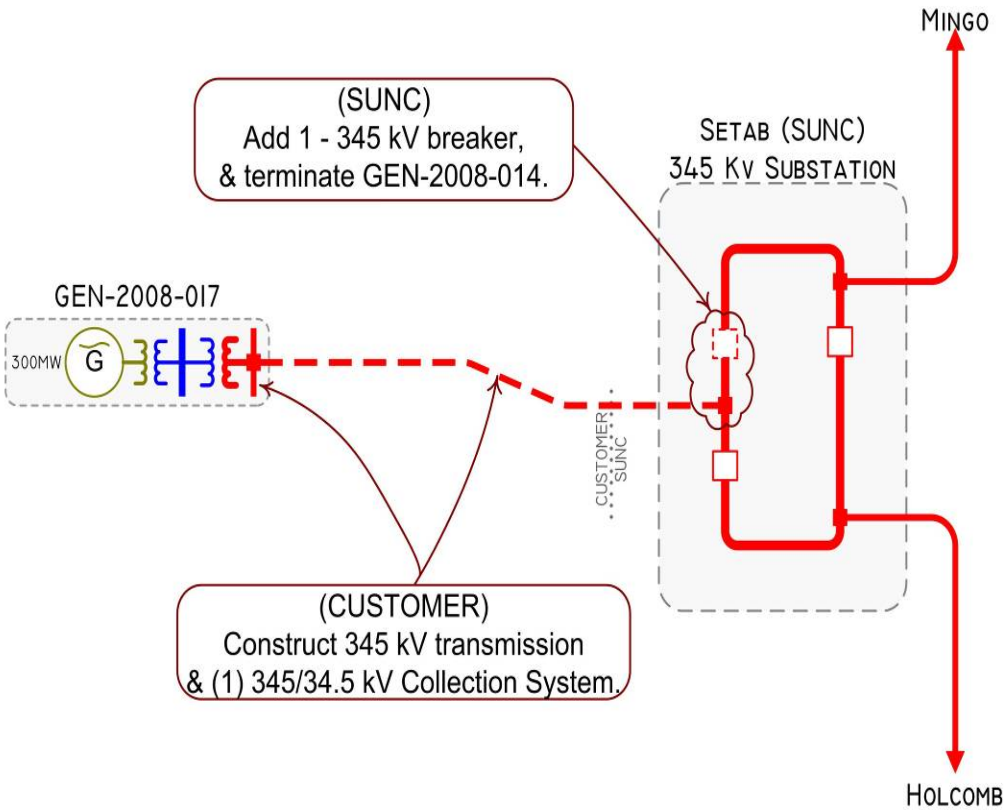
GEN-2008-014



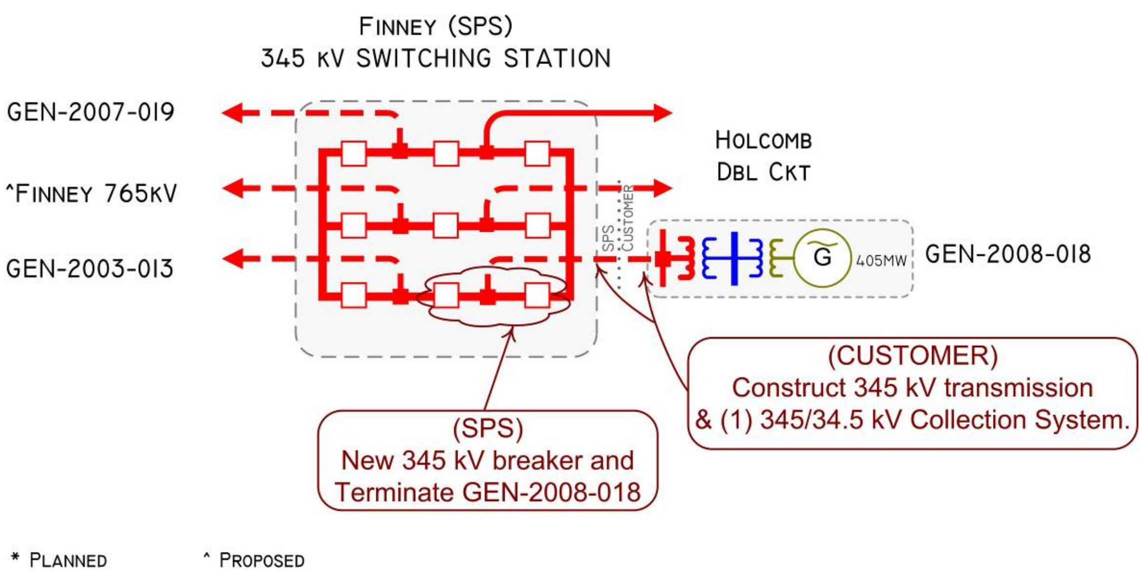
GEN-2008-016


GRASSLAND 230 KV
SWITCHING STATION
JONES
GRASSLAND 115KV
BORDEN COUNTY
(SPS)
New 230 kV breaker and
terminate GEN-2008-016.
GEN-2008-007
248MW
GEN-2008-016
CUSTOMER
SWPS
(CUSTOMER)
Construct 230 kV transmission
& 230/13.8 kV system.

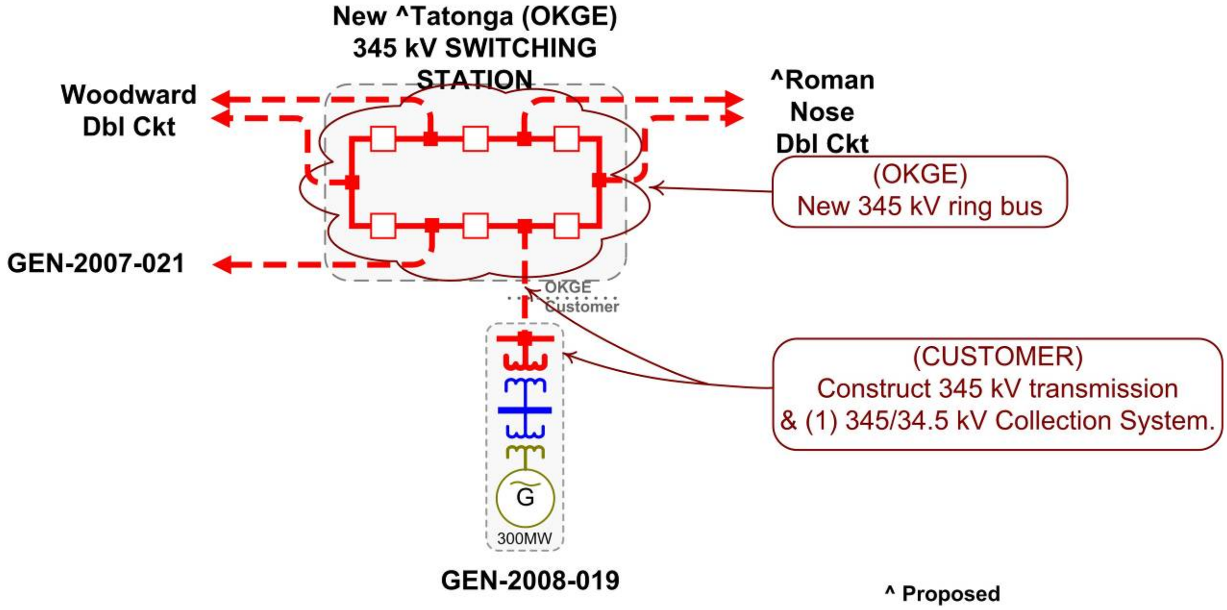
GEN-2008-017



GEN-2008-018



GEN-2008-019


New ^Tatonga (OKGE)
345 kV SWITCHING
STATION
Woodward
Dbl Ckt
^Roman
Nose
Dbl Ckt
(OKGE)
New 345 kV ring bus
GEN-2007-021
OKGE
Customer
(CUSTOMER)
Construct 345 kV transmission
& (1) 345/34.5 kV Collection System.
G
300MW
GEN-2008-019
^ Proposed

E: Cost Allocation per Interconnection Request

Appendix E.

Generation Interconnection Cost Allocation

Interconnection Request	Allocated Costs
GEN-2006-006	$35,563,756.51
GEN-2007-005	$35,472,167.17
GEN-2007-008	$55,366,724.68
GEN-2007-021	$15,548,585.74
GEN-2007-025	$10,368,078.00
GEN-2007-032	$2,150,000.00
GEN-2007-034	$18,388,094.85
GEN-2007-038	$27,412,702.75
GEN-2007-043	$8,732,000.00
GEN-2007-044	$21,693,277.22
GEN-2007-045	$58,802,379.75
GEN-2007-046	$42,727,596.34
GEN-2007-048	$68,680,627.38
GEN-2007-050	$14,882,752.26
GEN-2007-051	$12,640,991.69
GEN-2007-052	$750,000.00
GEN-2007-057	$8,604,572.48
GEN-2007-062	$68,076,301.20
GEN-2008-003	$9,334,846.93
GEN-2008-008	$5,551,410.25
GEN-2008-009	$5,637,298.25
GEN-2008-013	$9,277,000.00
GEN-2008-014	$8,921,005.33
GEN-2008-016	$23,823,506.90
GEN-2008-017	$24,079,208.81
GEN-2008-018	$40,575,397.31
GEN-2008-019	$21,693,277.22
All Upgrades Total	**$654,753,559.00**

F: Cost Allocation per Interconnection Request with Detail

Appendix F.
Generation Interconnection Cost Allocation

Interconnection Request		E + C Cost	Allocated Costs
GEN-2006-006			
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$2,832,593.52
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$5,163,389.00
	GEN-2006-006 Interconnection Cost	$5,447,481.00	$5,447,481.00
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$4,248,890.29
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$90,563.74
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$446,775.83
	Spearville - Comanche 345kV ckt 1	$50,000,000.00	$11,334,063.13
	Spearville 345/230kV transformer ckt #2	$6,000,000.00	$6,000,000.00
GEN-2006-006	**Total**		**$35,563,756.51**
GEN-2007-005			
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$1,923,573.31
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$1,851,349.54
	Conway - Wheeler County 345kV ckt #1	$40,000,000.00	$3,415,171.88
	Conway 345/115kV transformer	$10,000,000.00	$853,792.97
	Elk City Transformer 230/138kV ckt #1	$400,000.00	$30,601.45
	GEN-2007-005 Interconnection Cost	$600,000.00	$600,000.00
	Gray County - Stevens County 345kV ckt	$58,200,000.00	$11,626,299.37
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$2,885,359.96
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$69,015.22
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$343,052.53
	Spearville - Comanche 345kV ckt 1	$50,000,000.00	$901,962.69
	Tolk - Tuco 230kV ckt #1	$100,000.00	$8,467.46
	Wheeler County - Anadarko 345kV ckt #	$130,000,000.00	$10,507,104.50
	Wheeler County 345/230kV transformer	$6,000,000.00	$456,416.29
GEN-2007-005	**Total**		**$35,472,167.17**
GEN-2007-008			
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$2,422,562.57
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$3,829,780.29
	Conway - Wheeler County 345kV ckt #1	$40,000,000.00	$3,265,083.03
	Conway 345/115kV transformer	$10,000,000.00	$816,270.76
	Elk City Transformer 230/138kV ckt #1	$400,000.00	$104,604.18

Interconnection Request		E + C Cost	Allocated Costs
	GEN-2007-008 Interconnection Cost	$2,500,000.00	$2,500,000.00
	Gray County - Stevens County 345kV ckt	$58,200,000.00	$9,160,710.78
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$3,633,843.85
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$35,774.30
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$188,980.03
	Wheeler County - Anadarko 345kV ckt #	$130,000,000.00	$25,196,083.19
	Wheeler County 345/230kV transformer	$6,000,000.00	$4,213,031.70
GEN-2007-008	**Total**		**$55,366,724.68**
GEN-2007-021			
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$3,004,626.09
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$4,002,737.26
	GEN-2007-021 Interconnection Cost	$3,073,000.00	$3,073,000.00
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$4,506,939.14
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$157,854.47
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$803,428.77
GEN-2007-021	**Total**		**$15,548,585.74**
GEN-2007-025			
	GEN-2007-025 Interconnection Cost	$10,368,078.00	$10,368,078.00
GEN-2007-025	**Total**		**$10,368,078.00**
GEN-2007-032			
	Clinton Jct Switches	$150,000.00	$150,000.00
	GEN-2007-032 Interconnection Cost	$2,000,000.00	$2,000,000.00
GEN-2007-032	**Total**		**$2,150,000.00**
GEN-2007-034			
	Conway - Wheeler County 345kV ckt #1	$40,000,000.00	$1,275,321.39
	Conway 345/115kV transformer	$10,000,000.00	$318,830.35
	Elk City Transformer 230/138kV ckt #1	$400,000.00	$28,080.87
	GEN-2007-034 Interconnection Cost	$6,200,000.00	$6,200,000.00
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$54,505.90
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$270,471.90
	Tolk - Tuco 230kV ckt #1	$100,000.00	$59,999.75
	Wheeler County - Anadarko 345kV ckt #	$130,000,000.00	$10,151,819.93
	Wheeler County 345/230kV transformer	$6,000,000.00	$29,064.76
GEN-2007-034	**Total**		**$18,388,094.85**
GEN-2007-038			

Interconnection Request		E + C Cost	Allocated Costs
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$2,916,475.14
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$5,139,098.49
	GEN-2007-038 Interconnection Cost	$3,000,000.00	$3,000,000.00
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$4,374,712.71
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$90,689.64
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$447,037.64
	Spearville - Comanche 345kV ckt 1	$50,000,000.00	$11,444,689.13
GEN-2007-038	**Total**		**$27,412,702.75**
GEN-2007-043			
	GEN-2007-043 Interconnection Cost	$8,732,000.00	$8,732,000.00
GEN-2007-043	**Total**		**$8,732,000.00**
GEN-2007-044			
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$4,484,516.55
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$5,974,234.72
	GEN-2007-044 Interconnection Cost	$3,073,000.00	$3,073,000.00
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$6,726,774.83
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$235,603.69
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$1,199,147.42
GEN-2007-044	**Total**		**$21,693,277.22**
GEN-2007-045			
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$1,369,239.14
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$2,290,789.80
	Conway - Wheeler County 345kV ckt #1	$40,000,000.00	$20,361,547.11
	Conway 345/115kV transformer	$10,000,000.00	$5,090,386.78
	Elk City Transformer 230/138kV ckt #1	$400,000.00	$41,996.35
	GEN-2007-045 Interconnection Cost	$3,500,000.00	$3,500,000.00
	Grapevine - Kirby 115kV ckt #1	$100,000.00	$100,000.00
	Grapevine 230/115kV transformer	$3,000,000.00	$3,000,000.00
	Gray County - Stevens County 345kV ckt	$58,200,000.00	$4,677,765.81
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$2,053,858.72
	Nichols - Yarnell 115kV	$60,000.00	$60,000.00
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$29,318.04
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$150,595.88
	Wheeler County - Anadarko 345kV ckt #	$130,000,000.00	$16,076,882.12
GEN-2007-045	**Total**		**$58,802,379.75**
GEN-2007-046			

Interconnection Request		E + C Cost	Allocated Costs
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$2,011,350.87
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$1,714,341.82
	Conway - Wheeler County 345kV ckt #1	$40,000,000.00	$2,774,040.92
	Conway 345/115kV transformer	$10,000,000.00	$693,510.23
	Elk City Transformer 230/138kV ckt #1	$400,000.00	$26,407.04
	GEN-2007-046 Interconnection Cost	$8,000,000.00	$8,000,000.00
	Gray County - Stevens County 345kV ckt	$58,200,000.00	$12,949,804.59
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$3,017,026.31
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$77,818.05
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$385,211.97
	Spearville - Comanche 345kV ckt 1	$50,000,000.00	$1,224,013.17
	Tolk - Tuco 230kV ckt #1	$100,000.00	$7,225.48
	Wheeler County - Anadarko 345kV ckt #	$130,000,000.00	$9,486,841.28
	Wheeler County 345/230kV transformer	$6,000,000.00	$360,004.60
GEN-2007-046	**Total**		**$42,727,596.34**
GEN-2007-048			
	Amarillo South - Swisher 230kV Line Tra	$60,000.00	$60,000.00
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$3,455,095.32
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$4,210,151.24
	Conway - Wheeler County 345kV ckt #1	$40,000,000.00	$6,413,044.72
	Conway 345/115kV transformer	$10,000,000.00	$1,603,261.18
	Elk City Transformer 230/138kV ckt #1	$400,000.00	$73,897.71
	GEN-2007-048 Interconnection Cost	$3,500,000.00	$3,500,000.00
	Gray County - Stevens County 345kV ckt	$58,200,000.00	$17,814,314.70
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$5,182,642.98
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$99,850.72
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$502,717.60
	Spearville - Comanche 345kV ckt 1	$50,000,000.00	$498,016.21
	Wheeler County - Anadarko 345kV ckt #	$130,000,000.00	$24,418,835.42
	Wheeler County 345/230kV transformer	$6,000,000.00	$848,799.58
GEN-2007-048	**Total**		**$68,680,627.38**
GEN-2007-050			
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$3,087,862.48
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$4,113,624.07
	GEN-2007-050 Interconnection Cost	$1,214,000.00	$1,214,000.00
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$4,631,793.72

Interconnection Request		E + C Cost	Allocated Costs
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$309,693.34
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$1,525,778.66
GEN-2007-050	**Total**		**$14,882,752.26**
GEN-2007-051			
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$2,646,264.35
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$3,525,330.81
	GEN-2007-051 Interconnection Cost	$2,500,000.00	$2,500,000.00
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$3,969,396.53
GEN-2007-051	**Total**		**$12,640,991.69**
GEN-2007-052			
	GEN-2007-052 Interconnection Cost	$750,000.00	$750,000.00
GEN-2007-052	**Total**		**$750,000.00**
GEN-2007-057			
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$332,269.20
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$330,209.33
	Conway - Wheeler County 345kV ckt #1	$40,000,000.00	$632,954.15
	Conway 345/115kV transformer	$10,000,000.00	$158,238.54
	Elk City Transformer 230/138kV ckt #1	$400,000.00	$5,505.73
	GEN-2007-057 Interconnection Cost	$2,500,000.00	$2,500,000.00
	Gray County - Stevens County 345kV ckt	$58,200,000.00	$1,971,104.74
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$498,403.80
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$11,679.11
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$58,119.81
	Spearville - Comanche 345kV ckt 1	$50,000,000.00	$142,543.31
	Tolk - Tuco 230kV ckt #1	$100,000.00	$1,749.85
	Wheeler County - Anadarko 345kV ckt #	$130,000,000.00	$1,882,606.57
	Wheeler County 345/230kV transformer	$6,000,000.00	$79,188.34
GEN-2007-057	**Total**		**$8,604,572.48**
GEN-2007-062			
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$15,408,131.70
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$20,526,581.70
	GEN-2007-062 Interconnection Cost	$3,807,000.00	$3,807,000.00
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$23,112,197.55
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$870,253.94
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$4,352,136.31
GEN-2007-062	**Total**		**$68,076,301.20**

Interconnection Request		E + C Cost	Allocated Costs
GEN-2008-003			
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$1,834,553.59
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$2,443,976.65
	GEN-2008-003 Interconnection Cost	$1,214,000.00	$1,214,000.00
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$2,751,830.38
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$183,994.28
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$906,492.03
GEN-2008-003	**Total**		**$9,334,846.93**
GEN-2008-008			
	Conway - Wheeler County 345kV ckt #1	$40,000,000.00	$259,619.00
	Conway 345/115kV transformer	$10,000,000.00	$64,904.75
	Elk City Transformer 230/138kV ckt #1	$400,000.00	$11,135.86
	GEN-2008-008 Interconnection Cost	$1,000,000.00	$1,000,000.00
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$19,844.76
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$98,785.85
	Wheeler County - Anadarko 345kV ckt #	$130,000,000.00	$4,097,120.04
GEN-2008-008	**Total**		**$5,551,410.25**
GEN-2008-009			
	Conway - Wheeler County 345kV ckt #1	$40,000,000.00	$519,368.13
	Conway 345/115kV transformer	$10,000,000.00	$129,842.03
	Elk City Transformer 230/138kV ckt #1	$400,000.00	$11,238.25
	GEN-2008-009 Interconnection Cost	$750,000.00	$750,000.00
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$21,863.78
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$108,446.88
	Tolk - Tuco 230kV ckt #1	$100,000.00	$22,557.47
	Wheeler County - Anadarko 345kV ckt #	$130,000,000.00	$4,060,486.96
	Wheeler County 345/230kV transformer	$6,000,000.00	$13,494.74
GEN-2008-009	**Total**		**$5,637,298.25**
GEN-2008-013			
	GEN-2008-013 Interconnection Cost	$9,277,000.00	$9,277,000.00
GEN-2008-013	**Total**		**$9,277,000.00**
GEN-2008-014			
	Elk City Transformer 230/138kV ckt #1	$400,000.00	$20,504.35
	GEN-2008-014 Interconnection Cost	$1,500,000.00	$1,500,000.00
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$34,718.73

Interconnection Request		E + C Cost	Allocated Costs
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$175,336.59
	Wheeler County - Anadarko 345kV ckt #	$130,000,000.00	$7,190,445.66
GEN-2008-014	**Total**		**$8,921,005.33**
GEN-2008-016			
	Conway - Wheeler County 345kV ckt #1	$40,000,000.00	$1,083,849.67
	Conway 345/115kV transformer	$10,000,000.00	$270,962.42
	Elk City Transformer 230/138kV ckt #1	$400,000.00	$46,028.20
	GEN-2008-016 Interconnection Cost	$2,000,000.00	$2,000,000.00
	Grassland 230/115kV Transformer	$3,000,000.00	$3,000,000.00
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$82,120.18
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$408,772.10
	Wheeler County - Anadarko 345kV ckt #	$130,000,000.00	$16,931,774.33
GEN-2008-016	**Total**		**$23,823,506.90**
GEN-2008-017			
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$3,054,118.88
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$3,831,416.53
	GEN-2008-017 Interconnection Cost	$1,900,000.00	$1,900,000.00
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$4,581,178.32
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$116,573.54
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$577,080.48
	Spearville - Comanche 345kV ckt 1	$50,000,000.00	$10,018,841.06
GEN-2008-017	**Total**		**$24,079,208.81**
GEN-2008-018			
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$4,732,250.72
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$5,078,754.01
	GEN-2008-018 Interconnection Cost	$8,205,000.00	$8,205,000.00
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$7,098,376.08
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$172,660.89
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$852,484.30
	Spearville - Comanche 345kV ckt 1	$50,000,000.00	$14,435,871.31
GEN-2008-018	**Total**		**$40,575,397.31**
GEN-2008-019			
	Comanche - Medicine Lodge 345kV ckt 1	$60,000,000.00	$4,484,516.55
	Comanche - Woodward 345kV ckt1	$80,000,000.00	$5,974,234.72
	GEN-2008-019 Interconnection Cost	$3,073,000.00	$3,073,000.00
	Medicine Lodge - Wichita 345kV ckt 1	$90,000,000.00	$6,726,774.83

Interconnection Request		E + C Cost	Allocated Costs
	Sooner Wind - Mooreland 138kV	$3,000,000.00	$235,603.69
	Sooner Wind - Woodward 138kV ckt 1	$15,000,000.00	$1,199,147.42
GEN-2008-019	**Total**		**$21,693,277.22**
All Upgrades Total			**$654,753,559.00**

G: Cost Allocation per Proposed Network Upgrade

Appendix G. - Cost Allocation Per Upgrade

Upgrade	E + C Cost	Allocated Costs
Amarillo South - Swisher 230kV Line Trap		**$60,000.00**
Replace Line Traps at Amarillo South and Swisher		
GEN-2007-048	$60,000.00	$60,000.00
Upgrade Total		**$60,000.00**
Clinton Jct Switches		**$150,000.00**
Replace 600 A switches at Clinton Jct		
GEN-2007-032	$150,000.00	$150,000.00
Upgrade Total		**$150,000.00**
Comanche - Medicine Lodge 345kV ckt 1		**$60,000,000.00**
This line was assumed to be approximately 55 miles long, have 3000 amp equipment, and be insulated at 345kV. No step down at Medicine Lodge.		
GEN-2006-006	$60,000,000.00	$2,832,593.52
GEN-2007-005	$60,000,000.00	$1,923,573.31
GEN-2007-008	$60,000,000.00	$2,422,562.57
GEN-2007-021	$60,000,000.00	$3,004,626.09
GEN-2007-038	$60,000,000.00	$2,916,475.14
GEN-2007-044	$60,000,000.00	$4,484,516.55
GEN-2007-045	$60,000,000.00	$1,369,239.14
GEN-2007-046	$60,000,000.00	$2,011,350.87
GEN-2007-048	$60,000,000.00	$3,455,095.32
GEN-2007-050	$60,000,000.00	$3,087,862.48
GEN-2007-051	$60,000,000.00	$2,646,264.35
GEN-2007-057	$60,000,000.00	$332,269.20
GEN-2007-062	$60,000,000.00	$15,408,131.70
GEN-2008-003	$60,000,000.00	$1,834,553.59
GEN-2008-017	$60,000,000.00	$3,054,118.88
GEN-2008-018	$60,000,000.00	$4,732,250.72
GEN-2008-019	$60,000,000.00	$4,484,516.55
Upgrade Total		**$60,000,000.00**
Comanche - Woodward 345kV ckt1		**$80,000,000.00**
This line was assumed to be approximately 60 miles long, have 3000 amp equipment, and be insulated at 345kV.		
GEN-2006-006	$80,000,000.00	$5,163,389.00
GEN-2007-005	$80,000,000.00	$1,851,349.54
GEN-2007-008	$80,000,000.00	$3,829,780.29
GEN-2007-021	$80,000,000.00	$4,002,737.26
GEN-2007-038	$80,000,000.00	$5,139,098.49
GEN-2007-044	$80,000,000.00	$5,974,234.72
GEN-2007-045	$80,000,000.00	$2,290,789.80
GEN-2007-046	$80,000,000.00	$1,714,341.82

Upgrade	E + C Cost	Allocated Costs
GEN-2007-048	$80,000,000.00	$4,210,151.24
GEN-2007-050	$80,000,000.00	$4,113,624.07
GEN-2007-051	$80,000,000.00	$3,525,330.81
GEN-2007-057	$80,000,000.00	$330,209.33
GEN-2007-062	$80,000,000.00	$20,526,581.70
GEN-2008-003	$80,000,000.00	$2,443,976.65
GEN-2008-017	$80,000,000.00	$3,831,416.53
GEN-2008-018	$80,000,000.00	$5,078,754.01
GEN-2008-019	$80,000,000.00	$5,974,234.72
Upgrade Total		**$80,000,000.00**
Conway - Wheeler County 345kV ckt #1		**$40,000,000.00**
Build new 345kV line from Conway substation to new Mid-Point Substation on the Tuco - Woodward 345kV line		
GEN-2007-005	$40,000,000.00	$3,415,171.88
GEN-2007-008	$40,000,000.00	$3,265,083.03
GEN-2007-034	$40,000,000.00	$1,275,321.39
GEN-2007-045	$40,000,000.00	$20,361,547.11
GEN-2007-046	$40,000,000.00	$2,774,040.92
GEN-2007-048	$40,000,000.00	$6,413,044.72
GEN-2007-057	$40,000,000.00	$632,954.15
GEN-2008-008	$40,000,000.00	$259,619.00
GEN-2008-009	$40,000,000.00	$519,368.13
GEN-2008-016	$40,000,000.00	$1,083,849.67
Upgrade Total		**$40,000,000.00**
Conway 345/115kV transformer		**$10,000,000.00**
Add a 345/115kV stepdown at Conway substation for GEN-2007-045		
GEN-2007-005	$10,000,000.00	$853,792.97
GEN-2007-008	$10,000,000.00	$816,270.76
GEN-2007-034	$10,000,000.00	$318,830.35
GEN-2007-045	$10,000,000.00	$5,090,386.78
GEN-2007-046	$10,000,000.00	$693,510.23
GEN-2007-048	$10,000,000.00	$1,603,261.18
GEN-2007-057	$10,000,000.00	$158,238.54
GEN-2008-008	$10,000,000.00	$64,904.75
GEN-2008-009	$10,000,000.00	$129,842.03
GEN-2008-016	$10,000,000.00	$270,962.42
Upgrade Total		**$10,000,000.00**
Elk City Transformer 230/138kV ckt #1		**$400,000.00**
Replace equipment at Elk City substation to match the conductor rating of the 230kV line		
GEN-2007-005	$400,000.00	$30,601.45
GEN-2007-008	$400,000.00	$104,604.18
GEN-2007-034	$400,000.00	$28,080.87
GEN-2007-045	$400,000.00	$41,996.35

Upgrade	E + C Cost	Allocated Costs
GEN-2007-046	$400,000.00	$26,407.04
GEN-2007-048	$400,000.00	$73,897.71
GEN-2007-057	$400,000.00	$5,505.73
GEN-2008-008	$400,000.00	$11,135.86
GEN-2008-009	$400,000.00	$11,238.25
GEN-2008-014	$400,000.00	$20,504.35
GEN-2008-016	$400,000.00	$46,028.20
Upgrade Total		**$400,000.00**
GEN-2006-006 Interconnection Cost		**$5,447,481.00**
See one-line diagram		
GEN-2006-006	$5,447,481.00	$5,447,481.00
Upgrade Total		**$5,447,481.00**
GEN-2007-005 Interconnection Cost		**$600,000.00**
See one-line diagram		
GEN-2007-005	$600,000.00	$600,000.00
Upgrade Total		**$600,000.00**
GEN-2007-008 Interconnection Cost		**$2,500,000.00**
See one-line diagram		
GEN-2007-008	$2,500,000.00	$2,500,000.00
Upgrade Total		**$2,500,000.00**
GEN-2007-021 Interconnection Cost		**$3,073,000.00**
See one-line diagram		
GEN-2007-021	$3,073,000.00	$3,073,000.00
Upgrade Total		**$3,073,000.00**
GEN-2007-025 Interconnection Cost		**$10,368,078.00**
See one-line diagram		
GEN-2007-025	$10,368,078.00	$10,368,078.00
Upgrade Total		**$10,368,078.00**
GEN-2007-032 Interconnection Cost		**$2,000,000.00**
See one-line diagram		
GEN-2007-032	$2,000,000.00	$2,000,000.00
Upgrade Total		**$2,000,000.00**
GEN-2007-034 Interconnection Cost		**$6,200,000.00**
See one-line diagram		
GEN-2007-034	$6,200,000.00	$6,200,000.00
Upgrade Total		**$6,200,000.00**
GEN-2007-038 Interconnection Cost		**$3,000,000.00**
See one-line diagram		
GEN-2007-038	$3,000,000.00	$3,000,000.00

Upgrade	E + C Cost	Allocated Costs
Upgrade Total		**$3,000,000.00**
GEN-2007-043 Interconnection Cost		**$8,732,000.00**
See one-line diagram		
GEN-2007-043	$8,732,000.00	$8,732,000.00
Upgrade Total		**$8,732,000.00**
GEN-2007-044 Interconnection Cost		**$3,073,000.00**
See one-line diagram		
GEN-2007-044	$3,073,000.00	$3,073,000.00
Upgrade Total		**$3,073,000.00**
GEN-2007-045 Interconnection Cost		**$3,500,000.00**
See one-line diagram		
GEN-2007-045	$3,500,000.00	$3,500,000.00
Upgrade Total		**$3,500,000.00**
GEN-2007-046 Interconnection Cost		**$8,000,000.00**
See one-line diagram		
GEN-2007-046	$8,000,000.00	$8,000,000.00
Upgrade Total		**$8,000,000.00**
GEN-2007-048 Interconnection Cost		**$3,500,000.00**
See one-line diagram		
GEN-2007-048	$3,500,000.00	$3,500,000.00
Upgrade Total		**$3,500,000.00**
GEN-2007-050 Interconnection Cost		**$1,214,000.00**
See one-line diagram		
GEN-2007-050	$1,214,000.00	$1,214,000.00
Upgrade Total		**$1,214,000.00**
GEN-2007-051 Interconnection Cost		**$2,500,000.00**
See one-line diagram		
GEN-2007-051	$2,500,000.00	$2,500,000.00
Upgrade Total		**$2,500,000.00**
GEN-2007-052 Interconnection Cost		**$750,000.00**
See one-line diagram		
GEN-2007-052	$750,000.00	$750,000.00
Upgrade Total		**$750,000.00**
GEN-2007-057 Interconnection Cost		**$2,500,000.00**
See one-line diagram		
GEN-2007-057	$2,500,000.00	$2,500,000.00
Upgrade Total		**$2,500,000.00**

Upgrade	E + C Cost	Allocated Costs
GEN-2007-062 Interconnection Cost		**$3,807,000.00**
See one-line diagram		
GEN-2007-062	$3,807,000.00	$3,807,000.00
Upgrade Total		**$3,807,000.00**
GEN-2008-003 Interconnection Cost		**$1,214,000.00**
See one-line diagram		
GEN-2008-003	$1,214,000.00	$1,214,000.00
Upgrade Total		**$1,214,000.00**
GEN-2008-008 Interconnection Cost		**$1,000,000.00**
See one-line diagram		
GEN-2008-008	$1,000,000.00	$1,000,000.00
Upgrade Total		**$1,000,000.00**
GEN-2008-009 Interconnection Cost		**$750,000.00**
See one-line diagram		
GEN-2008-009	$750,000.00	$750,000.00
Upgrade Total		**$750,000.00**
GEN-2008-013 Interconnection Cost		**$9,277,000.00**
See one-line diagram		
GEN-2008-013	$9,277,000.00	$9,277,000.00
Upgrade Total		**$9,277,000.00**
GEN-2008-014 Interconnection Cost		**$1,500,000.00**
See one-line diagram		
GEN-2008-014	$1,500,000.00	$1,500,000.00
Upgrade Total		**$1,500,000.00**
GEN-2008-016 Interconnection Cost		**$2,000,000.00**
See one-line diagram		
GEN-2008-016	$2,000,000.00	$2,000,000.00
Upgrade Total		**$2,000,000.00**
GEN-2008-017 Interconnection Cost		**$1,900,000.00**
See one-line diagram		
GEN-2008-017	$1,900,000.00	$1,900,000.00
Upgrade Total		**$1,900,000.00**
GEN-2008-018 Interconnection Cost		**$8,205,000.00**
See one-line diagram		
GEN-2008-018	$8,205,000.00	$8,205,000.00
Upgrade Total		**$8,205,000.00**
GEN-2008-019 Interconnection Cost		**$3,073,000.00**
See one-line diagram		
GEN-2008-019	$3,073,000.00	$3,073,000.00

Upgrade	E + C Cost	Allocated Costs
Upgrade Total		**$3,073,000.00**
Grapevine - Kirby 115kV ckt #1		**$100,000.00**
Replace Jumpers		
GEN-2007-045	$100,000.00	$100,000.00
Upgrade Total		**$100,000.00**
Grapevine 230/115kV transformer		**$3,000,000.00**
Replace 230/115kV transformer at Grapevine		
GEN-2007-045	$3,000,000.00	$3,000,000.00
Upgrade Total		**$3,000,000.00**
Grassland 230/115kV Transformer		**$3,000,000.00**
New Xfmr		
GEN-2008-016	$3,000,000.00	$3,000,000.00
Upgrade Total		**$3,000,000.00**
Gray County - Stevens County 345kV ckt 1		**$58,200,000.00**
This line was assumed to be approximately 65 miles long, have 3000 amp equipment, and be insulated at 345kV		
GEN-2007-005	$58,200,000.00	$11,626,299.37
GEN-2007-008	$58,200,000.00	$9,160,710.78
GEN-2007-045	$58,200,000.00	$4,677,765.81
GEN-2007-046	$58,200,000.00	$12,949,804.59
GEN-2007-048	$58,200,000.00	$17,814,314.70
GEN-2007-057	$58,200,000.00	$1,971,104.74
Upgrade Total		**$58,200,000.00**
Medicine Lodge - Wichita 345kV ckt 1		**$90,000,000.00**
This line was assumed to be approximately 75 miles long, have 3000 amp equipment, and be insulated at 345kV. No step down at Medicine Lodge.		
GEN-2006-006	$90,000,000.00	$4,248,890.29
GEN-2007-005	$90,000,000.00	$2,885,359.96
GEN-2007-008	$90,000,000.00	$3,633,843.85
GEN-2007-021	$90,000,000.00	$4,506,939.14
GEN-2007-038	$90,000,000.00	$4,374,712.71
GEN-2007-044	$90,000,000.00	$6,726,774.83
GEN-2007-045	$90,000,000.00	$2,053,858.72
GEN-2007-046	$90,000,000.00	$3,017,026.31
GEN-2007-048	$90,000,000.00	$5,182,642.98
GEN-2007-050	$90,000,000.00	$4,631,793.72
GEN-2007-051	$90,000,000.00	$3,969,396.53
GEN-2007-057	$90,000,000.00	$498,403.80
GEN-2007-062	$90,000,000.00	$23,112,197.55
GEN-2008-003	$90,000,000.00	$2,751,830.38
GEN-2008-017	$90,000,000.00	$4,581,178.32
GEN-2008-018	$90,000,000.00	$7,098,376.08

Upgrade	E + C Cost	Allocated Costs
GEN-2008-019	$90,000,000.00	$6,726,774.83
Upgrade Total		**$90,000,000.00**
Nichols - Yarnell 115kV		**$60,000.00**
Replace Line Trap at Nichols and at Kirby		
GEN-2007-045	$60,000.00	$60,000.00
Upgrade Total		**$60,000.00**
Sooner Wind - Mooreland 138kV		**$3,000,000.00**
GEN-2006-006	$3,000,000.00	$90,563.74
GEN-2007-005	$3,000,000.00	$69,015.22
GEN-2007-008	$3,000,000.00	$35,774.30
GEN-2007-021	$3,000,000.00	$157,854.47
GEN-2007-034	$3,000,000.00	$54,505.90
GEN-2007-038	$3,000,000.00	$90,689.64
GEN-2007-044	$3,000,000.00	$235,603.69
GEN-2007-045	$3,000,000.00	$29,318.04
GEN-2007-046	$3,000,000.00	$77,818.05
GEN-2007-048	$3,000,000.00	$99,850.72
GEN-2007-050	$3,000,000.00	$309,693.34
GEN-2007-057	$3,000,000.00	$11,679.11
GEN-2007-062	$3,000,000.00	$870,253.94
GEN-2008-003	$3,000,000.00	$183,994.28
GEN-2008-008	$3,000,000.00	$19,844.76
GEN-2008-009	$3,000,000.00	$21,863.78
GEN-2008-014	$3,000,000.00	$34,718.73
GEN-2008-016	$3,000,000.00	$82,120.18
GEN-2008-017	$3,000,000.00	$116,573.54
GEN-2008-018	$3,000,000.00	$172,660.89
GEN-2008-019	$3,000,000.00	$235,603.69
Upgrade Total		**$3,000,000.00**
Sooner Wind - Woodward 138kV ckt 1		**$15,000,000.00**
Rebuild approximately 15 miles of 138kV line		
GEN-2006-006	$15,000,000.00	$446,775.83
GEN-2007-005	$15,000,000.00	$343,052.53
GEN-2007-008	$15,000,000.00	$188,980.03
GEN-2007-021	$15,000,000.00	$803,428.77
GEN-2007-034	$15,000,000.00	$270,471.90
GEN-2007-038	$15,000,000.00	$447,037.64
GEN-2007-044	$15,000,000.00	$1,199,147.42
GEN-2007-045	$15,000,000.00	$150,595.88
GEN-2007-046	$15,000,000.00	$385,211.97
GEN-2007-048	$15,000,000.00	$502,717.60

Upgrade	E + C Cost	Allocated Costs
GEN-2007-050	$15,000,000.00	$1,525,778.66
GEN-2007-057	$15,000,000.00	$58,119.81
GEN-2007-062	$15,000,000.00	$4,352,136.31
GEN-2008-003	$15,000,000.00	$906,492.03
GEN-2008-008	$15,000,000.00	$98,785.85
GEN-2008-009	$15,000,000.00	$108,446.88
GEN-2008-014	$15,000,000.00	$175,336.59
GEN-2008-016	$15,000,000.00	$408,772.10
GEN-2008-017	$15,000,000.00	$577,080.48
GEN-2008-018	$15,000,000.00	$852,484.30
GEN-2008-019	$15,000,000.00	$1,199,147.42
Upgrade Total		**$15,000,000.00**

Spearville - Comanche 345kV ckt 1 **$50,000,000.00**

This line was assumed to be approximately 55 miles long, have 3000 amp equipment, and be insulated at 345kV.

Upgrade	E + C Cost	Allocated Costs
GEN-2006-006	$50,000,000.00	$11,334,063.13
GEN-2007-005	$50,000,000.00	$901,962.69
GEN-2007-038	$50,000,000.00	$11,444,689.13
GEN-2007-046	$50,000,000.00	$1,224,013.17
GEN-2007-048	$50,000,000.00	$498,016.21
GEN-2007-057	$50,000,000.00	$142,543.31
GEN-2008-017	$50,000,000.00	$10,018,841.06
GEN-2008-018	$50,000,000.00	$14,435,871.31
Upgrade Total		**$50,000,000.00**

Spearville 345/230kV transformer ckt #2 **$6,000,000.00**

Add a second 345/230kV autotransformer at Spearville

Upgrade	E + C Cost	Allocated Costs
GEN-2006-006	$6,000,000.00	$6,000,000.00
Upgrade Total		**$6,000,000.00**

Tolk - Tuco 230kV ckt #1 **$100,000.00**

Replace Line Trap

Upgrade	E + C Cost	Allocated Costs
GEN-2007-005	$100,000.00	$8,467.46
GEN-2007-034	$100,000.00	$59,999.75
GEN-2007-046	$100,000.00	$7,225.48
GEN-2007-057	$100,000.00	$1,749.85
GEN-2008-009	$100,000.00	$22,557.47
Upgrade Total		**$100,000.00**

Wheeler County - Anadarko 345kV ckt #1 **$130,000,000.00**

Build new 345kV line from Mid-Point Substation on the Tuco-Woodward 345kV line to Anadarko

Upgrade	E + C Cost	Allocated Costs
GEN-2007-005	$130,000,000.00	$10,507,104.50
GEN-2007-008	$130,000,000.00	$25,196,083.19
GEN-2007-034	$130,000,000.00	$10,151,819.93
GEN-2007-045	$130,000,000.00	$16,076,882.12

Upgrade	E + C Cost	Allocated Costs
GEN-2007-046	$130,000,000.00	$9,486,841.28
GEN-2007-048	$130,000,000.00	$24,418,835.42
GEN-2007-057	$130,000,000.00	$1,882,606.57
GEN-2008-008	$130,000,000.00	$4,097,120.04
GEN-2008-009	$130,000,000.00	$4,060,486.96
GEN-2008-014	$130,000,000.00	$7,190,445.66
GEN-2008-016	$130,000,000.00	$16,931,774.33
Upgrade Total		**$130,000,000.00**
Wheeler County 345/230kV transformer		**$6,000,000.00**
Add a 345/230kV stepdown at the Mid-Point Substation on the Tuco-Woodward 345kV line to interconnect at SPS Wheeler County 230kV		
GEN-2007-005	$6,000,000.00	$456,416.29
GEN-2007-008	$6,000,000.00	$4,213,031.70
GEN-2007-034	$6,000,000.00	$29,064.76
GEN-2007-046	$6,000,000.00	$360,004.60
GEN-2007-048	$6,000,000.00	$848,799.58
GEN-2007-057	$6,000,000.00	$79,188.34
GEN-2008-009	$6,000,000.00	$13,494.74
Upgrade Total		**$6,000,000.00**
All Upgrades Total		**$654,753,559.00**

H: ACCC Analysis (No Upgrades)

GI Request	SEASON	ELEMENT	From	To	RATE	LOADING	TDF	CONTNAME
G06-06	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	121.0841	0.35409	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G06-06	10G	CIRCLE - MULLERGREN 230KV CKT 1	MULGREN6 230.00	CIRCLE 6 230.00	319	100.3699	0.18267	AXTELL - KNOLL345 345.00 345KV CKT 1
G06-06	10G	CIRCLE - MULLERGREN 230KV CKT 1	MULGREN6 230.00	CIRCLE 6 230.00	319	113.4888	0.21037	Hitchland Interchange - STEVENS CO 345.00 345KV CKT 1
G06-06	10G	CIRCLE - MULLERGREN 230KV CKT 1	MULGREN6 230.00	CIRCLE 6 230.00	319	107.4201	0.18781	SMOKYHLLS6 230.00 - SUMMIT 230KV CKT 1
G06-06	10G	CIRCLE - MULLERGREN 230KV CKT 1	MULGREN6 230.00	CIRCLE 6 230.00	319	107.4361	0.18783	KNOLL 230 - SMOKYHLLS6 230.00 230KV CKT 1
G06-06	10G	CIRCLE - MULLERGREN 230KV CKT 1	MULGREN6 230.00	CIRCLE 6 230.00	319	105.872	0.21127	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G06-06	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	157.1427	0.35409	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G06-06	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	101.5901	0.24684	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G06-06	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	120.7373	0.27579	KNOLL345 345.00 345/230KV TRANSFORMER CKT 1
G06-06	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	109.0286	0.29437	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G06-06	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	116.2148	0.2935	Hitchland Interchange - STEVENS CO 345.00 345KV CKT 1
G06-06	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORMEI	SPEARVL6 230.00	SPERVIL7 345.00	336	106.0023	0.89698	MULLERGREN - SPEARVILLE 230KV CKT 1
G06-06	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORMEI	SPEARVL6 230.00	SPERVIL7 345.00	336	106.176	0.89698	MULLERGREN - SPEARVILLE 230KV CKT 1
G06-06	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORMEI	SPEARVL6 230.00	SPERVIL7 345.00	336	106.176	0.89698	MULLERGREN - SPEARVILLE 230KV CKT 1
G06-06	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORMEI	SPEARVL6 230.00	SPERVIL7 345.00	336	106.0023	0.89698	MULLERGREN - SPEARVILLE 230KV CKT 1
G06-06	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	100.3049	0.35409	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G07-05	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.30434	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.23121	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	105.4311	0.3083	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	106.1218	0.30348	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	120.3263	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	108.241	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	101.5244	0.29443	BASE CASE
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	102.9024	0.30348	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	119.0029	0.31878	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	114.1611	0.30615	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	112.5803	0.30615	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	117.9216	0.30348	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	112.5803	0.30615	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	136.1815	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	136.1815	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	139.3298	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	139.3298	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	117.9216	0.30348	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	119.5359	0.30348	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1

GI Request	SEASON	ELEMENT	From		To		RATE	LOADING	TDF	CONTNAME
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	123.2916	0.3083	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	106.3229	0.29443	OGE3TERM10
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	106.3229	0.29443	OGE3TERM10
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	107.6105	0.29443	OGE3TERM10
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	107.6105	0.29443	OGE3TERM10
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	109.7122	0.29443	SPP-AEPW-25
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	109.7122	0.29443	SPP-AEPW-25
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	111.1511	0.29443	SPP-AEPW-25
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	111.1511	0.29443	SPP-AEPW-25
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	121.302	0.3083	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	121.302	0.3083	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	116.34	0.30638	PNM BLACKWATER DC TIE - Roosevelt County Interchange SOUTH 230KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	136.0297	0.31878	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	136.0297	0.31878	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	133.3236	0.31878	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	123.2916	0.3083	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	119.5359	0.30348	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	116.34	0.30638	PNM BLACKWATER DC TIE - Roosevelt County Interchange SOUTH 230KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	114.1611	0.30615	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	114.6822	0.30638	PNM BLACKWATER DC TIE - Roosevelt County Interchange SOUTH 230KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	114.6822	0.30638	PNM BLACKWATER DC TIE - Roosevelt County Interchange SOUTH 230KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	133.3236	0.31878	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	108.2102	0.29443	BASE CASE
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	109.5821	0.29443	BASE CASE
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	108.2102	0.29443	BASE CASE
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	126.0078	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	126.0078	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	123.8877	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	123.8877	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	122.299	0.30348	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	122.299	0.30348	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	120.6117	0.30348	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	120.6117	0.30348	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	109.5821	0.29443	BASE CASE
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO	230.00	ELKCITY6	230.00	351	128.615	0.29443	BASE CASE
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO	230.00	ELKCITY6	230.00	351	131.623	0.30348	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO	230.00	ELKCITY6	230.00	351	138.5548	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO	230.00	ELKCITY6	230.00	351	135.3624	0.3083	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO	230.00	ELKCITY6	230.00	351	114.5824	0.29443	OGE3TERM10

GI Request	SEASON	ELEMENT	From	To	RATE	LOADING	TDF	CONTNAME
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	135.626	0.31878	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	127.9097	0.30615	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	131.1444	0.31939	Hitchland Interchange - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	131.1444	0.30638	Hitchland Interchange - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	139.5739	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	127.8039	0.30348	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - GRAPEVINE INTERCHANGE 230I	GRAPEVINE 6 230.00	BECKHAM CO 230.00	351	112.378	0.31543	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - GRAPEVINE INTERCHANGE 230I	GRAPEVINE 6 230.00	BECKHAM CO 230.00	351	100.6986	0.30717	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - GRAPEVINE INTERCHANGE 230I	GRAPEVINE 6 230.00	BECKHAM CO 230.00	351	104.2418	0.32309	Hitchland Interchange - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - GRAPEVINE INTERCHANGE 230I	GRAPEVINE 6 230.00	BECKHAM CO 230.00	351	101.2013	0.30985	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - GRAPEVINE INTERCHANGE 230I	GRAPEVINE 6 230.00	BECKHAM CO 230.00	351	108.2302	0.32247	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - GRAPEVINE INTERCHANGE 230I	GRAPEVINE 6 230.00	BECKHAM CO 230.00	351	108.3806	0.31199	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - GRAPEVINE INTERCHANGE 230I	GRAPEVINE 6 230.00	BECKHAM CO 230.00	351	111.3742	0.31182	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	BECKHAM CO 230.00 - GRAPEVINE INTERCHANGE 230I	GRAPEVINE 6 230.00	BECKHAM CO 230.00	351	104.3	0.29628	BECKHAM CO 230.00 - BECKHAM EHV 230.00 230KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	141.6624	0.30348	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	141.6624	0.30348	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	157.5515	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	157.5515	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	145.7993	0.30615	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	148.5259	0.31878	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	142.2575	0.30615	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	152.7948	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	152.7948	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	145.7993	0.30615	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	141.9406	0.30638	PNM BLACKWATER DC TIE - Roosevelt County Interchange SOUTH 230KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	130.5185	0.29443	OGE3TERM10
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	130.5185	0.29443	OGE3TERM10
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	133.1155	0.29443	OGE3TERM10
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	133.1155	0.29443	OGE3TERM10
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	148.4081	0.3083	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	152.6319	0.3083	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	152.6319	0.3083	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1

GI Request	SEASON	ELEMENT	From		To		RATE	LOADING	TDF	CONTNAME
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	138.7274	0.30638	PNM BLACKWATER DC TIE - Roosevelt County Interchange SOUTH 230KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	142.2575	0.30615	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	141.9406	0.30638	PNM BLACKWATER DC TIE - Roosevelt County Interchange SOUTH 230KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	148.5259	0.31878	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	152.6611	0.31878	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	152.6611	0.31878	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	138.7274	0.30638	PNM BLACKWATER DC TIE - Roosevelt County Interchange SOUTH 230KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	155.543	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	132.7536	0.29443	BASE CASE
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	132.7536	0.29443	BASE CASE
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	150.9134	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	155.543	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	145.0378	0.30348	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	135.5183	0.29443	BASE CASE
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	144.5905	0.30348	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	148.2139	0.30348	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	148.2139	0.30348	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	150.9134	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	135.5183	0.29443	BASE CASE
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	148.4081	0.3083	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	145.0378	0.30348	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	144.5905	0.30348	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.5372	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.5372	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	104.3153	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	104.3153	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	100.4102	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	100.4102	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.0357	0.30615	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.0357	0.30615	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	103.8709	0.30615	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	103.8709	0.30615	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	112.6049	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	108.1575	0.31878	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	111.2029	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1

GI Request	SEASON	ELEMENT	From		To		RATE	LOADING	TDF	CONTNAME
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	111.2029	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	108.1575	0.31878	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	112.6049	0.31173	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.9144	0.30348	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.9144	0.30348	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	104.7661	0.3083	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	104.7661	0.3083	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.9468	0.3083	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.9468	0.3083	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	106.4491	0.30638	PNM BLACKWATER DC TIE - Roosevelt County Interchange SOUTH 230KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	106.4491	0.30638	PNM BLACKWATER DC TIE - Roosevelt County Interchange SOUTH 230KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	107.679	0.30638	PNM BLACKWATER DC TIE - Roosevelt County Interchange SOUTH 230KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	106.9174	0.31878	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	106.9174	0.31878	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	107.0918	0.30348	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	107.679	0.30638	PNM BLACKWATER DC TIE - Roosevelt County Interchange SOUTH 230KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	100.2426	0.29443	BASE CASE
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	101.3048	0.29443	BASE CASE
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	101.3048	0.29443	BASE CASE
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	100.2426	0.29443	BASE CASE
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	107.0918	0.30348	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	108.7253	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	108.7253	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	107.4711	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	107.4711	0.30813	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	110.0566	0.30348	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	108.827	0.30348	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	108.827	0.30348	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	110.0566	0.30348	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-08	10G	GRAPEVINE INTERCHANGE 230/115KV TRANSFORMER	GRAPEVINE 6	230.00	GRAPEVINE 3	115.00	128	118.7716	0.23272	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1
G07-08	10G	GRAPEVINE INTERCHANGE 230/115KV TRANSFORMER	GRAPEVINE 6	230.00	GRAPEVINE 3	115.00	128	118.6266	0.23272	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1
G07-21	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4	138.00	MOORLND4	138.00	287	173.2119	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-21	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	252.8193	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1

GI Request	SEASON	ELEMENT	From	To	RATE	LOADING	TDF	CONTNAME
G07-21	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.58743	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-21	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	141.8961	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-21	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	258.2896	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-21	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	101.8738	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-21	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	180.9222	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-21	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	167.4944	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-21	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	131.5875	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-21	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	238.3528	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-21	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	110.8915	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-21	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	198.2382	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-21	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	139.4352	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-34	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.27332	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-34	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	108.3223	0.25045	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-34	10G	DEAF SMITH COUNTY INTERCHANGE - G06-39T 230.0	G06-39T 230.00	DEAFSMITH 6 230.00	351	108.0012	0.28614	G06-39T 230.00 - PLANT X STATION 230KV CKT 1
G07-34	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	114.7617	0.25045	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-34	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	112.8452	0.27898	SUNDOWN INTERCHANGE - WOLFFORTH INTERCHANGE 230KV CKT 1
G07-34	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	104.0732	0.24561	MIDLAND COUNTY INTERCHANGE 230/138KV TRANSFORMER CKT 1
G07-34	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	104.0732	0.24561	HOBBS INTERCHANGE - MIDLAND COUNTY INTERCHANGE 230KV CKT 1
G07-34	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	101.9795	0.26066	JONES STATION - TUCO INTERCHANGE 230KV CKT 1
G07-34	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	113.5362	0.23968	PNM BLACKWATER DC TIE - Roosevelt County Interchange SOUTH 230KV CKT 1
G07-34	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	105.2035	0.23968	BASE CASE
G07-34	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	105.4831	0.27065	LUBBOCK SOUTH INTERCHANGE - WOLFFORTH INTERCHANGE 230KV CKT 1
G07-34	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	106.353	0.25106	PLANT X STATION - SUNDOWN INTERCHANGE 230KV CKT 1
G07-34	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	103.8148	0.25095	PLANT X STATION 230/115KV TRANSFORMER CKT 1
G07-38	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	121.0841	0.30534	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G07-38	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORMEI	SPERVIL7 345.00	SPEARVL6 230.00	336	105.5169	0.38535	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G07-38	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORMEI	SPERVIL7 345.00	SPEARVL6 230.00	336	105.5169	0.38535	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G07-38	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORMEI	SPERVIL7 345.00	SPEARVL6 230.00	336	105.3782	0.38535	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G07-38	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORMEI	SPERVIL7 345.00	SPEARVL6 230.00	336	105.3782	0.38535	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G07-38	10G	CIRCLE - MULLERGREN 230KV CKT 1	MULGREN6 230.00	CIRCLE 6 230.00	319	113.4888	0.19509	Hitchland Interchange - STEVENS CO 345.00 345KV CKT 1
G07-38	10G	CIRCLE - MULLERGREN 230KV CKT 1	MULGREN6 230.00	CIRCLE 6 230.00	319	105.872	0.19599	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-38	10G	CIRCLE - MULLERGREN 230KV CKT 1	MULGREN6 230.00	CIRCLE 6 230.00	319	100.3699	0.166	AXTELL - KNOLL345 345.00 345KV CKT 1
G07-38	10G	CIRCLE - MULLERGREN 230KV CKT 1	MULGREN6 230.00	CIRCLE 6 230.00	319	107.4201	0.17093	SMOKYHLLS6 230.00 - SUMMIT 230KV CKT 1
G07-38	10G	CIRCLE - MULLERGREN 230KV CKT 1	MULGREN6 230.00	CIRCLE 6 230.00	319	107.4361	0.17095	KNOLL 230 - SMOKYHLLS6 230.00 230KV CKT 1

GI Request	SEASON	ELEMENT	From	To	RATE	LOADING	TDF	CONTNAME
G07-38	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	101.5901	0.1793	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-38	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	120.7373	0.22306	KNOLL345 345.00 345/230KV TRANSFORMER CKT 1
G07-38	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	157.1427	0.30534	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G07-38	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	116.2148	0.22778	Hitchland Interchange - STEVENS CO 345.00 345KV CKT 1
G07-38	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	109.0286	0.22865	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-38	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	100.3049	0.30534	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G07-43	10G	G07-43T 345.00 345/34.5KV TRANSFORMER CKT 1	G07-43 34.500	G07-43T 345.00	330	122.2187	1	BASE CASE
G07-44	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	173.2119	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-44	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	252.8193	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-44	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.58743	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-44	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	141.8961	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-44	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	258.2896	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-44	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	101.8738	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-44	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	180.9222	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-44	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	167.4944	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-44	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	131.5875	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-44	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	238.3528	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-44	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	110.8915	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-44	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	198.2382	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-44	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	139.4352	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-45	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.2607	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	108.241	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	119.0029	0.17617	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	105.4311	0.16632	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO 230.00	ELKCITY6 230.00	351	120.3263	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	114.1611	0.16189	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	136.1815	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	136.1815	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	139.3298	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	139.3298	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	112.5803	0.16189	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1

GI Request	SEASON	ELEMENT	From		To		RATE	LOADING	TDF	CONTNAME
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	117.9216	0.15866	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	119.5359	0.15866	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	119.5359	0.15866	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	117.9216	0.15866	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	121.302	0.16632	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	121.302	0.16632	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	123.2916	0.16632	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	133.3236	0.17617	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	136.0297	0.17617	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	136.0297	0.17617	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	123.2916	0.16632	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	133.3236	0.17617	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	112.5803	0.16189	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	114.1611	0.16189	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	126.0078	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	126.0078	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	123.8877	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	123.8877	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	122.299	0.15866	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	122.299	0.15866	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	120.6117	0.15866	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	120.6117	0.15866	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO	230.00	ELKCITY6	230.00	351	138.5548	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO	230.00	ELKCITY6	230.00	351	124.987	0.17594	CHILDRESS - LAKE PAULINE 138KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO	230.00	ELKCITY6	230.00	351	135.3624	0.16632	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO	230.00	ELKCITY6	230.00	351	135.626	0.17617	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO	230.00	ELKCITY6	230.00	351	127.9097	0.16189	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO	230.00	ELKCITY6	230.00	351	131.1444	0.17679	Hitchland Interchange - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1	BECKHAM CO	230.00	ELKCITY6	230.00	351	139.5739	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - GRAPEVINE INTERCHANGE 230I	GRAPEVINE 6	230.00	BECKHAM CO	230.00	351	108.3806	0.17001	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - GRAPEVINE INTERCHANGE 230I	GRAPEVINE 6	230.00	BECKHAM CO	230.00	351	104.2418	0.18048	Hitchland Interchange - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - GRAPEVINE INTERCHANGE 230I	GRAPEVINE 6	230.00	BECKHAM CO	230.00	351	108.2302	0.17987	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1

GI Request	SEASON	ELEMENT	From	To	RATE	LOADING	TDF	CONTNAME
G07-45	10G	BECKHAM CO 230.00 - GRAPEVINE INTERCHANGE 230I	GRAPEVINE 6 230.00	BECKHAM CO 230.00	351	112.378	0.17491	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - GRAPEVINE INTERCHANGE 230I	GRAPEVINE 6 230.00	BECKHAM CO 230.00	351	104.3	0.15035	BECKHAM CO 230.00 - BECKHAM EHV 230.00 230KV CKT 1
G07-45	10G	BECKHAM CO 230.00 - GRAPEVINE INTERCHANGE 230I	GRAPEVINE 6 230.00	BECKHAM CO 230.00	351	111.3742	0.16984	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	CONWAY SUB - KIRBY SWITCHING STATION 115KV CKT	CONWAY3 115.00	KIRBY3 115.00	160	98.27024	0.33849	BASE CASE
G07-45	10G	CONWAY SUB - KIRBY SWITCHING STATION 115KV CKT	CONWAY3 115.00	KIRBY3 115.00	160	101.4	0.3376	G05-21 115.00 - KIRBY SWITCHING STATION 115KV CKT 1
G07-45	10G	CONWAY SUB - KIRBY SWITCHING STATION 115KV CKT	CONWAY3 115.00	KIRBY3 115.00	160	101.7	0.3376	G05-21 115.00 115/34.5KV TRANSFORMER CKT 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1	CONWAY3 115.00	YARNELL3 115.00	180	116.5353	0.68496	CHILDRESS - LAKE PAULINE 138KV CKT 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1	CONWAY3 115.00	YARNELL3 115.00	180	111.8513	0.67073	MCLEAN RURAL SUB - SHAMROCK 115KV CKT 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1	CONWAY3 115.00	YARNELL3 115.00	180	107.789	0.65405	BASE CASE
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1	CONWAY3 115.00	YARNELL3 115.00	180	106.5189	0.76008	GRAPEVINE INTERCHANGE 230/115KV TRANSFORMER CKT 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1	CONWAY3 115.00	YARNELL3 115.00	180	120.4181	0.66516	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1	CONWAY3 115.00	YARNELL3 115.00	180	113.3118	0.67073	MCCLELLAN SUB - MCLEAN RURAL SUB 115KV CKT 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1	CONWAY3 115.00	YARNELL3 115.00	180	113.6823	0.67073	KIRBY SWITCHING STATION - MCCLELLAN SUB 115KV CKT 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1	CONWAY3 115.00	YARNELL3 115.00	180	111.764	0.67073	SHAMROCK (SHAMRCK1) 115/69/14.4KV TRANSFORMER CKT 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1	CONWAY3 115.00	YARNELL3 115.00	180	107.789	0.65405	BASE CASE
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1	CONWAY3 115.00	YARNELL3 115.00	180	120.324	0.66516	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1	CONWAY3 115.00	YARNELL3 115.00	180	133.7303	0.84718	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATION 115KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	157.5515	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	145.7993	0.16189	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	141.6624	0.15866	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	141.6624	0.15866	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	145.7993	0.16189	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	157.5515	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	152.7948	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	152.7948	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	148.4081	0.16632	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	148.4081	0.16632	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	152.6319	0.16632	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	152.6611	0.17617	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	148.5259	0.17617	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	148.5259	0.17617	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	152.6319	0.16632	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1

GI Request	SEASON	ELEMENT	From		To		RATE	LOADING	TDF	CONTNAME
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	152.6611	0.17617	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	145.0378	0.15866	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	142.2575	0.16189	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	142.2575	0.16189	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	148.2139	0.15866	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	150.9134	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	144.5905	0.15866	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	155.543	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	144.5905	0.15866	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	148.2139	0.15866	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	150.9134	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	155.543	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	145.0378	0.15866	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATI(	KIRBY3	115.00	GRAPEVINE 3	115.00	96	106.5897	0.28178	SHAMROCK - WELLINGTON 138KV CKT 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATI(	KIRBY3	115.00	GRAPEVINE 3	115.00	96	116.9797	0.28178	KIRBY SWITCHING STATION - MCCLELLAN SUB 115KV CKT 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATI(	KIRBY3	115.00	GRAPEVINE 3	115.00	96	115.9822	0.28178	MCCLELLAN SUB - MCLEAN RURAL SUB 115KV CKT 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATI(	KIRBY3	115.00	GRAPEVINE 3	115.00	96	106.3183	0.28178	SHAMROCK (SHAMRCK2) 138/69/14.4KV TRANSFORMER CKT 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATI(	KIRBY3	115.00	GRAPEVINE 3	115.00	96	111.5779	0.28178	SHAMROCK (SHAMRCK1) 115/69/14.4KV TRANSFORMER CKT 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATI(	KIRBY3	115.00	GRAPEVINE 3	115.00	96	124.3116	0.30493	CHILDRESS - LAKE PAULINE 138KV CKT 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATI(	KIRBY3	115.00	GRAPEVINE 3	115.00	96	111.8869	0.28178	MCLEAN RURAL SUB - SHAMROCK 115KV CKT 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1	YARNELL3	115.00	NICHOLS 3	115.00	154	140.518	0.66516	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1	YARNELL3	115.00	NICHOLS 3	115.00	154	140.6275	0.66516	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1	YARNELL3	115.00	NICHOLS 3	115.00	154	147.1368	0.65405	BASE CASE
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1	YARNELL3	115.00	NICHOLS 3	115.00	154	130.5088	0.67073	SHAMROCK (SHAMRCK1) 115/69/14.4KV TRANSFORMER CKT 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1	YARNELL3	115.00	NICHOLS 3	115.00	154	147.1368	0.65405	BASE CASE
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1	YARNELL3	115.00	NICHOLS 3	115.00	154	156.1699	0.84718	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATION 115KV CKT 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1	YARNELL3	115.00	NICHOLS 3	115.00	154	132.3177	0.67073	MCCLELLAN SUB - MCLEAN RURAL SUB 115KV CKT 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1	YARNELL3	115.00	NICHOLS 3	115.00	154	132.7512	0.67073	KIRBY SWITCHING STATION - MCCLELLAN SUB 115KV CKT 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1	YARNELL3	115.00	NICHOLS 3	115.00	154	136.0915	0.68496	CHILDRESS - LAKE PAULINE 138KV CKT 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1	YARNELL3	115.00	NICHOLS 3	115.00	154	130.6104	0.67073	MCLEAN RURAL SUB - SHAMROCK 115KV CKT 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1	YARNELL3	115.00	NICHOLS 3	115.00	154	126.044	0.66711	BOWERS INTERCHANGE - GRAPEVINE INTERCHANGE 115KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.5372	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	104.3153	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	104.3153	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.5372	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	100.4102	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	100.4102	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1

GI Request	SEASON	ELEMENT	From		To		RATE	LOADING	TDF	CONTNAME
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	111.2029	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	111.2029	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.0357	0.16189	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.0357	0.16189	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	103.8709	0.16189	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	103.8709	0.16189	G05-17T 345.00 - Hitchland Interchange 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	112.6049	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	106.9174	0.17617	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.9144	0.15866	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.9144	0.15866	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	107.0918	0.15866	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	107.0918	0.15866	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	112.6049	0.17122	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	101.3401	0.21322	CONWAY SUB - YARNELL SUB 115KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	104.7661	0.16632	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	104.7661	0.16632	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.9468	0.16632	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	105.9468	0.16632	G05-15T 345.00 - TUCO INTERCHANGE 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	101.3401	0.21322	CONWAY SUB - YARNELL SUB 115KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	108.1575	0.17617	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	102.4303	0.21322	CONWAY SUB - YARNELL SUB 115KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	102.4303	0.21322	CONWAY SUB - YARNELL SUB 115KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	101.3383	0.21322	NICHOLS STATION - YARNELL SUB 115KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	101.3383	0.21322	NICHOLS STATION - YARNELL SUB 115KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	102.4284	0.21322	NICHOLS STATION - YARNELL SUB 115KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	102.4284	0.21322	NICHOLS STATION - YARNELL SUB 115KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	106.9174	0.17617	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	108.827	0.15866	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	108.1575	0.17617	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	108.7253	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	108.7253	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	107.4711	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	107.4711	0.16614	G05-15T 345.00 - OKLAUNION 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	108.827	0.15866	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6	230.00	ELKCTY-4	138.00	287	110.0566	0.15866	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1

GI Request	SEASON	ELEMENT	From	To	RATE	LOADING	TDF	CONTNAME
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFOR	ELKCITY6 230.00	ELKCTY-4 138.00	287	110.0566	0.15866	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-45	14SP	NICHOLS STATION - WHITAKER SUB 115KV CKT 1	NICHOLS 3 115.00	WHITAKER 3 115.00	239	104.0847	0.15011	EAST PLANT INTERCHANGE - HARRINGTON STATION 230KV CKT 1
G07-45	14SP	NICHOLS STATION - WHITAKER SUB 115KV CKT 1	NICHOLS 3 115.00	WHITAKER 3 115.00	239	104.0887	0.15011	EAST PLANT INTERCHANGE 230/115KV TRANSFORMER CKT 1
G07-46	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.31843	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-48	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.27906	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	112.2661	0.26882	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	173.2119	0.26882	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	110.8	0.17451	OKLA WIND ENERGY CENTER 138/34.5KV TRANSFORMER CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	252.8193	0.27248	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	112.3706	0.19966	WOODWARD (WOODWRD2) 138/69/13.2KV TRANSFORMER CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	101.3903	0.17753	DEWEY - TALOGA 138KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	151.4093	0.27248	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	110.6	0.17451	FPL SWITCH - OKLA WIND ENERGY CENTER 138KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	100.4327	0.17606	BASE CASE
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	103.7	0.17504	FT SUPPLY - SLEEPING 138.00 138KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	103.7	0.20912	FT SUPPLY - SLEEPING 138.00 138KV CKT 1
G07-50	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.4143	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	127.0869	0.26882	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	141.8961	0.26882	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	146.0752	0.17606	BASE CASE
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	230.3062	0.27248	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	132.3	0.17451	OKLA WIND ENERGY CENTER 138/34.5KV TRANSFORMER CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	123.1367	0.17606	OGE3TERM1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	124.8845	0.17606	OGE3TERM4
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	158.3905	0.19966	WOODWARD (WOODWRD2) 138/69/13.2KV TRANSFORMER CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	132.1	0.17451	FPL SWITCH - OKLA WIND ENERGY CENTER 138KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	130.8	0.20912	FT SUPPLY - SLEEPING 138.00 138KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	130.8	0.17504	FT SUPPLY - SLEEPING 138.00 138KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	131.4522	0.17753	DEWEY - TALOGA 138KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	258.2896	0.27248	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	101.8738	0.26882	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	117.7401	0.19966	WOODWARD (WOODWRD2) 138/69/13.2KV TRANSFORMER CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	105.3279	0.17606	BASE CASE
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	153.3611	0.27248	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	180.9222	0.27248	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1

GI Request	SEASON	ELEMENT	From	To	RATE	LOADING	TDF	CONTNAME
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	110.7876	0.19966	WOODWARD (WOODWRD2) 138/69/13.2KV TRANSFORMER CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	167.4944	0.27248	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	140.0725	0.27248	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	131.5875	0.26882	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	116.3916	0.26882	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	209.2451	0.27248	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	128.1198	0.17606	BASE CASE
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	238.3528	0.27248	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	108.9091	0.17606	OGE3TERM10
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	115.9	0.17451	FPL SWITCH - OKLA WIND ENERGY CENTER 138KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	115.3	0.17504	FT SUPPLY - SLEEPING 138.00 138KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	140.9226	0.19966	WOODWARD (WOODWRD2) 138/69/13.2KV TRANSFORMER CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	109.2522	0.17606	OGE3TERM4
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	107.3442	0.17606	OGE3TERM1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	114.7382	0.17753	DEWEY - TALOGA 138KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	116.1	0.17451	OKLA WIND ENERGY CENTER 138/34.5KV TRANSFORMER CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	115.3	0.20912	FT SUPPLY - SLEEPING 138.00 138KV CKT 1
G07-50	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	110.8915	0.26882	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	104.5	0.17451	OKLA WIND ENERGY CENTER 138/34.5KV TRANSFORMER CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	103.2	0.17504	FT SUPPLY - SLEEPING 138.00 138KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	104.3	0.17451	FPL SWITCH - OKLA WIND ENERGY CENTER 138KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	198.2382	0.27248	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	170.7914	0.27248	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	103.2	0.20912	FT SUPPLY - SLEEPING 138.00 138KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	104.3065	0.17753	DEWEY - TALOGA 138KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	114.3396	0.17606	BASE CASE
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	126.7408	0.19966	WOODWARD (WOODWRD2) 138/69/13.2KV TRANSFORMER CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	139.4352	0.27248	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-50	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	112.2869	0.27248	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	100.4327	0.42203	BASE CASE
G07-51	10G	MOORELAND 138/34.5KV TRANSFORMER CKT 1	G07-51 34.500	MOORLND4 138.00	110	144.7168	1	BASE CASE
G07-51	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.28719	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-51	10G	WOODWARD - WOODWARD 69KV CKT 1	WODWRD 2 69.000	WOODWRD2 69.000	65	139.078	0.17945	FPL SWITCH - MOORELAND 138KV CKT 1
G07-51	10G	WOODWARD - WOODWARD 69KV CKT 1	WODWRD 2 69.000	WOODWRD2 69.000	65	104.7235	0.17848	FPL SWITCH - WOODWARD 138KV CKT 1
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	124.9081	0.4483	ELK CITY - RHWIND4 138.00 138KV CKT 1
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	146.0752	0.42203	BASE CASE
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	109.6	0.42106	TOLK STATION EAST 230/24.0KV TRANSFORMER CKT 1
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	104.7723	0.46278	CLEO CORNER - GLASS MOUNTAIN 138KV CKT 1
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	123.1367	0.42203	OGE3TERM1

GI Request	SEASON	ELEMENT	From	To	RATE	LOADING	TDF	CONTNAME
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	124.8845	0.42203	OGE3TERM4
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	108.3149	0.45754	CEDARDALE - MOORELAND 138KV CKT 1
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	109.0005	0.45754	CEDARDALE - OKEENE 138KV CKT 1
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	105.4488	0.4703	CLEO CORNER - MEN TAP 138KV CKT 1
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	124.1913	0.48039	MOORELAND - MOREWOOD SW 138KV CKT 1
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	106.3679	0.4703	IMO TAP - MEN TAP 138KV CKT 1
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	104.0791	0.46278	GLASS MOUNTAIN - MOORELAND 138KV CKT 1
G07-51	10G	WOODWARD - WOODWARD 69KV CKT 1	WODWRD 2 69.000	WOODWRD2 69.000	65	151.4697	0.17848	FPL SWITCH - WOODWARD 138KV CKT 1
G07-51	10G	WOODWARD - WOODWARD 69KV CKT 1	WODWRD 2 69.000	WOODWRD2 69.000	65	158.7657	0.17945	FPL SWITCH - MOORELAND 138KV CKT 1
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	105.3279	0.42203	BASE CASE
G07-51	10G	WOODWARD - WOODWARD 69KV CKT 1	WODWRD 2 69.000	WOODWRD2 69.000	65	118.0039	0.17945	FPL SWITCH - MOORELAND 138KV CKT 1
G07-51	10G	WOODWARD - WOODWARD 69KV CKT 1	WODWRD 2 69.000	WOODWRD2 69.000	65	110.2419	0.17848	FPL SWITCH - WOODWARD 138KV CKT 1
G07-51	10G	WOODWARD - WOODWARD 69KV CKT 1	WODWRD 2 69.000	WOODWRD2 69.000	65	111.0121	0.17945	FPL SWITCH - MOORELAND 138KV CKT 1
G07-51	10G	WOODWARD - WOODWARD 69KV CKT 1	WODWRD 2 69.000	WOODWRD2 69.000	65	103.1878	0.17848	FPL SWITCH - WOODWARD 138KV CKT 1
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	128.1198	0.42203	BASE CASE
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	113.5376	0.4483	ELK CITY - RHWIND4 138.00 138KV CKT 1
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	108.9091	0.42203	OGE3TERM10
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	117.628	0.48039	MOORELAND - MOREWOOD SW 138KV CKT 1
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	109.2522	0.42203	OGE3TERM4
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	107.3442	0.42203	OGE3TERM1
G07-51	10G	WOODWARD - WOODWARD 69KV CKT 1	WODWRD 2 69.000	WOODWRD2 69.000	65	134.5373	0.17848	FPL SWITCH - WOODWARD 138KV CKT 1
G07-51	10G	WOODWARD - WOODWARD 69KV CKT 1	WODWRD 2 69.000	WOODWRD2 69.000	65	141.8242	0.17945	FPL SWITCH - MOORELAND 138KV CKT 1
G07-51	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	114.3396	0.42203	BASE CASE
G07-51	10G	WOODWARD - WOODWARD 69KV CKT 1	WODWRD 2 69.000	WOODWRD2 69.000	65	119.2632	0.17848	FPL SWITCH - WOODWARD 138KV CKT 1
G07-51	10G	WOODWARD - WOODWARD 69KV CKT 1	WODWRD 2 69.000	WOODWRD2 69.000	65	126.9955	0.17945	FPL SWITCH - MOORELAND 138KV CKT 1
G07-52	14SP	ANADARKO 138/13.8KV TRANSFORMER CKT 1	G07-52 13.800	ANADARK4 138.00	75	127.5591	0.5	BASE CASE
G07-52	14SP	ANADARKO 138/13.8KV TRANSFORMER CKT 1	G07-52 13.800	ANADARK4 138.00	75	203.655	1	ANADARKO 138/13.8KV TRANSFORMER CKT 2
G07-52	14SP	ANADARKO 138/13.8KV TRANSFORMER CKT 1	G07-52 13.800	ANADARK4 138.00	75	203.655	1	ANADARKO 138/13.8KV TRANSFORMER CKT 2
G07-52	14SP	ANADARKO 138/13.8KV TRANSFORMER CKT 1	G07-52 13.800	ANADARK4 138.00	75	127.5591	0.5	BASE CASE
G07-52	14SP	ANADARKO 138/13.8KV TRANSFORMER CKT 2	G07-52 13.800	ANADARK4 138.00	75	127.5591	0.5	BASE CASE
G07-52	14SP	ANADARKO 138/13.8KV TRANSFORMER CKT 2	G07-52 13.800	ANADARK4 138.00	75	203.655	1	ANADARKO 138/13.8KV TRANSFORMER CKT 1
G07-52	14SP	ANADARKO 138/13.8KV TRANSFORMER CKT 2	G07-52 13.800	ANADARK4 138.00	75	203.655	1	ANADARKO 138/13.8KV TRANSFORMER CKT 1
G07-52	14SP	ANADARKO 138/13.8KV TRANSFORMER CKT 2	G07-52 13.800	ANADARK4 138.00	75	127.5591	0.5	BASE CASE
G07-52	14WP	ANADARKO 138/13.8KV TRANSFORMER CKT 1	G07-52 13.800	ANADARK4 138.00	75	203.6173	1	ANADARKO 138/13.8KV TRANSFORMER CKT 2
G07-52	14WP	ANADARKO 138/13.8KV TRANSFORMER CKT 1	G07-52 13.800	ANADARK4 138.00	75	203.6173	1	ANADARKO 138/13.8KV TRANSFORMER CKT 2
G07-52	14WP	ANADARKO 138/13.8KV TRANSFORMER CKT 1	G07-52 13.800	ANADARK4 138.00	75	127.5175	0.5	BASE CASE
G07-52	14WP	ANADARKO 138/13.8KV TRANSFORMER CKT 1	G07-52 13.800	ANADARK4 138.00	75	127.5175	0.5	BASE CASE
G07-52	14WP	ANADARKO 138/13.8KV TRANSFORMER CKT 2	G07-52 13.800	ANADARK4 138.00	75	127.5175	0.5	BASE CASE
G07-52	14WP	ANADARKO 138/13.8KV TRANSFORMER CKT 2	G07-52 13.800	ANADARK4 138.00	75	127.5175	0.5	BASE CASE
G07-52	14WP	ANADARKO 138/13.8KV TRANSFORMER CKT 2	G07-52 13.800	ANADARK4 138.00	75	203.6173	1	ANADARKO 138/13.8KV TRANSFORMER CKT 1
G07-52	14WP	ANADARKO 138/13.8KV TRANSFORMER CKT 2	G07-52 13.800	ANADARK4 138.00	75	203.6173	1	ANADARKO 138/13.8KV TRANSFORMER CKT 1
G07-57	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.30151	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	112.2661	0.23117	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	173.2119	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	252.8193	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	151.4093	0.23484	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-62	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.46637	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	127.0869	0.23117	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	141.8961	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	230.3062	0.23484	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1

GI Request	SEASON	ELEMENT	From		To		RATE	LOADING	TDF	CONTNAME
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	258.2896	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4	138.00	MOORLND4	138.00	287	101.8738	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	180.9222	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	153.3611	0.23484	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	140.0725	0.23484	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	167.4944	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4	138.00	MOORLND4	138.00	287	131.5875	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4	138.00	MOORLND4	138.00	287	116.3916	0.23117	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	238.3528	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	209.2451	0.23484	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4	138.00	MOORLND4	138.00	287	110.8915	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	170.7914	0.23484	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	198.2382	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	139.4352	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	112.2869	0.23484	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4	138.00	MOORLND4	138.00	287	112.2661	0.26882	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4	138.00	MOORLND4	138.00	287	173.2119	0.26882	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	151.4093	0.27248	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	112.3706	0.19966	WOODWARD (WOODWRD2) 138/69/13.2KV TRANSFORMER CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	110.8	0.17451	OKLA WIND ENERGY CENTER 138/34.5KV TRANSFORMER CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	252.8193	0.27248	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	110.6	0.17451	FPL SWITCH - OKLA WIND ENERGY CENTER 138KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	101.3903	0.17753	DEWEY - TALOGA 138KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	100.4327	0.17606	BASE CASE
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	103.7	0.20912	FT SUPPLY - SLEEPING 138.00 138KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	103.7	0.17504	FT SUPPLY - SLEEPING 138.00 138KV CKT 1
G08-03	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(		NORTWST7	345.00	1195	103.3367	0.4143	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4	138.00	MOORLND4	138.00	287	127.0869	0.26882	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4	138.00	MOORLND4	138.00	287	141.8961	0.26882	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	132.3	0.17451	OKLA WIND ENERGY CENTER 138/34.5KV TRANSFORMER CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	230.3062	0.27248	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1

GI Request	SEASON	ELEMENT	From		To		RATE	LOADING	TDF	CONTNAME
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	158.3905	0.19966	WOODWARD (WOODWRD2) 138/69/13.2KV TRANSFORMER CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	146.0752	0.17606	BASE CASE
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	123.1367	0.17606	OGE3TERM1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	124.8845	0.17606	OGE3TERM4
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	132.1	0.17451	FPL SWITCH - OKLA WIND ENERGY CENTER 138KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	258.2896	0.27248	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	130.8	0.20912	FT SUPPLY - SLEEPING 138.00 138KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	130.8	0.17504	FT SUPPLY - SLEEPING 138.00 138KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	131.4522	0.17753	DEWEY - TALOGA 138KV CKT 1
G08-03	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4	138.00	MOORLND4	138.00	287	101.8738	0.26882	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	117.7401	0.19966	WOODWARD (WOODWRD2) 138/69/13.2KV TRANSFORMER CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	105.3279	0.17606	BASE CASE
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	180.9222	0.27248	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	153.3611	0.27248	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	110.7876	0.19966	WOODWARD (WOODWRD2) 138/69/13.2KV TRANSFORMER CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	140.0725	0.27248	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	167.4944	0.27248	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4	138.00	MOORLND4	138.00	287	131.5875	0.26882	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4	138.00	MOORLND4	138.00	287	116.3916	0.26882	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	128.1198	0.17606	BASE CASE
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	209.2451	0.27248	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	115.3	0.20912	FT SUPPLY - SLEEPING 138.00 138KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	238.3528	0.27248	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	108.9091	0.17606	OGE3TERM10
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	115.9	0.17451	FPL SWITCH - OKLA WIND ENERGY CENTER 138KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	109.2522	0.17606	OGE3TERM4
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	114.7382	0.17753	DEWEY - TALOGA 138KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	115.3	0.17504	FT SUPPLY - SLEEPING 138.00 138KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	107.3442	0.17606	OGE3TERM1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	116.1	0.17451	OKLA WIND ENERGY CENTER 138/34.5KV TRANSFORMER CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	140.9226	0.19966	WOODWARD (WOODWRD2) 138/69/13.2KV TRANSFORMER CKT 1
G08-03	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4	138.00	MOORLND4	138.00	287	110.8915	0.26882	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	104.3	0.17451	FPL SWITCH - OKLA WIND ENERGY CENTER 138KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	198.2382	0.27248	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	104.5	0.17451	OKLA WIND ENERGY CENTER 138/34.5KV TRANSFORMER CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	126.7408	0.19966	WOODWARD (WOODWRD2) 138/69/13.2KV TRANSFORMER CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4	138.00	WINDFRM4	138.00	153	103.2	0.17504	FT SUPPLY - SLEEPING 138.00 138KV CKT 1

GI Request	SEASON	ELEMENT	From	To	RATE	LOADING	TDF	CONTNAME
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	170.7914	0.27248	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	103.2	0.20912	FT SUPPLY - SLEEPING 138.00 138KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	104.3065	0.17753	DEWEY - TALOGA 138KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	114.3396	0.17606	BASE CASE
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	139.4352	0.27248	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-03	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	112.2869	0.27248	TATONGA EHV 345.00 - WWRDEHV7 345.00 345KV CKT 1
G08-08	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.26331	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G08-08	10G	DEAF SMITH COUNTY INTERCHANGE - G06-39T 230.0	G06-39T 230.00	DEAFSMITH 6 230.00	351	108.0012	0.17852	G06-39T 230.00 - PLANT X STATION 230KV CKT 1
G08-09	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.27362	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G08-09	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	108.3223	0.23632	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G08-09	10G	DEAF SMITH COUNTY INTERCHANGE - G06-39T 230.0	G06-39T 230.00	DEAFSMITH 6 230.00	351	108.0012	0.28994	G06-39T 230.00 - PLANT X STATION 230KV CKT 1
G08-09	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	101.9795	0.24755	JONES STATION - TUCO INTERCHANGE 230KV CKT 1
G08-09	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	112.8452	0.26516	SUNDOWN INTERCHANGE - WOLFFORTH INTERCHANGE 230KV CKT 1
G08-09	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	114.7617	0.23632	Hitchland Interchange - WWRDEHV7 345.00 345KV CKT 1
G08-09	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	104.0732	0.23241	MIDLAND COUNTY INTERCHANGE 230/138KV TRANSFORMER CKT 1
G08-09	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	103.1406	0.23241	CAPROCK REC-PHILLIPS - CAPROCK REC-TATE 138KV CKT 1
G08-09	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	103.8148	0.23539	PLANT X STATION 230/115KV TRANSFORMER CKT 1
G08-09	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	105.4831	0.25709	LUBBOCK SOUTH INTERCHANGE - WOLFFORTH INTERCHANGE 230KV CKT 1
G08-09	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	105.2035	0.2254	BASE CASE
G08-09	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	113.5362	0.2254	PNM BLACKWATER DC TIE - Roosevelt County Interchange SOUTH 230KV CKT 1
G08-09	10G	TOLK STATION EAST - TUCO INTERCHANGE 230KV CKT	TOLK_EAST 6 230.00	TUCO_INT 6 230.00	351	104.0732	0.23241	HOBBS INTERCHANGE - MIDLAND COUNTY INTERCHANGE 230KV CKT 1
G08-09	14SP	ROOSEVELT COUNTY INTERCHANGE 230/115KV TRANS	ROSEVELT_N 6230.0(	ROOSEVELT 3 115.00	289.8	103.7737	0.35357	OASIS INTERCHANGE - Roosevelt County Interchange SWITCH #4K33 230KV CKT 1
G08-09	14SP	ROOSEVELT COUNTY INTERCHANGE 230/115KV TRANS	ROSEVELT_N 6230.0(	ROOSEVELT 3 115.00	289.8	103.7737	0.35357	OASIS INTERCHANGE - Roosevelt County Interchange SWITCH #4K33 230KV CKT 1
G08-09	14SP	ROOSEVELT COUNTY INTERCHANGE 230/115KV TRANS	ROSEVELT_N 6230.0(	ROOSEVELT 3 115.00	289.8	103.7737	0.35388	OASIS INTERCHANGE - Roosevelt County Interchange SWITCH #4K33 230KV CKT 1
G08-14	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.19984	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G08-16	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.26342	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G08-16	10G	DEAF SMITH COUNTY INTERCHANGE - G06-39T 230.0	G06-39T 230.00	DEAFSMITH 6 230.00	351	108.0012	0.18042	G06-39T 230.00 - PLANT X STATION 230KV CKT 1
G08-17	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORME	SPERVIL7 345.00	SPEARVL6 230.00	336	105.5169	0.16757	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G08-17	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORME	SPERVIL7 345.00	SPEARVL6 230.00	336	105.5169	0.16757	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G08-17	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORME	SPERVIL7 345.00	SPEARVL6 230.00	336	105.3782	0.16757	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G08-17	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORME	SPERVIL7 345.00	SPEARVL6 230.00	336	105.3782	0.16757	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G08-17	10G	CIRCLE - MULLERGREN 230KV CKT 1	MULGREN6 230.00	CIRCLE 6 230.00	319	113.4888	0.16917	Hitchland Interchange - STEVENS CO 345.00 345KV CKT 1
G08-17	10G	CIRCLE - MULLERGREN 230KV CKT 1	MULGREN6 230.00	CIRCLE 6 230.00	319	105.872	0.17007	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1

GI Request	SEASON	ELEMENT	From	To	RATE	LOADING	TDF	CONTNAME
G08-17	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	109.0286	0.15395	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G08-17	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	116.2148	0.15307	Hitchland Interchange - STEVENS CO 345.00 345KV CKT 1
G08-18	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	121.0841	0.17974	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G08-18	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORMEI	SPERVIL7 345.00	SPEARVL6 230.00	336	105.5169	0.21431	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G08-18	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORMEI	SPERVIL7 345.00	SPEARVL6 230.00	336	105.5169	0.21431	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G08-18	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORMEI	SPERVIL7 345.00	SPEARVL6 230.00	336	105.3782	0.21431	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G08-18	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORMEI	SPERVIL7 345.00	SPEARVL6 230.00	336	105.3782	0.21431	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G08-18	10G	CIRCLE - MULLERGREN 230KV CKT 1	MULGREN6 230.00	CIRCLE 6 230.00	319	113.4888	0.17808	Hitchland Interchange - STEVENS CO 345.00 345KV CKT 1
G08-18	10G	CIRCLE - MULLERGREN 230KV CKT 1	MULGREN6 230.00	CIRCLE 6 230.00	319	105.872	0.17898	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G08-18	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	109.0286	0.17756	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G08-18	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	157.1427	0.17974	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G08-18	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	116.2148	0.17668	Hitchland Interchange - STEVENS CO 345.00 345KV CKT 1
G08-18	10G	MULLERGREN - SPEARVILLE 230KV CKT 1	SPEARVL6 230.00	MULGREN6 230.00	355.3	100.3049	0.17974	KNOLL345 345.00 - SPEARVILLE 345KV CKT 1
G08-19	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	173.2119	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-19	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	252.8193	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-19	10G	G08-19 345.00 345/34.5KV TRANSFORMER CKT 1	G08-19 34.500	G08-19 345.00	150	162.2622	1	BASE CASE
G08-19	10G	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1	TATONGA EHV 345.0(	NORTWST7 345.00	1195	103.3367	0.58743	FINNEY SWITCHING STATION - STEVENS CO 345.00 345KV CKT 1
G08-19	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	141.8961	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-19	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	258.2896	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-19	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	101.8738	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-19	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	180.9222	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-19	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	167.4944	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-19	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	131.5875	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-19	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	238.3528	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-19	10G	FPL SWITCH - MOORELAND 138KV CKT 1	WINDFRM4 138.00	MOORLND4 138.00	287	110.8915	0.23117	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-19	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	198.2382	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G08-19	10G	FPL SWITCH - WOODWARD 138KV CKT 1	WOODWRD4 138.00	WINDFRM4 138.00	153	139.4352	0.23484	NORTHWEST - TATONGA EHV 345.00 345KV CKT 1
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1			153	166.1332	0.23475	515375 WWRDEHV7 345 515378 TATONGA EHV 345 1
G07-62	10G	FPL SWITCH - WOODWARD 138KV CKT 1			153	166.0025	0.23475	514880 NORTWST7 345 515378 TATONGA EHV 345 1
G07-62	10G	FPL SWITCH - MOORELAND 138KV CKT 1			286.7	120.2602	0.2324	515375 WWRDEHV7 345 515378 TATONGA EHV 345 1
G07-62	10G	FPL SWITCH - MOORELAND 138KV CKT 1			286.7	120.1904	0.2324	514880 NORTWST7 345 515378 TATONGA EHV 345 1
G06-06	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORMER CKT 1			325.7	133.5116	0.9012	539679 MULGREN6 230 539695 SPEARVL6 230 1
G06-06	10G	SPEARVILLE (SPEARVL) 345/230/13.8KV TRANSFORMER CKT 1			331.2	131.2944	0.9012	539679 MULGREN6 230 539695 SPEARVL6 230 1
G06-06	10G	MULLERGREN - SPEARVILLE 230KV CKT 1			354.6	111.8464	0.76557	3Wnd: OPEN B$0762 SPEARVL 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	136.6622	0.31518	515375 WWRDEHV7 345 523097 HITCHLAND 7 345 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	135.7257	0.31518	515375 WWRDEHV7 345 523097 HITCHLAND 7 345 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	129.7887	0.31334	511456 O.K.U.-7 345 560071 G05-15T 345 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	128.9028	0.31334	511456 O.K.U.-7 345 560071 G05-15T 345 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	128.3481	0.31375	525832 TUCO_INT 7 345 560071 G05-15T 345 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	129.094	0.32412	523853 FINNEY7 345 560010 STEVENS CO 345 1

GI Request	SEASON	ELEMENT	From	To	RATE	LOADING	TDF	CONTNAME
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	127.4728	0.31375	525832 TUCO_INT 7 345 560071 G05-15T 345 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	128.2133	0.32412	523853 FINNEY7 345 560010 STEVENS CO 345 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	125.2685	0.3107	523097 HITCHLAND 7 345 560043 G05-17T 345 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	124.416	0.3107	523097 HITCHLAND 7 345 560043 G05-17T 345 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	124.0473	0.30718	515375 WWRDEHV7 345 515378 TATONGA EHV 345 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	124.012	0.30718	514880 NORTWST7 345 515378 TATONGA EHV 345 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	123.2038	0.30718	515375 WWRDEHV7 345 515378 TATONGA EHV 345 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	123.2038	0.30718	514880 NORTWST7 345 515378 TATONGA EHV 345 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	123.3834	0.31125	3Wnd: OPEN B$0855 WAUK 90343-A 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	122.5798	0.31125	3Wnd: OPEN B$0855 WAUK 90343-A 1
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	116.1968	0.29779	Base Case
G07-08	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	115.4111	0.29779	Base Case
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1			349.5	110.7165	0.31518	515375 WWRDEHV7 345 523097 HITCHLAND 7 345 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1			349.5	105.1508	0.31334	511456 O.K.U.-7 345 560071 G05-15T 345 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1			349.5	104.5883	0.32412	523853 FINNEY7 345 560010 STEVENS CO 345 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1			349.5	103.9843	0.31375	525832 TUCO_INT 7 345 560071 G05-15T 345 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1			317.3	103.699	0.29779	Base Case
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1			349.5	101.4907	0.3107	523097 HITCHLAND 7 345 560043 G05-17T 345 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1			349.5	100.5019	0.30718	515375 WWRDEHV7 345 515378 TATONGA EHV 345 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1			349.5	100.5019	0.30718	514880 NORTWST7 345 515378 TATONGA EHV 345 1
G07-08	10G	BECKHAM CO 230.00 - ELK CITY 230KV 230KV CKT 1			349.5	100.2292	0.32567	523097 HITCHLAND 7 345 560010 STEVENS CO 345 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	113.8052	0.17467	515375 WWRDEHV7 345 523097 HITCHLAND 7 345 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATION 115KV CKT 1			94.5	285.2171	0.80427	524072 YARNELL3 115 524079 CONWAY3 115 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATION 115KV CKT 1			94.5	284.0531	0.80427	524043 NICHOLS 3 115 524072 YARNELL3 115 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	113.037	0.17467	515375 WWRDEHV7 345 523097 HITCHLAND 7 345 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1			153.3	224.6133	0.99551	524079 CONWAY3 115 524088 KIRBY3 115 1
G07-45	10G	CONWAY SUB - KIRBY SWITCHING STATION 115KV CKT 1			158.4	218.2022	0.99551	524072 YARNELL3 115 524079 CONWAY3 115 1
G07-45	10G	CONWAY SUB - KIRBY SWITCHING STATION 115KV CKT 1			158.4	217.3815	0.99551	524043 NICHOLS 3 115 524072 YARNELL3 115 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1			179.7	192.3385	0.99551	524079 CONWAY3 115 524088 KIRBY3 115 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATION 115KV CKT 1			94.5	147.0609	0.28405	523804 MCCLELLAN 3 115 524088 KIRBY3 115 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATION 115KV CKT 1			94.5	144.627	0.28405	523804 MCCLELLAN 3 115 523811 MCLEAN 3 115 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1			153.3	179.7595	0.84954	523770 GRAPEVINE 3 115 524088 KIRBY3 115 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATION 115KV CKT 1			94.5	145.287	0.30758	512101 CHILD4WT 138 512110 LAKEP4WT 138 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATION 115KV CKT 1			94.5	140.5001	0.28405	3Wnd: OPEN B$0746 SHAMRCK1 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATION 115KV CKT 1			94.5	140.5001	0.28405	512107 SHAM 3WT 115 523811 MCLEAN 3 115 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATION 115KV CKT 1			94.5	136.9022	0.28405	3Wnd: OPEN B$0747 SHAMRCK2 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATION 115KV CKT 1			94.5	136.5847	0.28405	512104 WELL 4WT 138 512105 SHAM 4WT 138 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1			119.1	165.2435	0.655	Base Case
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	106.9267	0.17136	511456 O.K.U.-7 345 560071 G05-15T 345 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1			179.7	154.0742	0.84954	523770 GRAPEVINE 3 115 524088 KIRBY3 115 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	106.2092	0.17136	511456 O.K.U.-7 345 560071 G05-15T 345 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1			153.3	142.468	0.67195	523804 MCCLELLAN 3 115 524088 KIRBY3 115 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1			153.3	141.3889	0.66637	3Wnd: OPEN B$0338 ELKCTY-6 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1			153.3	141.3889	0.66637	511490 ELKCITY6 230 560012 BECKHAM CO 230 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1			153.3	141.5548	0.67195	523804 MCCLELLAN 3 115 523811 MCLEAN 3 115 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1			153.3	141.7979	0.68641	512101 CHILD4WT 138 512110 LAKEP4WT 138 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1			153.3	139.9892	0.67195	3Wnd: OPEN B$0746 SHAMRCK1 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1			153.3	139.9892	0.67195	512107 SHAM 3WT 115 523811 MCLEAN 3 115 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	105.4674	0.17177	525832 TUCO_INT 7 345 560071 G05-15T 345 1
G07-45	10G	NICHOLS STATION - YARNELL SUB 115KV CKT 1			153.3	139.218	0.66796	523748 BOWERS 3 115 523770 GRAPEVINE 3 115 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	105.7025	0.18151	523853 FINNEY7 345 560010 STEVENS CO 345 1
G07-45	10G	GRAPEVINE INTERCHANGE - KIRBY SWITCHING STATION 115KV CKT 1			83.3	124.5616	0.25649	Base Case
G07-45	10G	GRAPEVINE INTERCHANGE 230/115KV TRANSFORMER CKT 1			124.2	140.1667	0.62624	524072 YARNELL3 115 524079 CONWAY3 115 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	104.7607	0.17177	525832 TUCO_INT 7 345 560071 G05-15T 345 1
G07-45	10G	GRAPEVINE INTERCHANGE 230/115KV TRANSFORMER CKT 1			124.2	139.5226	0.62624	524043 NICHOLS 3 115 524072 YARNELL3 115 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	104.9941	0.18151	523853 FINNEY7 345 560010 STEVENS CO 345 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1			179.7	122.3169	0.67195	523804 MCCLELLAN 3 115 524088 KIRBY3 115 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1			179.7	121.5378	0.67195	523804 MCCLELLAN 3 115 523811 MCLEAN 3 115 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1			179.7	121.3407	0.66637	3Wnd: OPEN B$0338 ELKCTY-6 1

GI Request	SEASON	ELEMENT	From	To	RATE	LOADING	TDF	CONTNAME
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1			179.7	121.3407	0.66637	511490 ELKCITY6 230 560012 BECKHAM CO 230 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1			179.7	121.7452	0.68641	512101 CHILD4WT 138 512110 LAKEP4WT 138 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1			179.7	124.0545	0.76214	523770 GRAPEVINE 3 115 523771 GRAPEVINE 6 230 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1			179.7	120.1466	0.67195	3Wnd: OPEN B$0746 SHAMRCK1 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1			179.7	120.1466	0.67195	512107 SHAM 3WT 115 523811 MCLEAN 3 115 1
G07-45	10G	CONWAY SUB - YARNELL SUB 115KV CKT 1			163.7	121.0171	0.655	Base Case
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	102.3885	0.16643	523097 HITCHLAND 7 345 560043 G05-17T 345 1
G07-45	10G	CONWAY SUB - KIRBY SWITCHING STATION 115KV CKT 1			158.4	107.5999	0.33999	560038 G05-21 34.5 560039 G05-21 .600 1
G07-45	10G	CONWAY SUB - KIRBY SWITCHING STATION 115KV CKT 1			158.4	107.5368	0.33999	560037 G05-21 115 560038 G05-21 34.5 1
G07-45	10G	CONWAY SUB - KIRBY SWITCHING STATION 115KV CKT 1			158.4	107.4737	0.33999	524088 KIRBY3 115 560037 G05-21 115 1
G07-45	10G	CONWAY SUB - KIRBY SWITCHING STATION 115KV CKT 1			137.1	107.6043	0.3405	Base Case
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	101.7045	0.16643	523097 HITCHLAND 7 345 560043 G05-17T 345 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	101.2951	0.16237	515375 WWRDEHV7 345 515378 TATONGA EHV 345 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	101.2598	0.16237	514880 NORTWST7 345 515378 TATONGA EHV 345 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	100.7314	0.15187	524911 ROSEVELT_S 6 230 599955 PNM-DC6 230 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	100.6192	0.16237	515375 WWRDEHV7 345 515378 TATONGA EHV 345 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	100.6192	0.16237	514880 NORTWST7 345 515378 TATONGA EHV 345 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			283	100.5801	0.16691	523804 MCCLELLAN 3 115 524088 KIRBY3 115 1
G07-45	10G	CONWAY SUB - KIRBY SWITCHING STATION 115KV CKT 1			158.4	100.4593	0.34519	515375 WWRDEHV7 345 523097 HITCHLAND 7 345 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	100.0595	0.15187	524911 ROSEVELT_S 6 230 599955 PNM-DC6 230 1
G07-45	10G	ELK CITY 230KV (ELKCTY-6) 230/138/13.8KV TRANSFORMER CKT 1			285.1	100.0534	0.21668	524072 YARNELL3 115 524079 CONWAY3 115 1
G07-48	10G	AMARILLO SOUTH INTERCHANGE - G07-48T 230.00 230KV CKT 1			350.3	114.4733	1	525213 SWISHER 6 230 560164 G07-48T 230 1
G07-48	10G	G07-48T 230.00 - SWISHER COUNTY INTERCHANGE 230KV CKT 1			350.6	114.3754	1	524415 AMA_SOUTH 6 230 560164 G07-48T 230 1
G08-16	10G	GRASSLAND INTERCHANGE 230/115KV TRANSFORMER CKT 1			114.8	172.5783	0.66379	526338 JONES_BUS2 6 230 526677 GRASSLAND 6 230 1
G07-32	10G	CLINTON JUNCTION - G07-32T 138.00 138KV CKT 1			142.6	105.1893	1	520600 G07-32T 138 520856 CLINTON4 138 1
G07-32	10G	CLINTON - G07-32T 138.00 138KV CKT 1			142.7	105.1156	1	511485 CLINTJC4 138 520600 G07-32T 138 1
G07-32	10G	CLINTON JUNCTION - G07-32T 138.00 138KV CKT 1			142.6	106.5217	1	520856 CLINTON4 138 521092 WEATHFD4 138 1
G07-32	10G	CLINTON JUNCTION - G07-32T 138.00 138KV CKT 1			142.6	108.906	1	520950 HYDRO 4 138 521092 WEATHFD4 138 1

I: ACCC Analysis (Upgrades Included no threshold)

See Attachment

J: Stability Study for Group 1

Draft Report

For

Southwest Power Pool

From

S&C Electric Company

CLUSTER GROUP 1 GENERATION INTERCONNECTION IMPACT RESTUDY

S&C Project No. 4161

December 17, 2009

S&C Electric Company

S&C Electric Company, Chicago, IL 60626-3997, Phone: (773) 338-1000

Power Systems Services Division Fax: (773) 338-4254

TABLE OF CONTENTS

Report Revision History:

Date of Report	Issue	Comments
December 17, 2009	Rev. A	Draft for review and comments

Report prepared by:

George Tsai
Senior Engineer

Report approved by:

Vincent Stewart
Manager – Consulting and Analytical Services

EXECUTIVE SUMMARY

S&C Electric Company previously performed an interconnection impact study for the Cluster Group 1 projects in response to a request through the Southwest Power Pool (SPP) Tariff studies. As a result of a reduction in the number of wind generation projects in Cluster Group 1, SPP has recently requested a restudy with the remaining projects. Cluster Group 1 consists of GEN-2007-021, GEN-2007-044, GEN-2007-050, GEN-2007-051, GEN-2007-062, GEN-2008-003, GEN-2008-013 and GEN-2008-019. Previously it included GEN-2007-060 and GEN-2007-061.

Cluster Group 1 generation projects can successfully interconnect into the transmission system at their desired locations provided that the wind farms can supply the reactive power needed to meet a voltage schedule equal to the base case voltage or nominal voltage, whichever is higher at the Point of Interconnection (POI) for single transmission facility outage contingencies specified by SPP. Cluster Group 1 leading power factor requirements for worst single transmission facility outage contingencies consist of the following:

- 98.83 % leading power factor at Tatonga 345 kV POI
- 99.52 % leading power factor at Woodward 138 kV POI
- 73.88 % leading power factor at Mooreland 138 kV POI
- 94.77 % leading power factor at Woodward 345 kV POI
- 98.10 % leading power factor at POI in the Wichita – Woodring 345 kV line

The system will remain stable for 3-phase and single-line-to-ground fault contingencies at locations specified by SPP provided that there are two Woodward 345/138 kV transformers with similar specifications in parallel. Otherwise, undamped voltage, frequency and power oscillations may be observed at the terminals of wind turbine generators from GEN-2008-003, GEN-2007-050, GEN-2001-014, GEN-2006-046, GEN 2001-037, GEN-2002-005, and GEN-2007-051 for faults #7, #8. #57 and #58. SPP intends to install two 345/138 kV transformers.

Cluster Group 1 and prior queued project will survive each fault contingency for Winter and Summer Peak with the exception of GEN-2001-037 for fault contingency #63 for summer peak. No remedial action is required. The system will be stable regardless of whether GEN-2001-037 trips off or survives fault contingency #63.

1. INTRODUCTION

S&C Electric Company previously performed an interconnection impact study for the Cluster Group 1 projects in response to a request through the Southwest Power Pool (SPP) Tariff studies. As a result of a reduction in the number of projects in Cluster Group 1, SPP has recently requested a restudy with the remaining projects.

Cluster Group 1 projects consist of eight (8) wind farms that would be located in areas controlled by Oklahoma Gas and Electric (OKGE), Western Farmers Electric Cooperative (WFEC), and Westar Energy, Inc. (WERE) with in-service year request of 2010.

Cluster Group 1 consists of the following wind generation projects:

GEN-2007-021 – GE 1.5 MW – 201 MW
GEN-2007-044 – GE 1.5 MW – 300 MW
GEN-2007-050 – Siemens 2.3 MW – 171 MW
GEN-2007-051 – GE 1.5 MW – 200 MW
GEN-2007-062 – GE 1.5 MW – 765 MW
GEN-2008-003 – Siemens 2.3 MW – 101 MW
GEN-2008-013 – GE 1.5 MW – 300 MW
GEN-2008-019 – Mitsubishi 2.4 MW – 300 MW

No longer part of Cluster Group 1:

GEN-2007-060 – GE 1.5 MW – 202 MW
GEN-2007-061 – GE 1.5 MW – 200 MW

Studies were performed for summer and winter 2010 peak loading conditions with studied wind farms operating at rated output power. Seasonal power flow models including aggregate models of the projects studied were provided by SPP. Wind turbine generators represented by the projects are General Electric GE 1.5 MW, Siemens SWT 2.3 MW (SWT-2.3-93 60 Hz), and Mitsubishi MWT-95 – 2.4 MW.

2. TRANSMISSION SYSTEM AND STUDY AREA

The study area involves transmission facilities at 345, 230 and 138 kV. The wind generation projects will interconnect at the following locations:

345 kV Tatonga substation (OKGE): GEN-2007-021, GEN-2007-044, and GEN-2008-019.
138 kV Woodward substation (OKGE): GEN-2007-050 and GEN-2008-003
138 kV Mooreland substation (WFEC): GEN-2007-051
345 kV Woodward substation (OKGE): GEN-2007-062
345 kV substation located between Wichita and Woodring (WERE): GEN-2008-013

The following areas were monitored for power flow and dynamic stability analysis:

Oklahoma Gas and Electric (OKGE)
Western Farmers Electric Cooperative (WFEC)
AEP West (AEPW)
Sunflower Electric Power Company (SUNC)
Mid-Kansas Electric Company (MKEC)
Southwestern Public Service (SPS)
Westar Energy, Inc (WERE)

3. POWER FLOW BASE CASES

The following power flow base cases were received from SPP on October 16, 2009:

ICS08-01_G1_10SP_Restudy_w06-49.sav – Summer peak 2010, which includes aggregate representation of wind turbine generators for Cluster Group 1 wind farms and prior queued projects at 100% output power. Other cluster projects were also included with wind farms at 20% output power.

ICS08-01_G1_10WP_Restudy_w06-49.sav – Winter peak 2010, which includes aggregate representation of wind turbine generators for Cluster Group 1 wind farms and prior queued projects at 100% output power. Other cluster projects were also included with wind farms at 20% output power.

Bases provided by SPP had a single Woodward 345/138 kV transformer.

4. Wind Farm Models

Cluster Group 1 wind farms and prior queued projects were modeled as aggregates of wind turbine generators. The aggregate models were part of the base case supplied by SPP.

4.1 General Electric GE – 1.5 MW/60 Hz Wind Turbine Generator

The GE 1.5 MW wind turbine generator is a widely used variable-speed doubly-fed induction generator with power converter and electrical pitch control. The standard GE turbine can operate continuously between 95% leading (capacitive) to 95% lagging (inductive). With an optional upgrade, the turbines can continuously operate between 90% leading to 90% lagging. For wind farms that are required to meet a voltage schedule at the POI, the GE WindCONTROL system is available to dynamically control the power factor of each wind turbine generator as well as the switching operation of any capacitor/reactor bank. The GE controls feature local and remote voltage and power factor control.

4.2 Siemens SWT – 2.3 MW (SWT-2.3-93 60 Hz) 60 Hz Wind Turbine Generator

The SWT 2.3 MW wind turbine generator is an induction generator (squirrel cage type) with PWM control for variable reactive power output control, which can be configured to control the 0.69 kV terminal voltage. The continuous reactive output capability of the machine is dependent on the terminal voltage and the real output power of the wind turbine generator. The power curve indicates that at rated 2.3 MW output power and 1.0 p.u. voltage, the wind turbine generator is capable of operating continuously between 86% leading to 86% lagging. Leading power factor range significantly decreases at any voltage other than 1.0 p.u. Also, an increase in terminal voltage would result in higher lagging power factor capability and a decrease in terminal voltage would result in lower lagging power factor capability. For steady-state operation, the wind turbine generator features local voltage and power factor control modes of operation.

4.3 Mitsubishi MWT-95 – 2.4 MW/60 Hz Wind Turbine Generator

The MWT-95 - 2.4 MW wind turbine generator is a variable-speed doubly-fed induction generator with pitch control. At rated 2.4 MW output power, the turbines can operate at any fixed power factor setpoint between 95% leading to 90% lagging. The fixed power factor setpoint can be changed manually through software to cater various system conditions. The manufacturer also supplies a permanently connected 0.11 MVAR capacitor bank located at the terminal of the wind turbine generator.

5. POWER FLOW ANALYSIS

SPP has specific voltage requirements for interconnecting wind farm projects. Wind generation projects are required to meet a voltage schedule at the POI consistent with the voltage in the SPP base case or nominal voltage, whichever is higher, for single transmission facility outage contingencies specified by SPP. Also, transmission voltages should not exceed 105% of nominal system voltage during normal and emergency operating conditions. The above is true in general; however, voltage deviations of up to 110% may be allowed depending on equipment ratings and specific location requirements.

It may not be possible in all cases to meet the voltage requirements specified by SPP since actual requirements on the wind farm(s) may exceed the ±95% power factor FERC 661A requires for large generator interconnection agreements (LGIA) that the wind farm project maintain a power factor within +/-95% measured at the point of interconnection.

Voltage schedules at the point of interconnect locations from the original Cluster Group 1 base cases are listed in Table 5.1. Because the voltage schedules at Tatonga 345 kV and Wichita – Woodring 345 kV locations for summer peak are under 1.0 pu, the associated wind farm projects are required to supply the necessary reactive power to meet at least a 1.0 pu voltage schedule within the power factor limits established by FERC.

Table 5.1: Base Case Voltage of Point of Interconnection Locations

Point of Interconnection	Summer Peak 2010	Winter Peak 2010
Tatonga 345 kV (515378)	343.34 kV	341.14 kV
Woodward 138kV (515376)	140.37 kV	140.22 kV
Mooreland 138kV (520999)	140.72 kV	141.20 kV
Woodward 345kV (515375)	353.73 kV	353.42 kV
Wichita – Woodring 345kV (532796-514715)	344.83 kV	346.90 kV

5.1 Facility Outage Contingencies

Single transmission facility outage contingencies specified by SPP are listed in Table 5.2.

Table 5.2: List of N-1 Outage Contingencies

Cont.	Description
N-1_1	Outage of one of the Woodward (515375) to Tatonga (515378) 345kV line
N-1_2	Outage of one of the Woodward (515375) to Hitchland (523097) 345kV line
N-1_3	Outage of the Woodward (515375) to Comanche (531487) 345kV line
N-1_4	Outage of the Woodward 345kV (515375) to 138kV (515376) transformer
N-1_5	Outage of one of the Tatonga (515378) to Northwest (514880) 345kV line
N-1_6	Outage of the GEN-2008-013 (210130) to Woodring (514715) 345kV line
N-1_8	Outage of one of the Comanche (531487) to GEN-2007-025 (532781) 345kV line
N-1_9	Outage of the Comanche (531487) to Spearville (531469) 345kV line
N-1_10	Outage of the GEN-2007-040 (210400) to Spearville (531469) 345kV line
N-1_11	Outage of the Spearville 345kV (531469) to 230kV (539695) transformer
N-1_12	Outage of the Wichita (532796) to Benton (532791) 345kV line
N-1_13	Outage of Wichita 345kV (532796) to 138kV (533040) transformer 12X
N-1_14	Outage of the Woodring (514715) to Cimarron (514901) 345kV line
N-1_15	Outage of the Woodring (514715) to Sooner (514803) 345kV line
N-1_16	Outage of the Cimarron (514901) to Draper (514934) 345kV line
N-1_17	Outage of the Northwest (514880) to Arcadia (514908) 345kV line
N-1_18	Outage of the Northwest (514880) to Spring Creek (514881) 345kV line
N-1_19	Outage of the Northwest (514880) to Cimarron (514901) 345kV line
N-1_20	Outage of Northwest 345kV (514880) to 138kV (514879) transformer T2
N-1_21	Outage of the Hitchland (523097) to GEN-2003-013 (560029) 345kV line
N-1_22	Outage of the Hitchland (523097) to GEN-2005-017 (51700) 345kV line
N-1_23	Outage of the GEN-2005-017 (51700) to Potter (523961) 345kV line
N-1_24	Outage of the Potter (523961) to Grapevine (523772) 345kV line
N-1_25	Outage of the GEN-2003-013 (560029) to Finney (523853) 345kV line
N-1_26	Outage of the Woodward EHV (515376) to Iodine (514796) 138kV line
N-1_27	Outage of the Woodward (514785) to GEN-2001-037 (515785) 138kV line
N-1_28	Outage of the GEN-2001-037 (515785) to Mooreland (520999) 138kV line
N-1_29	Outage of the Mooreland (520999) to Iodine (520957) 138kV line
N-1_30	Outage of the Mooreland (520999) to Glass Mountain (514788) 138kV line
N-1_31	Outage of the Mooreland (520999) to Cedardale (520848) 138kV line
N-1_32	Outage of the Mooreland (520999) to Morewood (521001) 138kV line
N-1_33	Outage of the Mooreland (520999) to Taloga (521065) 138kV line

Cont.	Description
N-1_34	Outage of the Taloga 138kV (521065) to 69kV (521064) transformer
N-1_35	Outage of the Dewey (514787) to Taloga (521065) 138kV line
N-1_36	Outage of the Dewey (514787) to Southard (514822) 138kV line
N-1_37	Outage of the Woodward (515375) to Midpoint/Wheeler (525835) 345kV line
N-1_38	Outage of the Midpoint/Wheeler (525835) to Anadarko (521210) 345kV line
N-1_39	Outage of the Midpoint/Wheeler (525835) to Tuco (525832) 345kV line

5.2 Power Factor Requirements at the Point of Interconnection

The power factor needs of a wind farm or group of wind farm projects to deliver leading or lagging reactive power to maintain a voltage schedule at the POI consistent with SPP requirements is summarized in Table 5.3. Table 5.3 identifies the outage contingencies from Table 5.2 which create the greatest leading or lagging reactive power demands from the interconnecting projects. These requirements are based on a single Woodward 345/138 kV transformer. SPP intends to install two transformers in parallel of similar specification.

Table 5.3: Power factor needs at POI

Point of Interconnection	Voltage Schedule to Meet	Worst Case Contingency (from Table 5.2)	Power Factor	
Tatonga 345 kV	345 kV	N-1_3 Winter Peak	98.83%	leading
Woodward 138kV	140.37 kV	N-1_4 Summer Peak	99.52%	leading
Mooreland 138kV	140.72 kV	N-1_4 Summer Peak	73.88%	leading
Woodward 345kV	353.73 kV	N-1_5 Summer Peak	94.77%	leading
Wichita – Woodring 345kV	345 kV	N-1_5 Summer Peak	98.10%	leading

Results indicate that GEN-2007-51 and GEN-2007-062 would have to operate beyond 95% leading power factor to meet the voltage schedules in Table 5.1.

6. TRANSIENT STABILITY ANALYSIS AND RESULTS

Transient stability analysis was performed for fault contingencies in Table 6.1.

Table 6.1: SPP fault contingencies

Cont. No.	Cont. Name	Description
1	FLT01-3PH	3 phase fault on one of the Woodward (515375) to Tatonga (515378) 345kV lines, near Woodward. a. Apply fault at the Woodward 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.
2	FLT02-1PH	Single phase fault and sequence like previous
3	FLT03-3PH	3 phase fault on one of the Woodward (515375) to Hitchland (523097) 345kV lines, near Woodward. a. Apply fault at the Woodward 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.
4	FLT04-1PH	Single phase fault and sequence like previous
5	FLT05-3PH	3 phase fault on the Woodward (515375) to Comanche (531487) 345kV line, near Woodward. a. Apply fault at the Woodward 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.
6	FLT06-1PH	Single phase fault and sequence like previous
7	FLT07-3PH	3 phase fault on the Woodward 345kV (515375) to 138kV (515376) transformer, near the 345 kV bus. a. Apply fault at the Woodward 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
8	FLT08-1PH	Single phase fault and sequence like previous
9	FLT09-3PH	3 phase fault on one of the Tatonga (515378) to Woodward (515375) 345kV lines, near Tatonga. a. Apply fault at the Tatonga 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.
10	FLT10-1PH	Single phase fault and sequence like previous
11	FLT11-3PH	3 phase fault on one of the Tatonga (515378) to Northwest (514880) 345kV lines, near Tatonga. a. Apply fault at the Tatonga 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.
12	FLT12-1PH	Single phase fault and sequence like previous

Cont. No.	Cont. Name	Description
13	FLT13-3PH	3 phase fault on the GEN-2008-013 (210130) to Woodring (514715) 345kV line, near GEN-2008-013. a. Apply fault at the GEN-2008-013 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	FLT14-1PH	Single phase fault and sequence like previous
17	FLT17-3PH	3 phase fault on one of the Comanche (531487) to GEN-2007-025 (532781) 345kV lines, near Comanche. a. Apply fault at the Comanche 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.
18	FLT18-1PH	Single phase fault and sequence like previous
19	FLT19-3PH	3 phase fault on the Comanche (531487) to Spearville (531469) 345kV line, near Comanche. a. Apply fault at the Comanche 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.
20	FLT20-1PH	Single phase fault and sequence like previous
21	FLT21-3PH	3 phase fault on the Spearville (531469) to Comanche (531487) 345kV line, near Spearville. a. Apply fault at the Spearville 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.
22	FLT22-1PH	Single phase fault and sequence like previous
25	FLT25-3PH	3 phase fault on the GEN-2007-040 (210400) to Spearville (531469) 345kV line, near GEN-2007-004. a. Apply fault at the GEN-2007-040 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.
26	FLT26-1PH	Single phase fault and sequence like previous
27	FLT27-3PH	3 phase fault on the Spearville 345kV (531469) to 230kV (539695) transformer, near the 345 kV bus. a. Apply fault at the Spearville 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
28	FLT28-1PH	Single phase fault and sequence like previous
29	FLT29-3PH	3 phase fault on the Wichita (532796) to Benton (532791) 345kV line, near Wichita. a. Apply fault at the Wichita 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.
30	FLT30-1PH	Single phase fault and sequence like previous

Cont. No.	Cont. Name	Description
31	FLT31-3PH	3 phase fault on Wichita 345kV (532796) to 138kV (533040) transformer 12X, near the 345 kV bus. a. Apply fault at the Wichita 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
32	FLT32-1PH	Single phase fault and sequence like previous
33	FLT33-3PH	3 phase fault on the Woodring (514715) to Cimarron (514901) 345kV line, near Woodring. a. Apply fault at the Woodring 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.
34	FLT34-1PH	Single phase fault and sequence like previous
35	FLT35-3PH	3 phase fault on the Woodring (514715) to Sooner (514803) 345kV line, near Woodring. a. Apply fault at the Woodring 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.
36	FLT36-1PH	Single phase fault and sequence like previous
37	FLT37-3PH	3 phase fault on the Cimarron (514901) to Draper (514934) 345kV line, near Cimarron. a. Apply fault at the Cimarron 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.
38	FLT38-1PH	Single phase fault and sequence like previous
39	FLT39-3PH	3 phase fault on the Northwest (514880) to Arcadia (514908) 345kV line, near Northwest. a. Apply fault at the Northwest 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.
40	FLT40-1PH	Single phase fault and sequence like previous
41	FLT41-3PH	3 phase fault on the Northwest (514880) to Spring Creek (514881) 345kV line, near Northwest. a. Apply fault at the Northwest 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.
42	FLT42-1PH	Single phase fault and sequence like previous
43	FLT43-3PH	3 phase fault on the Northwest (514880) to Cimarron (514901) 345kV line, near Northwest. a. Apply fault at the Northwest 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.
44	FLT44-1PH	Single phase fault and sequence like previous

Cont. No.	Cont. Name	Description
45	FLT45-3PH	3 phase fault on Northwest 345kV (514880) to 138kV (514879) transformer T2, near the 345 kV bus. a. Apply fault at the Northwest 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
46	FLT46-1PH	Single phase fault and sequence like previous
47	FLT47-3PH	3 phase fault on the Hitchland (523097) to GEN-2003-013 (560029) 345kV line, near Hitchland. a. Apply fault at the Hitchland 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.
48	FLT48-1PH	Single phase fault and sequence like previous
49	FLT49-3PH	3 phase fault on the Hitchland (523097) to GEN-2005-017 (51700) 345kV line, near Hitchland. a. Apply fault at the Hitchland 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.
50	FLT50-1PH	Single phase fault and sequence like previous
51	FLT51-3PH	3 phase fault on the GEN-2005-017 (51700) to Potter (523961) 345kV line, near GEN-2005-017. a. Apply fault at the GEN-2005-017 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.
52	FLT52-1PH	Single phase fault and sequence like previous
55	FLT55-3PH	3 phase fault on the GEN-2003-013 (560029) to Finney (523853) 345kV line, near GEN-2003-013. a. Apply fault at the GEN-2003-013 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.
56	FLT56-1PH	Single phase fault and sequence like previous
57	FLT57-3PH	3 phase fault on the Woodward 138kV (515376) to 345kV (515375) transformer, near the 138kV bus. a. Apply fault at the Woodward 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
58	FLT58-1PH	Single phase fault and sequence like previous
59	FLT59-3PH	3 phase fault on the Woodward EHV (515376) to Iodine (514796) 138kV line, near Woodward EHV. a. Apply fault at the Woodward EHV 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
60	FLT60-1PH	Single phase fault and sequence like previous

Cont. No.	Cont. Name	Description
61	FLT61-3PH	3 phase fault on the Woodward (514785) to GEN-2001-037 (515785) 138kV line, near Woodward. a. Apply fault at the Woodward 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
62	FLT62-1PH	Single phase fault and sequence like previous
63	FLT63-3PH	3 phase fault on the GEN-2001-037 (515785) to Woodward (514785) 138kV line, near GEN-2001-037. a. Apply fault at the GEN-2001-037 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
64	FLT64-1PH	Single phase fault and sequence like previous
65	FLT65-3PH	3 phase fault on the GEN-2001-037 (515785) to Mooreland (520999) 138kV line, near GEN-2001-037. a. Apply fault at the GEN-2001-037 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
66	FLT66-1PH	Single phase fault and sequence like previous
67	FLT67-3PH	3 phase fault on the Mooreland (520999) to GEN-2001-037 (515785) 138kV line, near Mooreland. a. Apply fault at the Mooreland 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
68	FLT68-1PH	Single phase fault and sequence like previous
69	FLT69-3PH	3 phase fault on the Mooreland (520999) to Iodine (520957) 138kV line, near Mooreland. a. Apply fault at the Mooreland 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
70	FLT70-1PH	Single phase fault and sequence like previous
71	FLT71-3PH	3 phase fault on the Mooreland (520999) to Glass Mountain (514788) 138kV line, near Mooreland. a. Apply fault at the Mooreland 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
72	FLT72-1PH	Single phase fault and sequence like previous
73	FLT73-3PH	3 phase fault on the Mooreland (520999) to Cedardale (520848) 138kV line, near Mooreland. a. Apply fault at the Mooreland 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.

Cont. No.	Cont. Name	Description
74	FLT74-1PH	Single phase fault and sequence like previous
75	FLT75-3PH	3 phase fault on the Mooreland (520999) to Morewood (521001) 138kV line, near Mooreland. a. Apply fault at the Mooreland 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
76	FLT76-1PH	Single phase fault and sequence like previous
77	FLT77-3PH	3 phase fault on the Mooreland (520999) to Taloga (521065) 138kV line, near Mooreland. a. Apply fault at the Mooreland 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
78	FLT78-1PH	Single phase fault and sequence like previous
79	FLT79-3PH	3 phase fault on the Taloga 138kV (521065) to 69kV (521064) transformer, near the 138kV bus. a. Apply fault at the Taloga 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
80	FLT80-1PH	Single phase fault and sequence like previous
81	FLT81-3PH	3 phase fault on the Taloga (521065) to Dewey (514787) 138kV line, near Taloga. a. Apply fault at the Taloga 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
82	FLT82-1PH	Single phase fault and sequence like previous
85	FLT85-3PH	3 phase fault on the Dewey (514787) to Southard (514822) 138kV line, near Dewey. a. Apply fault at the Dewey 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
86	FLT86-1PH	Single phase fault and sequence like previous
87	FLT87-3PH	3 phase fault on the Woodward (515375) to Midpoint/Wheeler (525835) 345kV line, near Woodward. a. Apply fault at the Woodward 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.
88	FLT88-1PH	Single phase fault and sequence like previous
89	FLT89-3PH	3 phase fault on one of the Midpoint/Wheeler (525835) to Anadarko (521210) 345kV lines, near Midpoint/Wheeler. a. Apply fault at the Midpoint/Wheeler 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.
90	FLT90-1PH	Single phase fault and sequence like previous

Cont. No.	Cont. Name	Description
91	FLT91-3PH	3 phase fault on one of the Midpoint/Wheeler (525835) to Tuco (525832) 345kV lines, near Midpoint/Wheeler. a. Apply fault at the Midpoint/Wheeler 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.
92	FLT92-1PH	Single phase fault and sequence like previous

Single line to ground faults were simulated in a manner consistent with currently accepted practices, that is to assume that a single line to ground will cause a voltage drop at the fault location of 60% of nominal.

The control areas monitored:

- Oklahoma Gas and Electric (OKGE)
- Western Farmers Electric Cooperative (WFEC)
- AEP West (AEPW)
- Sunflower Electric Power Company (SUNC)
- Mid-Kansas Electric Company (MKEC)
- Southwestern Public Service (SPS)
- Westar Energy, Inc (WERE)

The prior queued projects monitored are listed in Table 6.2.

Table 6.2: Prior queued wind farm projects monitored

Request	Size	Wind Turbine Model	Point of Interconnection
GEN-2002-005	120	Acciona 1.5MW	Moorewood – Elk City 138kV
GEN-2001-037	102	GE 1.5MW	Woodward-Mooreland 138kV
GEN-2005-008	120	GE 1.5MW	Woodward 138kV
GEN-2006-046	130	Mitsubishi 2.4MW	Taloga 138kV
GEN-2001-014	94	Suzlon 2.1MW	Fort Supply 138kV
GEN-2007-006	160	Suzlon 2.1MW	Roman Nose 138kV

6.1 Stability Criteria

Disturbances including three-phase and single-phase to ground faults should not cause synchronous and asynchronous plants to become unstable or disconnect from the transmission grid.

The criterion for synchronous generator stability as defined by NERC is:

"Power system stability is defined as that condition in which the difference of the angular positions of synchronous machine rotor becomes constant following an aperiodic system disturbance."

Voltage magnitudes and frequencies at terminals of asynchronous generators should not exceed magnitudes and durations that will cause protection elements to operate. Furthermore, the response after the disturbance needs to be studied at the terminals of the machine to insure that there are no sustained oscillations in power output, speed, frequency, etc.

Voltage magnitudes and angles after the disturbance should settle to a constant and reasonable operating level. Frequencies should settle to the nominal 60 Hz power frequency.

6.2 Modeling of Wind Turbine Generators

Transient stability simulations used an updated version of the GE 1.5 MW originally released under PSS/E Wind package issue 2.0.0 as a library model. S&C found that the existing GE 1.5 MW model would negatively interact with the Mitsubishi MWT-92/95 PSS/E model. PTI provided the updated model to S&C with the necessary corrections on August 1, 2008. The Mitsubishi library model has a file modified date of December 11, 2006 and the Siemens model has file modified date of May 14, 2007.

The voltage and frequency relay settings used with the GE 1.5 MW model for the Cluster Group 1 projects are listed in Table 6.3. The Mitsubishi and Siemens wind turbine generator relay settings are listed in Table 6.4 and 6.5 respectively.

Table 6.3: GE 1.5 MW relay settings of Cluster Group 1 projects

Relay type	Description	Trip setting and time delay	Units
Undervoltage (27-1)	Relay trips if |Vbus|<	0.85	Pu
	for t =	10.0	S
Undervoltage (27-2)	Relay trips if |Vbus|<	0.75	Pu
	for t =	1.0	S
Undervoltage (27-3)	Relay trips if |Vbus|<	0.70	Pu
	for t =	0.625	S
Undervoltage (27-4)	Relay trips if |Vbus|<	0.15	Pu
	for t =	0.625	S
Overvoltage (59-1)	Relay trips if |Vbus|>	1.1	Pu
	for t =	1.0	S
Overvoltage (59-2)	Relay trips if |Vbus|>	1.15	Pu
	for t =	0.1	S
Overvoltage (59-3)	Relay trips if |Vbus|>	1.3	Pu
	for t =	0.02	S
Underfrequency (81U-1)	Relay trips if Fbus <	57.5	Hz
	for t =	10.0	S
Underfrequency (81U-2)	Relay trips if Fbus <	56.5	Hz
	for t =	0.02	S
Overfrequency (81O-1)	Relay trips if Fbus >	61.5	Hz
	for t =	30.0	S
Overfrequency (81U-2)	Relay trips if Fbus >	62.5	Hz
	for t =	0.02	S

Table 6.4: Mitsubishi MWT-95 - 2.4 MW relay settings of GEN-2008-019

Relay type	Description	Trip setting and time delay	units
Undervoltage (27-1)	Relay trips if |Vbus|<	0.90	pu
	for t =	3.00	s
Undervoltage (27-2)	Relay trips if |Vbus|<	0.85	pu
	for t =	2.842	s
Undervoltage (27-3)	Relay trips if |Vbus|<	0.75	pu
	for t =	2.525	s
Undervoltage (27-4)	Relay trips if |Vbus|<	0.65	pu
	for t =	2.208	s
Undervoltage (27-5)	Relay trips if |Vbus|<	0.55	pu
	for t =	1.892	s
Undervoltage (27-6)	Relay trips if |Vbus|<	0.45	pu
	for t =	1.575	s
Undervoltage (27-7)	Relay trips if |Vbus|<	0.35	pu
	for t =	1.258	s
Undervoltage (27-8)	Relay trips if |Vbus|<	0.25	pu
	for t =	0.942	s
Undervoltage (27-9)	Relay trips if |Vbus|<	0.20	pu
	for t =	0.783	s
Undervoltage (27-10)	Relay trips if |Vbus|<	0.025	pu
	for t =	0.15	s
Overvoltage (59-1)	Relay trips if |Vbus|>	1.10	pu
	for t =	0.020	s
Overfrequency (81O)	Relay trips if Fbus >	61.00	Hz
	for t =	0.30	s
Underfrequency (81U)	Relay trips if Fbus <	59.00	Hz
	for t =	0.30	s

Table 6.5: Siemens SWT 2.3 MW (SWT-2.3-93 60 Hz) relay settings of GEN-2007-050 and GEN-2008-003

Relay type	Description	Trip setting and time delay	Units
Undervoltage (27-1)	Relay trips if |Vbus|<	0.90	Pu
	for t =	3	S
Undervoltage (27-2)	Relay trips if |Vbus|<	0.5	Pu
	for t =	1.735	S
Undervoltage (27-3)	Relay trips if |Vbus|<	0.85	Pu
	for t =	0.650	S
Undervoltage (27-4)	Relay trips if |Vbus|<	0.15	Pu
	for t =	0.075	S
Overvoltage (59-1)	Relay trips if |Vbus|>	1.10	Pu
	for t =	1	S
Overvoltage (59-2)	Relay trips if |Vbus|>	1.20	Pu
	for t =	0.2	S
Underfrequency (81U-1)	Relay trips if Fbus <	0.95	Pu
	for t =	10	S
Underfrequency (81U-2)	Relay trips if Fbus <	0.94	Pu
	for t =	0.1	S
Overfrequency (81O-1)	Relay trips if Fbus >	1.04	Pu
	for t =	0.1	S

6.3 Modeling of Power Factor Requirements

Wind farm projects were setup in the load flow model to satisfy a minimum voltage schedule at the POI as listed in Table 5.1, with the exception of the voltage schedule at Tatonga 345 kV (515378) and the point of interconnection location between Wichita – Woodring 345kV, which need to be at or above nominal voltage. Power factor requirements in Table 5.3 were limited to ±95% power factor per wind farm project.

GE wind turbine generators were set up to either control the terminal voltage at wind turbine locations or at the POI. Siemens turbines were setup to operate at a fixed 99% leading power factor. Clipper C93 turbines were setup to meet a voltage schedule of 1.0 pu at wind turbine locations. Mitsubishi turbines were setup to operate at a fixed 97% leading power factor. Capacitor banks were added to wind farms at 34.5 kV to provide the additional reactive power support required to meet the power factor requirements listed in Table 5.3. Table 6.6

summarizes the control scheme for each project, location and size of cap banks as well as transformer no-load tap settings. Figures 6.1 to 6.5 show the power flow diagrams corresponding to each point of interconnection and wind farm projects for the worst contingencies, which are listed in Table 5.3.

Table 6.6: Summary of wind farm control, capacitor bank sizes and transformer tap settngs assumptions for transient stability analysis

Project Name	Point of Interconnection	Wind Turbine Generator: Model	Wind Turbine Generator: Power Factor Range	Wind Turbine Generator: Control Scheme and Settings	Mechanically Switched Cap Bank Requirement: Size (MVAR)	Mechanically Switched Cap Bank Requirement: Location	XFMR no-load tap setting (% of high side winding): 345/138 kV	XFMR no-load tap setting (% of high side winding): 138/34.5 kV and 345/34.5 kV		XFMR no-load tap setting (% of high side winding): Wind Turbine Generator Step Up	
GEN-2007-021	Tatonga 345 kV	GE 1.5 MW	+/- 90%	Meet 1.00 pu voltage at POI	none			102.5		100.0	
GEN-2007-044	Tatonga 345 kV	GE 1.5MW	+/- 90%	Meet 1.00 pu voltage at POI	none			102.5		100.0	
GEN-2007-050	Woodward 138 kV	Siemens 2.3MW	+/- 86%@1.00 pu voltage	Meet 1.00 pu voltage at WTG	61.20	34.5 kV collector bus #1		105.0	(MAIN #1)	100.0	(GSU eq #1)
					61.20	34.5 kV collector bus #2		105.0	(MAIN #2)	100.0	(GSU eq #2)
GEN-2007-051	Mooreland 138 kV	GE 1.5MW	+/- 90%	Meet 1.049 pu voltage at generator (summer) Meet 1.048 pu voltage at generator (winter)	46.00	138 kV POI		105.0	(MAIN #1)	100.0	(GSU eq #1)
								105.0	(MAIN #2)	100.0	(GSU eq #2)
GEN-2007-062	Woodward 345 kV	GE 1.5MW	+/- 95%[1]	Meet 1.049 pu voltage at generator (summer) Meet 1.048 pu voltage at generator (winter)	100.00 (1st step)	345 kV POI		105.0	(MAIN #1)	100.0	(GSU eq #1)
								105.0	(MAIN #2)	100.0	(GSU eq #2)
					100.00[2] (2nd step)			105.0	(MAIN #3)	100.0	(GSU eq #3)
								105.0	(MAIN #4)	100.0	(GSU eq #4)
GEN-2008-003	Woodward 138 kV	Siemens 2.3 MW	+/- 86%@1.00 pu voltage	Meet 1.00 pu voltage at WTG	39.60	34.5 kV collector bus		105.0		100.0	
GEN-2008-013	Wichita – Woodring 345 kV	GE 1.5 MW	+/- 95% (note 1)	Meet 1.01 pu voltage at POI	none			102.5	(MAIN #1)	100.0	(GSU eq #1)
								105.0	(MAIN #2)	100.0	(GSU eq #2)
										125.0	(GSU eq #3)
GEN-2008-019	Tatonga 345 kV	Mitsubishi 2.4 MW	-90% to +95%	Fixed 97% leading power factor	46.8	138 kV XFMR secondary	102.5	105.0		100.0	

Notes:

1 Assume standard reactive output capability. Wind farm developer to confirm this information

2 Switched on for voltages below 1.0253 pu and switched off for voltages above 1.06 pu

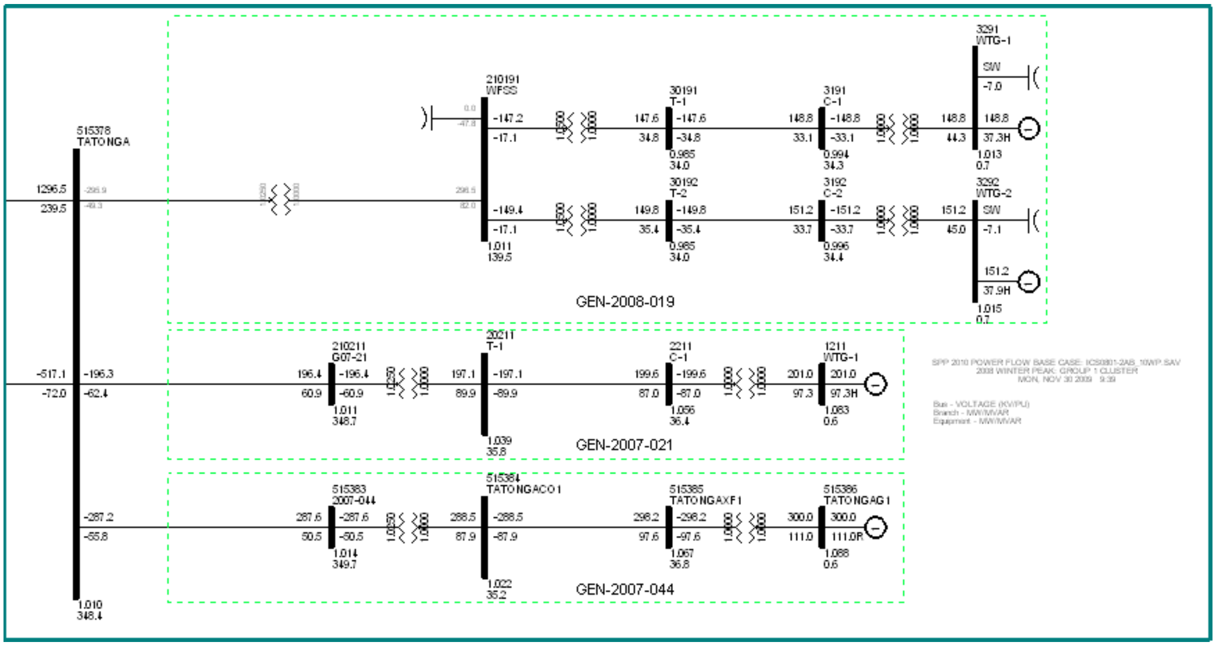


Figure 6.1: Power flow diagram of wind projects connected to Taloga 345 kV for N-1_3 winter peak outage contingency

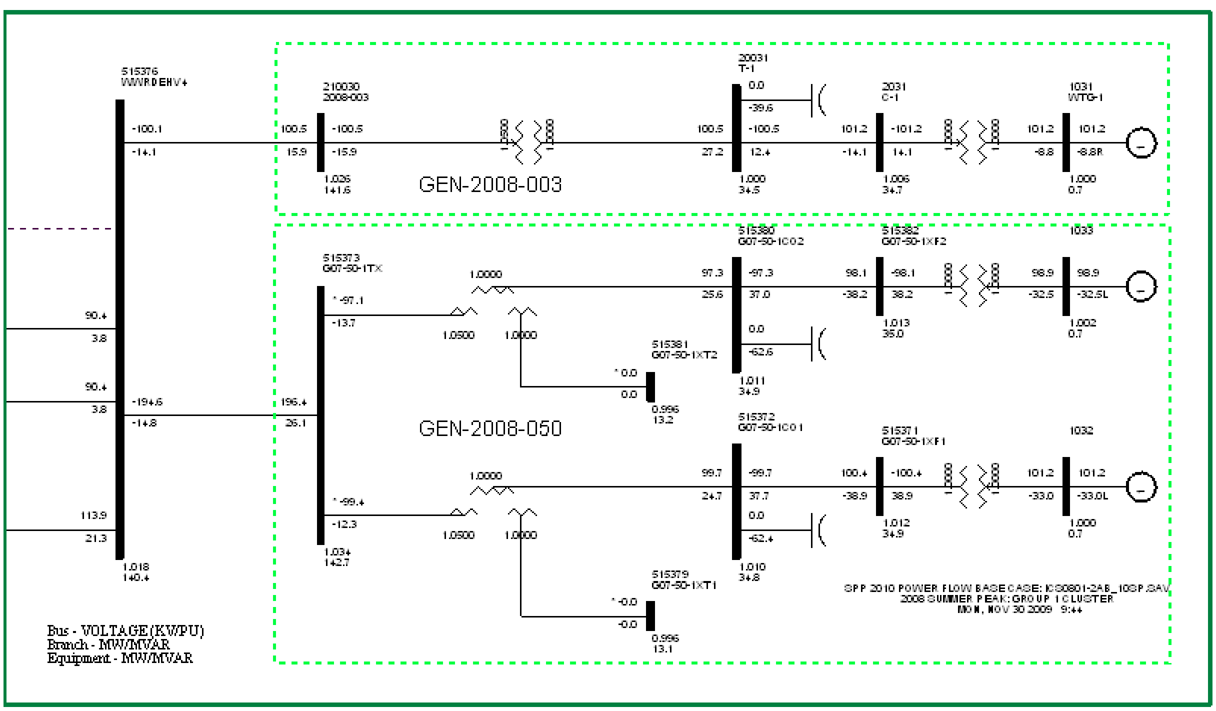


Figure 6.2: Power flow diagram of wind projects connected to Woodward 138 kV for N-1_4 summer peak outage contingency

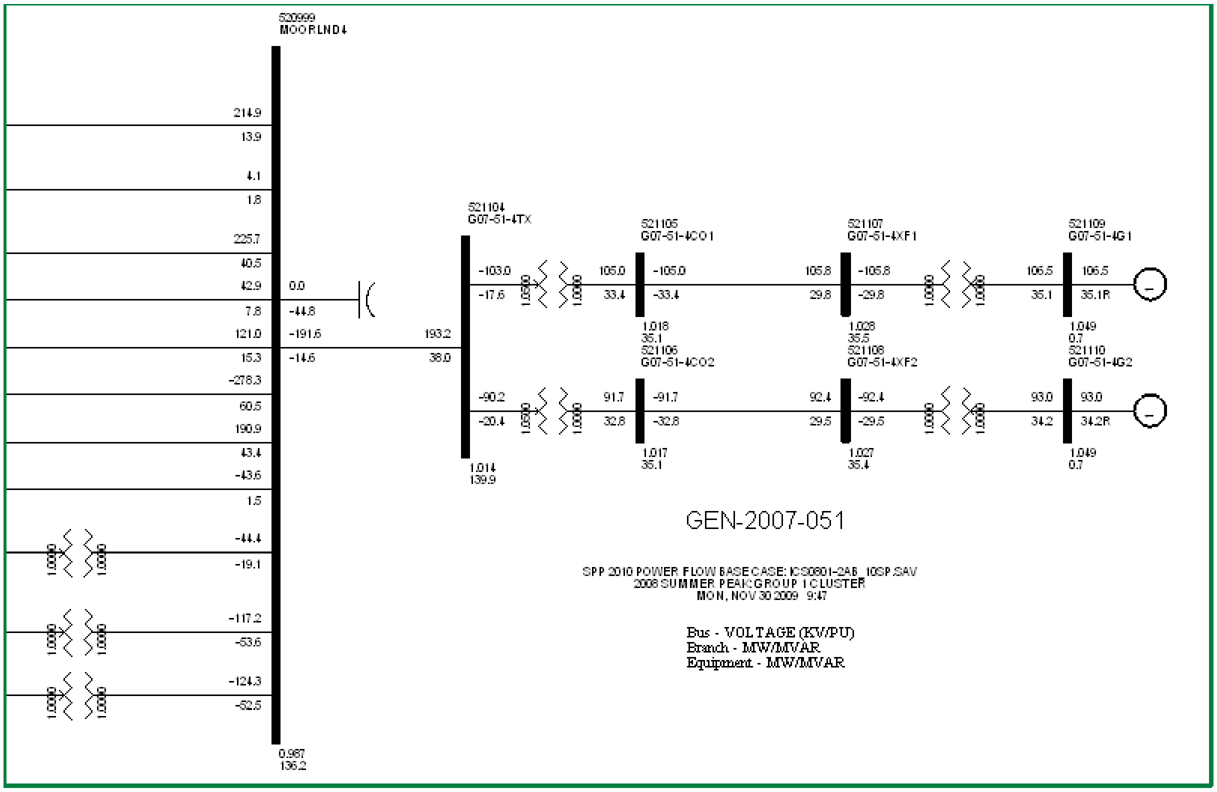


Figure 6.3: Power flow diagram of Mooreland 138 kV and GEN-2007-051 for N-1_4 summer peak outage contingency

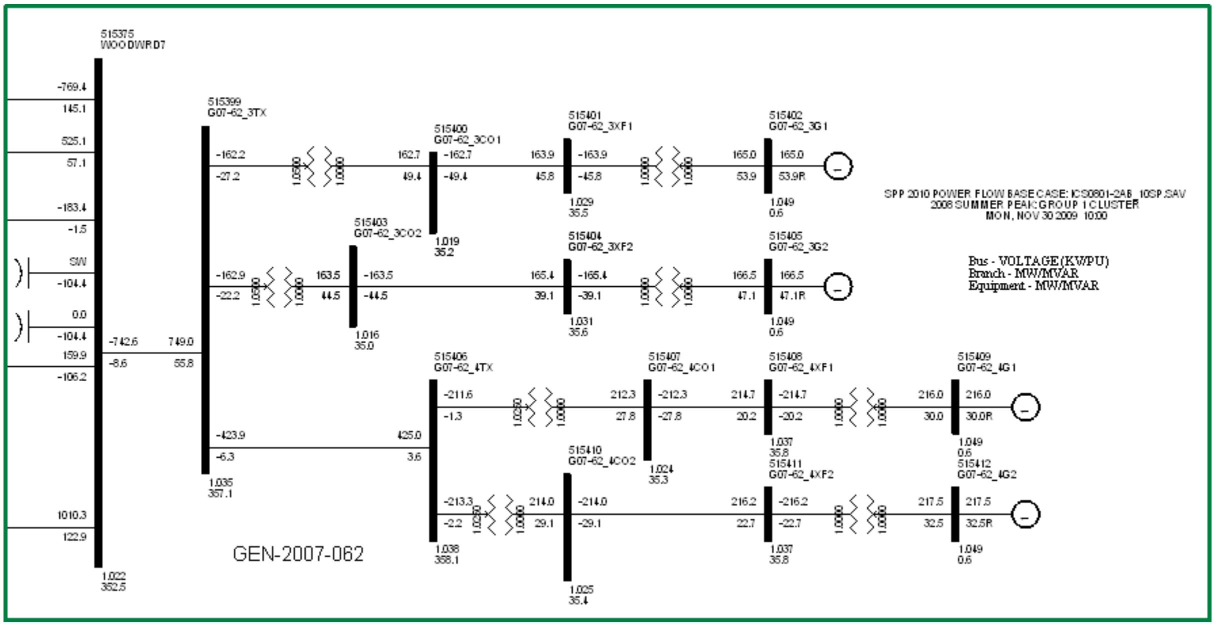


Figure 6.4: Power flow diagram of wind projects connected to Woodward 345 kV for N-1_5 summer peak outage contingency

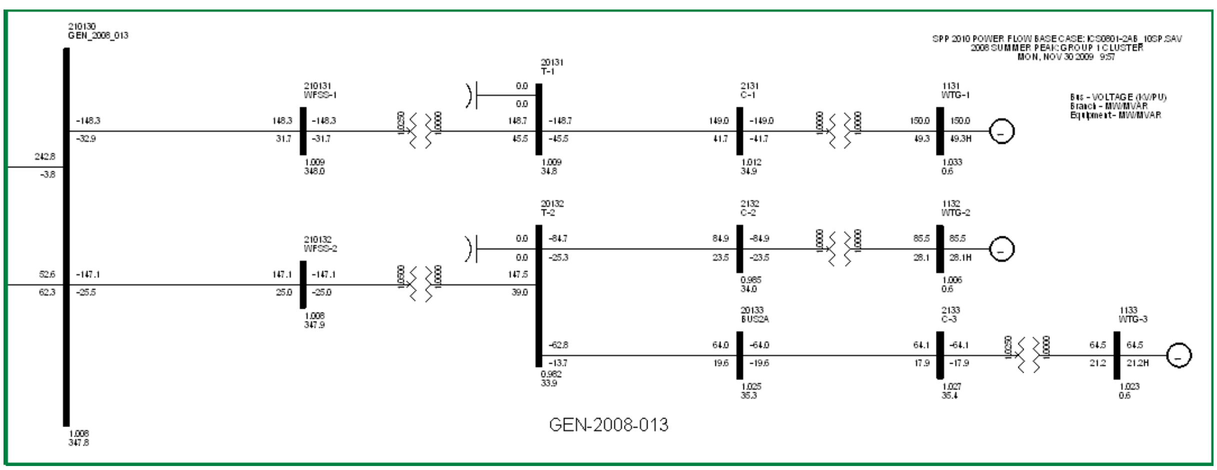


Figure 6.5: Power flow diagram of the Wichita – Woodring 345kV POI and GEN-2008-013 for N-1_5 summer peak outage contingency

6.4 Transient Stability Results: Summer Peak 2010

An undisturbed run of 10 seconds was performed on the Summer Peak 2010 power flow case that was modified with items listed in Table 5.4. Voltage, angle and frequency were flat throughout the run, which indicated proper initialization of dynamic models.

Areas monitored are stable for fault contingencies in Table 5.4 with the exception of #7, #8, #57, and #58. Undamped voltage, frequency, and power oscillations are present at the terminals of wind turbine generators from GEN-2008-003, GEN-2007-050, GEN-2001-014, GEN-2006-046, GEN 2001-037, GEN-2002-005, and GEN-2007-051. SPP has indicated that a second Woodward 345/138 kV transformer in parallel with the first is needed for stability and that it should have been added to the base cases. Simulations with the second transformer show that all power oscillations are well damped and the system is stable.

Fault #63 – 3 phase fault near GEN-2001-037, on the GEN-2001-037 to Woodward 138kV line with reclosing, would cause GEN-2001-037 GE 1.5 MW wind turbine generators to trip off on under-voltage relay (V_N < 70 %). Figure 6.7 shows the GEN-2001-037 wind turbine generators tripping off due to fault #63. Table 6.7 lists voltage and frequency relay settings of GEN-2001-037 wind turbine generators.

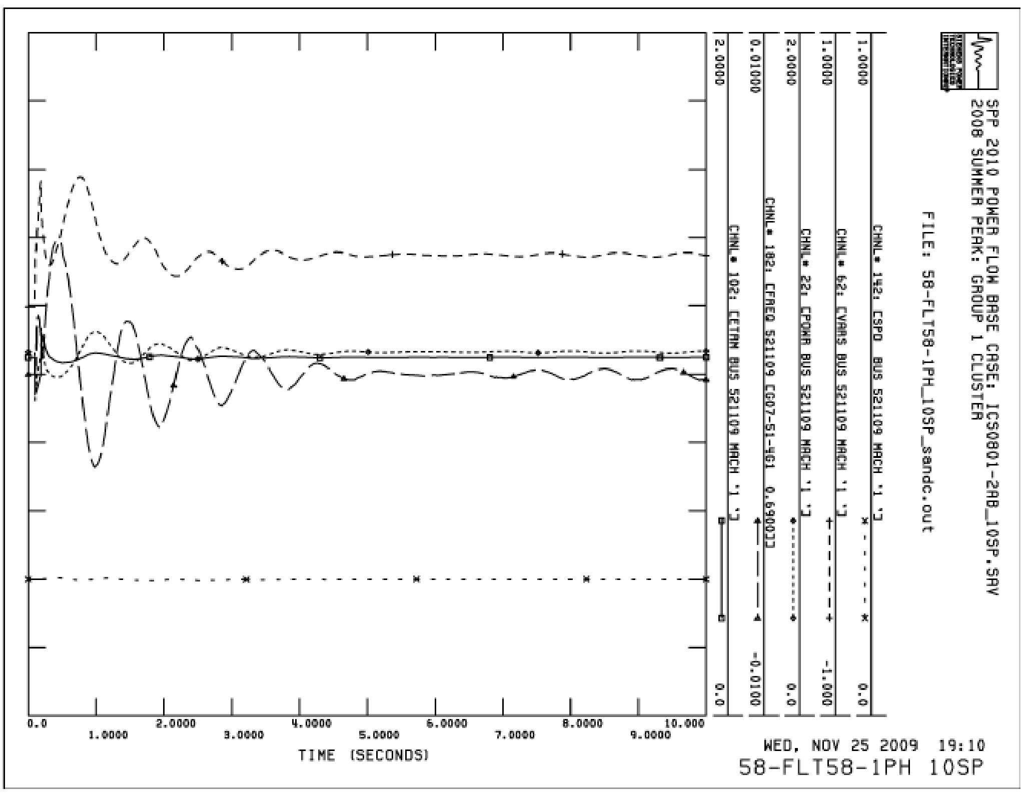


Figure 6.6: Oscillations at GEN-2007-051 for fault contingency #58 – summer

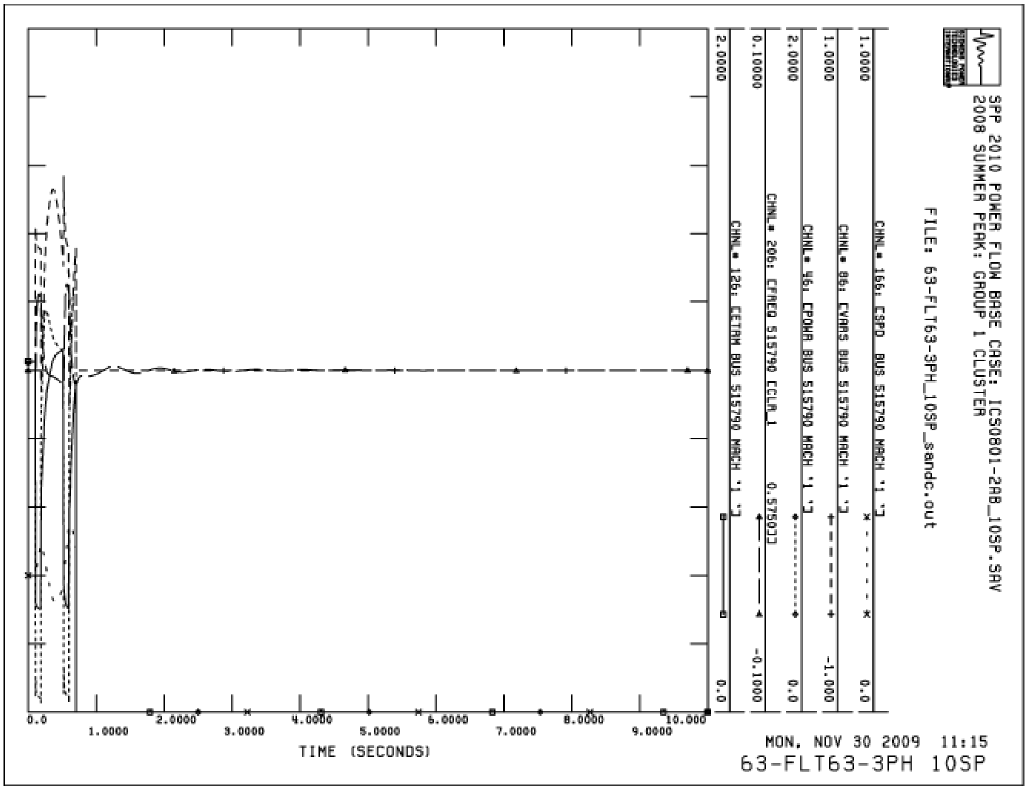
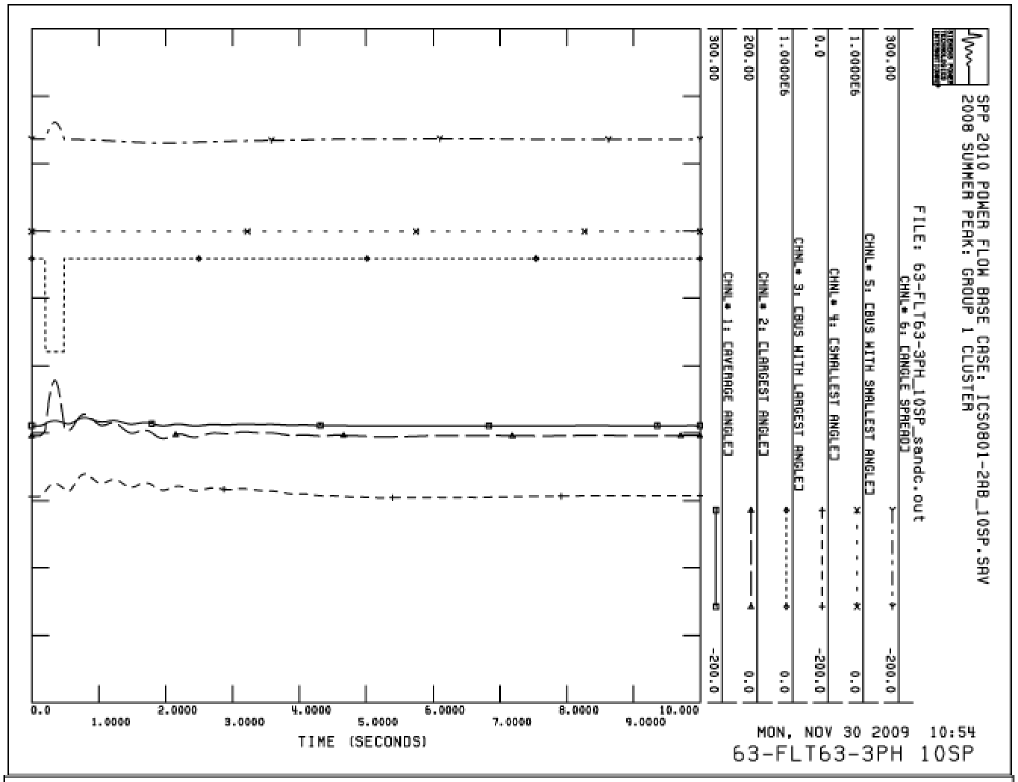


Figure 6.7: Trip event at GEN-2002-037 for fault contingency #63 – summer peak

Table 6.7: GE 1.5 MW relay settings of GEN-2001-037

<table>
<tr><th>Relay type</th><th>Description</th><th>Trip setting and time delay</th><th>Units</th></tr>
<tr><td rowspan="2">Undervoltage (27-1)</td><td>Relay trips if |Vbus|<</td><td>0.85</td><td>Pu</td></tr>
<tr><td>for t =</td><td>10.0</td><td>S</td></tr>
<tr><td rowspan="2">Undervoltage (27-2)</td><td>Relay trips if |Vbus|<</td><td>0.75</td><td>Pu</td></tr>
<tr><td>for t =</td><td>1.0</td><td>S</td></tr>
<tr><td rowspan="2">Undervoltage (27-3)</td><td>Relay trips if |Vbus|<</td><td>0.70</td><td>Pu</td></tr>
<tr><td>for t =</td><td>0.10</td><td>S</td></tr>
<tr><td rowspan="2">Undervoltage (27-4)</td><td>Relay trips if |Vbus|<</td><td>0.3</td><td>Pu</td></tr>
<tr><td>for t =</td><td>0.02</td><td>S</td></tr>
<tr><td rowspan="2">Overvoltage (59-1)</td><td>Relay trips if |Vbus|></td><td>1.1</td><td>Pu</td></tr>
<tr><td>for t =</td><td>1.0</td><td>S</td></tr>
<tr><td rowspan="2">Overvoltage (59-2)</td><td>Relay trips if |Vbus|></td><td>1.15</td><td>Pu</td></tr>
<tr><td>for t =</td><td>0.1</td><td>S</td></tr>
<tr><td rowspan="2">Overvoltage (59-3)</td><td>Relay trips if |Vbus|></td><td>1.3</td><td>Pu</td></tr>
<tr><td>for t =</td><td>0.02</td><td>S</td></tr>
<tr><td rowspan="2">Underfrequency (81U-1)</td><td>Relay trips if Fbus <</td><td>57.5</td><td>Hz</td></tr>
<tr><td>for t =</td><td>10.0</td><td>S</td></tr>
<tr><td rowspan="2">Underfrequency (81U-2)</td><td>Relay trips if Fbus <</td><td>56.5</td><td>Hz</td></tr>
<tr><td>for t =</td><td>0.02</td><td>S</td></tr>
<tr><td rowspan="2">Overfrequency (81O-1)</td><td>Relay trips if Fbus ></td><td>61.5</td><td>Hz</td></tr>
<tr><td>for t =</td><td>30.0</td><td>S</td></tr>
<tr><td rowspan="2">Overfrequency (81U-2)</td><td>Relay trips if Fbus ></td><td>62.5</td><td>Hz</td></tr>
<tr><td>for t =</td><td>0.02</td><td>S</td></tr>
</table>

Fault contingency #63 was re-studied with voltage protection disabled to prevent the wind turbine generators at GEN-2001-037 from tripping off. The results, which are shown in Figure 6.2, indicate that the system will be stable if GEN-2001-037 were to survive the fault. Whether the wind farm stays connected or disconnects, the system will be stable after the fault is cleared.


SPP 2010 POWER FLOW BASE CASE: ICS0801-2AB_10SP.SAV
2008 SUMMER PEAK: GROUP 1 CLUSTER
FILE: 63-FLT63-3PH_10SP_sandc.out
CHNL# 6: [ANGLE SPREAD]
CHNL# 5: [BUS WITH SMALLEST ANGLE]
CHNL# 4: [SMALLEST ANGLE]
CHNL# 3: [BUS WITH LARGEST ANGLE]
CHNL# 2: [LARGEST ANGLE]
CHNL# 1: [AVERAGE ANGLE]
TIME (SECONDS)
MON, NOV 30 2009 10:54
63-FLT63-3PH 10SP

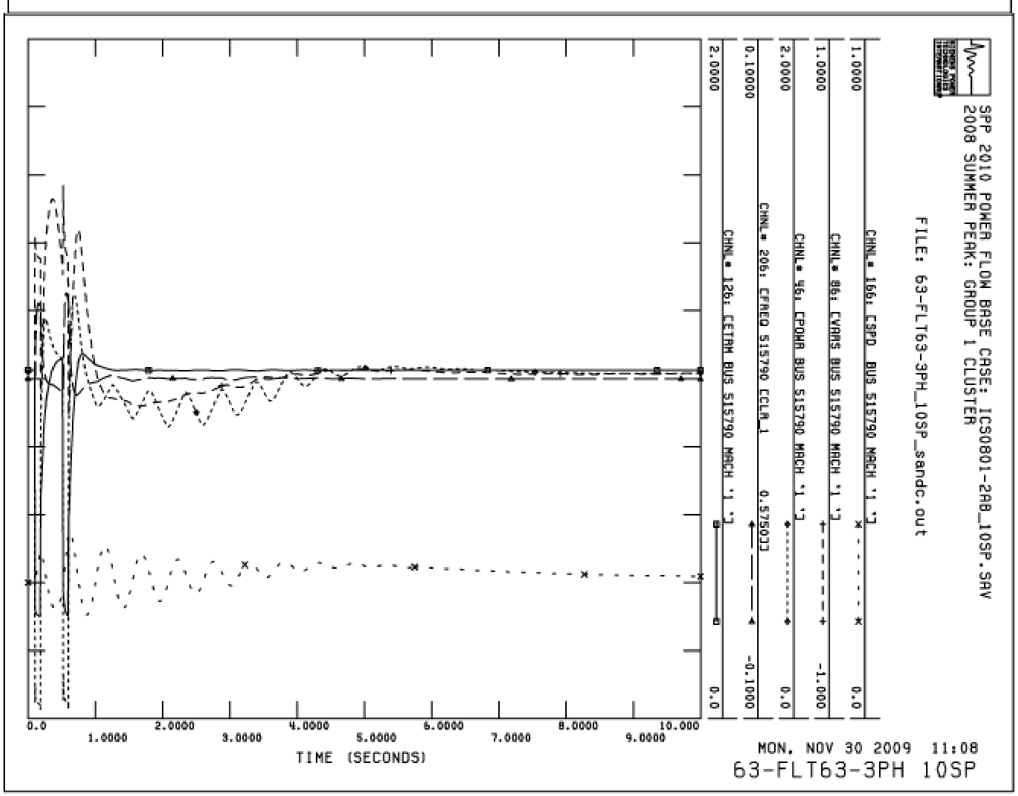

SPP 2010 POWER FLOW BASE CASE: ICS0801-2AB_10SP.SAV
2008 SUMMER PEAK: GROUP 1 CLUSTER
FILE: 63-FLT63-3PH_10SP_sandc.out
CHNL# 166: [SPD BUS 515790 MACH '1 ']
CHNL# 86: [VARS BUS 515790 MACH '1 ']
CHNL# 46: [POWR BUS 515790 MACH '1 ']
CHNL# 206: [FREQ 515790 CCLR_1 0.57503]
CHNL# 126: [ETRM BUS 515790 MACH '1 ']
TIME (SECONDS)
MON, NOV 30 2009 11:08
63-FLT63-3PH 10SP

Figure 6.8: Trip event at GEN-2002-037 for fault contingency #63 – summer peak with wind turbine protection disabled.

6.5 Transient Stability Results: Winter Peak 2010

An undisturbed run of 10 seconds was performed on the Winter Peak 2010 power flow case that was modified with items listed in Table 5.4. Voltage, angle and frequency were flat throughout the run, which indicated proper initialization of dynamic models.

Likewise to the Summer Peak 2010 case, the areas monitored are stable for fault contingencies in Table 5.4 with the exception of #7, #8, #57, and #58. Undamped voltage, frequency, and power oscillations are present at the terminals of wind turbine generators from GEN-2008-003, GEN-2007-050, GEN-2001-014, GEN-2006-046, GEN 2001-037, GEN-2002-005, and GEN-2007-051. SPP has indicated that a second Woodward 345/138 kV transformer in parallel with the first is needed for stability and that it should have been added to the base cases. Simulations with the second transformer show that all power oscillations are well damped and the system is stable.

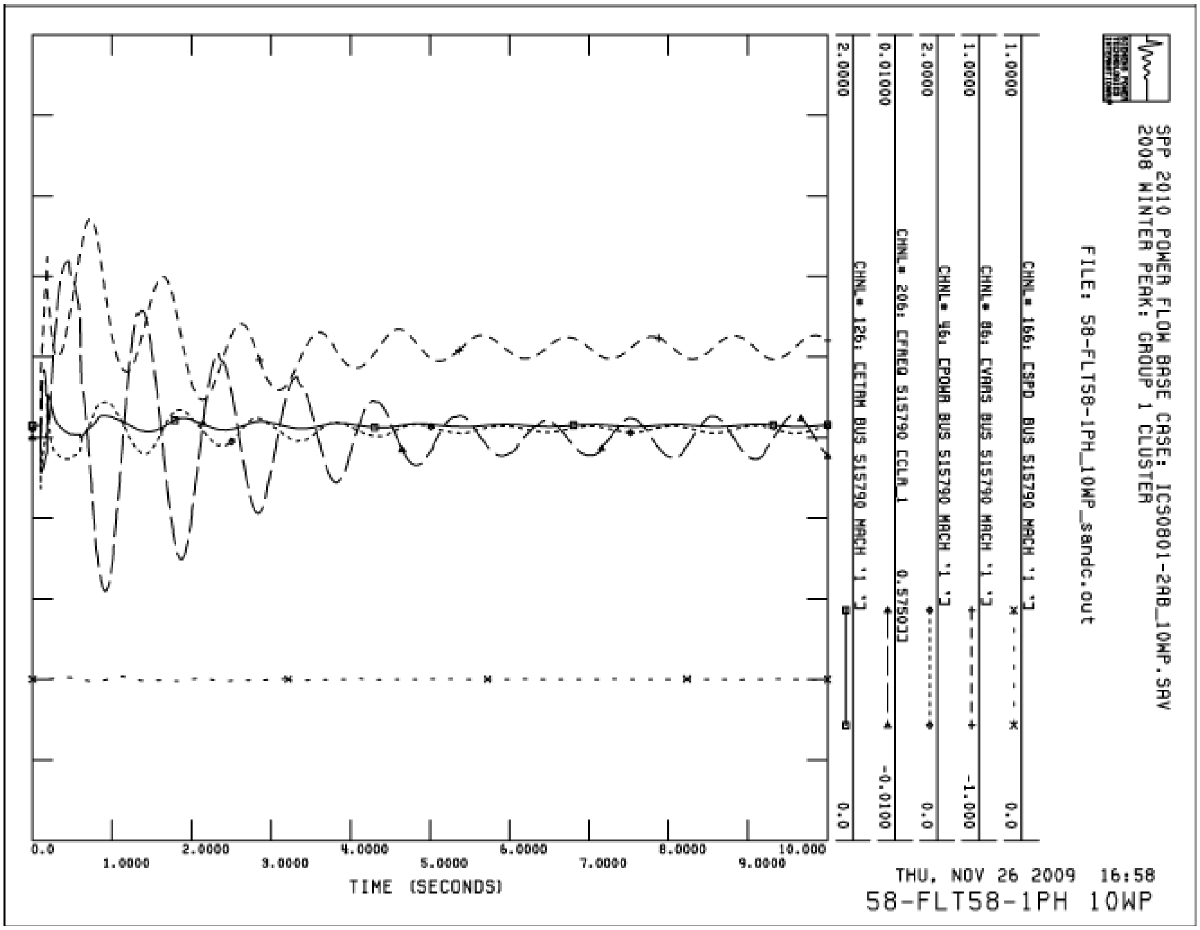


Figure 6.8: Oscillations at GEN-2001-037 for fault contingency #58 – winter

Table 6.8: Transient Stability Results Summary

Cont. No.	Cont. Name	Summer Peak 2010	Winter Peak 2010
1	FLT01-3PH	STABLE	STABLE
2	FLT02-1PH	STABLE	STABLE
3	FLT03-3PH	STABLE	STABLE
4	FLT04-1PH	STABLE	STABLE
5	FLT05-3PH	STABLE	STABLE
6	FLT06-1PH	STABLE	STABLE
7	FLT07-3PH	UNSTABLE[1]	UNSTABLE[1]
8	FLT08-1PH	UNSTABLE[1]	UNSTABLE[1]
9	FLT09-3PH	STABLE	STABLE
10	FLT10-1PH	STABLE	STABLE
11	FLT11-3PH	STABLE	STABLE
12	FLT12-1PH	STABLE	STABLE
13	FLT13-3PH	STABLE	STABLE
14	FLT14-1PH	STABLE	STABLE

Cont. No.	Cont. Name	Summer Peak 2010	Winter Peak 2010
17	FLT17-3PH	STABLE	STABLE
18	FLT18-1PH	STABLE	STABLE
19	FLT19-3PH	STABLE	STABLE
20	FLT20-1PH	STABLE	STABLE
21	FLT21-3PH	STABLE	STABLE
22	FLT22-1PH	STABLE	STABLE
25	FLT25-3PH	STABLE	STABLE
26	FLT26-1PH	STABLE	STABLE
27	FLT27-3PH	STABLE	STABLE
28	FLT28-1PH	STABLE	STABLE
29	FLT29-3PH	STABLE	STABLE
30	FLT30-1PH	STABLE	STABLE
31	FLT31-3PH	STABLE	STABLE
32	FLT32-1PH	STABLE	STABLE
33	FLT33-3PH	STABLE	STABLE
34	FLT34-1PH	STABLE	STABLE
35	FLT35-3PH	STABLE	STABLE
36	FLT36-1PH	STABLE	STABLE
37	FLT37-3PH	STABLE	STABLE
38	FLT38-1PH	STABLE	STABLE
39	FLT39-3PH	STABLE	STABLE
40	FLT40-1PH	STABLE	STABLE
41	FLT41-3PH	STABLE	STABLE
42	FLT42-1PH	STABLE	STABLE
43	FLT43-3PH	STABLE	STABLE
44	FLT44-1PH	STABLE	STABLE
45	FLT45-3PH	STABLE	STABLE
46	FLT46-1PH	STABLE	STABLE
47	FLT47-3PH	STABLE	STABLE
48	FLT48-1PH	STABLE	STABLE
49	FLT49-3PH	STABLE	STABLE
50	FLT50-1PH	STABLE	STABLE
51	FLT51-3PH	STABLE	STABLE
52	FLT52-1PH	STABLE	STABLE
55	FLT55-3PH	STABLE	STABLE
56	FLT56-1PH	STABLE	STABLE
57	FLT57-3PH	UNSTABLE[1]	UNSTABLE[1]
58	FLT58-1PH	UNSTABLE[1]	UNSTABLE[1]
59	FLT59-3PH	STABLE	STABLE
60	FLT60-1PH	STABLE	STABLE
61	FLT61-3PH	STABLE	STABLE
62	FLT62-1PH	STABLE	STABLE
63	FLT63-3PH	STABLE GEN-2001-037 trips off[2]	STABLE

Cont. No.	Cont. Name	Summer Peak 2010	Winter Peak 2010
64	FLT64-1PH	STABLE	STABLE
65	FLT65-3PH	STABLE	STABLE
66	FLT66-1PH	STABLE	STABLE
67	FLT67-3PH	STABLE	STABLE
68	FLT68-1PH	STABLE	STABLE
69	FLT69-3PH	STABLE	STABLE
70	FLT70-1PH	STABLE	STABLE
71	FLT71-3PH	STABLE	STABLE
72	FLT72-1PH	STABLE	STABLE
73	FLT73-3PH	STABLE	STABLE
74	FLT74-1PH	STABLE	STABLE
75	FLT75-3PH	STABLE	STABLE
76	FLT76-1PH	STABLE	STABLE
77	FLT77-3PH	STABLE	STABLE
78	FLT78-1PH	STABLE	STABLE
79	FLT79-3PH	STABLE	STABLE
80	FLT80-1PH	STABLE	STABLE
81	FLT81-3PH	STABLE	STABLE
82	FLT82-1PH	STABLE	STABLE
85	FLT85-3PH	STABLE	STABLE
86	FLT86-1PH	STABLE	STABLE
87	FLT87-3PH	STABLE	STABLE
88	FLT88-1PH	STABLE	STABLE
89	FLT89-3PH	STABLE	STABLE
90	FLT90-1PH	STABLE	STABLE
91	FLT91-3PH	STABLE	STABLE
92	FLT92-1PH	STABLE	STABLE

Notes:

1. Stable with two parallel Woodward 345/138 kV transformers
2. Trips off on Vn<70%. Also stable if GEN-2001-037 survives

7. CONCLUSIONS AND RECOMMENDATIONS

1 Cluster Group 1 wind farms are required to demonstrate that they can operate at the following power factors for the worst single transmission facility outage contingency in each case.

- 98.83 % leading power factor at Tatonga 345 kV POI
- 99.52 % leading power factor at Woodward 138 kV POI
- 73.88 % leading power factor at Mooreland 138 kV POI

- 94.77 % leading power factor at Woodward 345 kV POI
- 98.10 % leading power factor at POI in the Wichita – Woodring 345 kV line

2 It is recommended that wind farm developers take advantage of the reactive output power capability of GE wind turbine generators to meet the voltage schedule at the POI. This will reduce capacitor bank requirements.

3 The system will remain stable for 3-phase and single-line-to-ground fault contingencies at locations specified by SPP provided that there is a second Woodward 345/138 kV transformer in parallel with the first transformer. Otherwise, undamped voltage, frequency, and power oscillations will be observed at wind turbine generator terminals from GEN-2008-003, GEN-2007-050, GEN-2001-014, GEN-2006-046, GEN 2001-037, GEN-2002-005, and GEN-2007-051 for faults #7, #8. #57 and #58. SPP intendeds to have two 345/138 kV transformers at Woodward.

4 Cluster Group 1 and prior queued project will survive each fault contingency for Winter and Summer Peak with the exception of GEN-2001-037 for fault contingency #63 for summer peak. No remedial action is required. The system will be stable regardless of whether GEN-2001-037 trips off or survives fault contingency #63.

K: Stability Study for Group 2

R161-09

Generator Interconnection Impact Restudy for Cluster #1 : ICS-2008-001-Group 2

Prepared for

Southwest Power Pool, Inc.

Submitted by:
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Arthur Pinheiro, Senior Manager

Final Report: December 23, 2009
Draft Report: December 8, 2009

Siemens PTI Project Number: P/21-113379-B-1

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Contents

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Section

1

Introduction

1.1 Background

Pursuant to the tariff and at the request of the Southwest Power Pool (SPP), Siemens PTI performed the Impact Study R100-09 *"Generator Interconnection Impact Study for Cluster # 1: ICS-2008-001 - Group 2"* to satisfy the Impact Study Agreement executed by the customers. The requests for interconnection were placed with SPP in accordance to SPP's Open Access Transmission Tariff, which covers new generation interconnections on SPP's transmission system.

Along the interconnection process some proposed wind projects no longer intend to interconnect to SPP's system, such that they dropped their positions in the queue list. The following wind generation projects are not part of group 2 anymore:

- GEN-2007-033
- GEN-2007-041
- GEN-2007-042
- GEN-2007-056

Without these wind projects the network as planned by SPP has suffered a significant change, therefore a reevaluation is required to determine the system behavior under the new scenario.

The purpose of this report is to present the results of the stability and power factor analysis performed to reevaluate the impact of the proposed cluster of interconnections of the ICS-2008-001 with regard to Group 2 remaining wind projects on the Southwest Power Pool system. Eventual indicative solutions to the identified issues are proposed based on the impact of each generation interconnection on the Southwest Power Pool system.

In the new scenario, Group 2 of ICS-2008-001 comprises three different projects interconnected in the 115 kV system, described in detail on Section 2.

Transient stability analysis was performed using the package provide by SPP. It contains the latest stability database in PSS™E version 30.3.2. The stability package also includes the dynamic data for the previously queued projects.

1.2 Purpose

The steady state and stability restudy was carried out to:

1. Determine the ability of the proposed generation facilities to remain in synchronism and within applicable planning standards following two types of system faults tested a) unsuccessful reclosing b) normally cleared faults.
2. Determine the amount of transient support required from the costumer to meet the power factor requirement at the POI.
3. Determine the ability of the wind farm to meet FERC Order 661A (low voltage ride through and wind farm recovery to pre-fault voltage) with and without additional reactive support.

Section

2

Model Development

The study has considered the 2010 Summer Peak and Winter Peak load flow models with the required interconnection generation modeled. The base cases also contain all the significant previous queued generation interconnection projects in the interconnection queue.

2.1 Power Flow Data

The Group 2 of ICS-2008-001 contains three generation interconnection requests. Table 2-1 presents the size of the wind generation projects, the Wind Turbine Generator (WTG) manufacturers, the reactive capability of each generation project point of interconnection, as well as the PSS®E bus numbers in the load flow model.

Table 2-1 – Details of the Interconnection Requests

Request	Size (MW)	Model	Reactive Capability of Wind Fam		Point of Interconnection	Bus Number
			Max(MVAR)	Min (MVAR)		
GEN-2007-005	200	Furhlander 1.5 MW	65.6	-65.6	PRINGLE 115kV	523266
GEN-2007-046	199.5	GE 1.5 MW	65	-65	HITCHLAND 115kV	523093
GEN-2007-057	34.5	GE 1.5 MW	11.3	-11.3	MOORE CO EAST 115kV	523308

The analysis was carried out using the database package provided by SPP which also includes the modeling data for the previously queued projects, as listed in the Table 2-2 below

Table 2-2 – Details of the Prior Queued Interconnection Requests

Request	Size (MW)	Model	Point of Interconnection	Bus Number
GEN-2002-006	150	GE 1.5 MW	TEXAS CO 115kV	523090
GEN-2002-008	240	GE 1.5 MW	HITCHLAND 345 kV	523097
GEN-2002-009	80	Suzlon 2.1 MW	HANSFORD 345 kV	523195
GEN-2003-013	196	GE 1.5 MW	HITCHLAND-FINNEY 345 kV	560029
GEN-2003-020	160	GE 1.5 MW	CARSON CO 115 kV	523924
GEN-2005-002	80	Gamesa 2.0 MW	RIVERVIEW-PRINGLE 115 kV	99937
GEN-2005-017	340	GE 1.5 MW	HITCHLAND-POTTER 345 kV	51700
GEN-2006-020	19.5	GE 1.5 MW	HITCHLAND-SHERMAN TAP 115 kV	560200
GEN-2006-044	370	GE 1.5 MW	HITCHLAND 345 kV	523097
GEN-2006-049	400	GE 1.5 MW	HITCHLAND-FINNEY 345 kV	560029

Figures 2-1 and 2-2 present the surrounding area of the Group 2 points of interconnection. The single line diagrams show the line flows and voltage profile for the base cases considered in the study: summer and winter peak scenarios, respectively.

Figure 2-1 - Group 2 Points of Interconnection Surrounding Area – Summer Peak

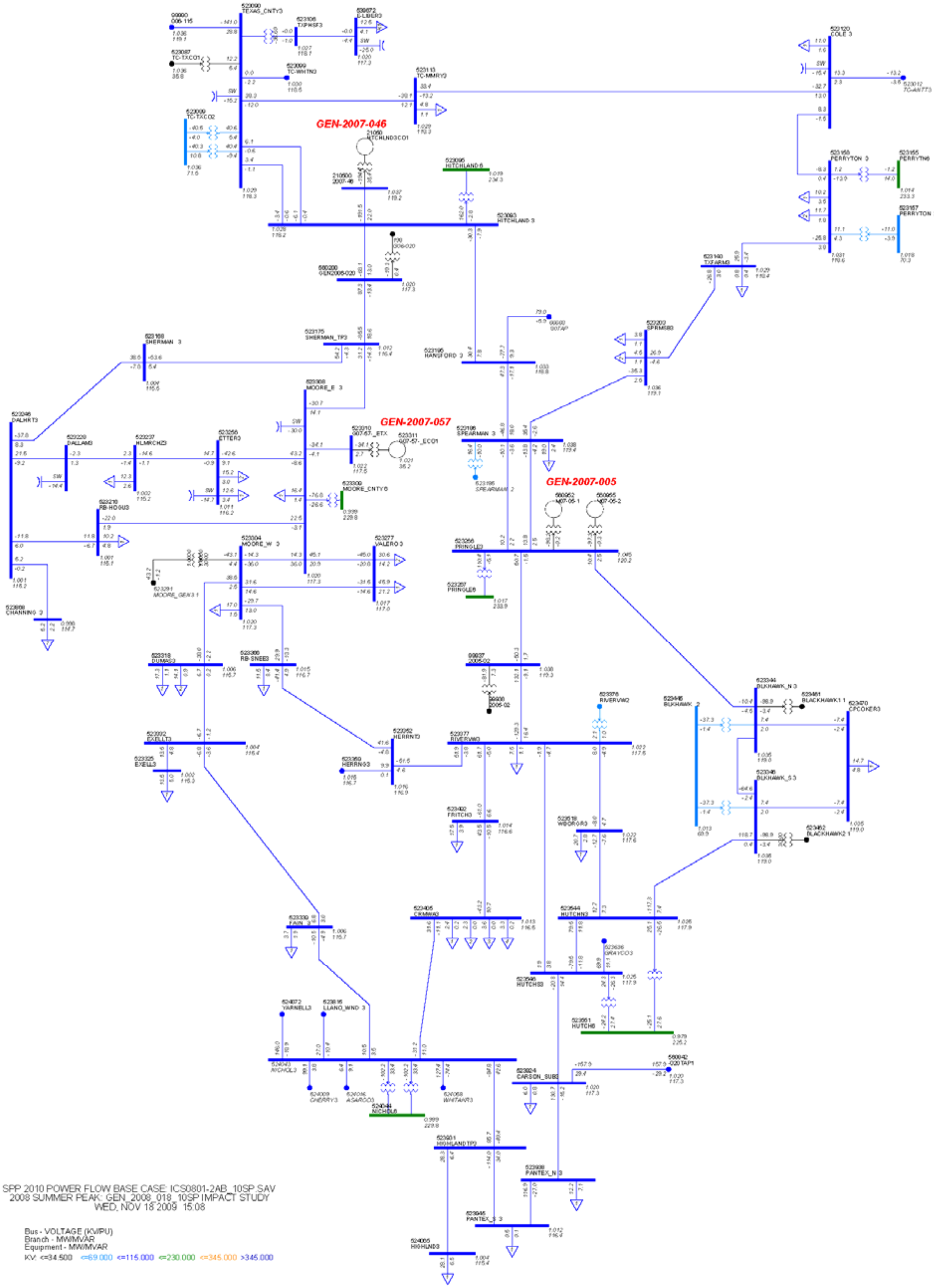
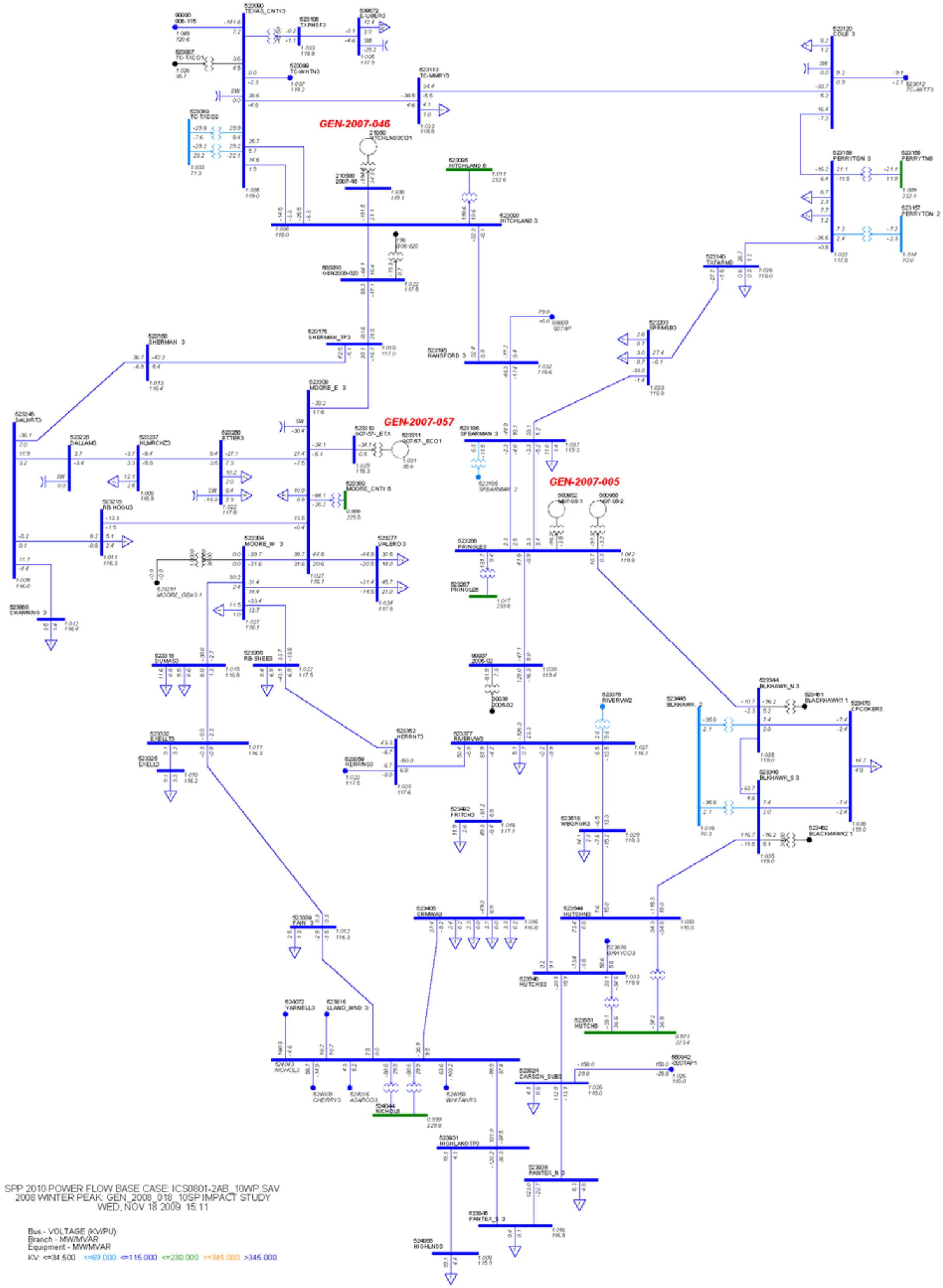


Figure 2-2 - Group 2 Points of Interconnection Surrounding Area – Winter Peak



Figures A-1 trough A-3 in Appendix A present single line diagrams, presenting the modeling details of each one of the three Group 2 interconnection requests considered in the restudy.

2.2 Stability Database

The transient stability analysis was performed using the data provided by SPP. Stability models for the Group 2 interconnection requests were added to the dynamic database, based on the technical documentation given. All turbine parameters used in the simulation models are the default parameters in the wind turbine package. It is assumed that each wind turbine generators (WTGs) would be controlling the voltage of its own bus. The default voltage protection model set points recommended by the manufacturer were used, that is, the wind units were modeled with their built-in voltage ride through capability.

In the analysis, the wind generation projects are modeled using equivalents representing groups of turbines and the respective collector systems.

Also, the default frequency protection model set points recommended by the manufacturer were used.

The PSS®E dynamic models output list is shown in Appendix B, documenting the model parameters of each one of the Group 2 wind turbines modeled in the stability analysis.

Section
3

Methodology and Assumptions

The study considered the 2010 power flow cases with the required interconnection generation requests modeled as described in Section 2. The base case also contains all the significant previous queued projects in the interconnection queue.

The monitored areas in this study are shown in Table 3-1.

Table 3-1 – Areas of Interest

Area Number	Area Name
520	AEPW
524	OKGE
525	WFEC
526	SPS
531	MIDW
534	SUNC
536	WERE

3.1 Methodology

3.1.1 Stability Simulations

The dynamic simulations were performed using the PSS®E version 30.3.2 with the latest stability database provided by SPP. Three-phase faults and single-phase faults in the neighborhood of ICS-2008-001 – Group 2 points of interconnection were simulated. Any adverse impact on the system stability was documented and further investigated with appropriate solutions to determine whether a static or dynamic VAR device is required or not.

3.1.2 Steady State Simulations

3.1.2.1 N-1 Contingency Analysis

An N-1 contingency analysis was performed to evaluate voltage violations, if any, caused by disturbances (tripping of the faulted line). The voltages at each POI were monitored for deviations from the base case voltage and the percentage deviations were documented.

The summer peak and winter peak load flow cases were adjusted to ensure there are no relevant pre contingency voltage criteria violations. During contingency analysis it was reported voltages of any monitored bus found to be outside the range of the post-contingency criteria and / or having more than 1% of project impact.

3.1.2.2 Power Factor Analysis

A QV analysis was performed to determine the reactive support requirement at each project's POI. QV tables, tabulated for base case and contingency conditions, are used to determine the reactive power support required at each POI, in order to maintain the scheduled pre contingency bus voltages.

These tables are obtained through a series of AC load flow calculations. Starting with no reactive support at a bus, the voltage is computed for a series of power flows as the reactive support is increased in steps, until the power flow experiences convergence difficulties as the system approaches the voltage collapse point.

3.2 Disturbances for Stability Analysis

The stability simulations considered three-phase (3PH) faults and single line-to-ground (SLG) faults. For transmission line outages the complete fault clearing process includes the following sequence of events:

1) Line fault, cleared after 5 cycles by tripping the both line terminals

2) After 20 cycles the line is reclosed under fault conditions (unsuccessful reclosing)

3) The fault is cleared by tripping both ends of the faulted line. Once again, 5 cycles later.

Furthermore, the clearing process for transformer faults is:

1) Transformer fault, cleared after 5 cycles by tripping the equipment

The disturbances evaluated are listed in the following Table 3-2:

Note: Some of the contingencies tested in the previous analysis are no longer relevant for this restudy as some projects have dropped the queue; however the contingency number remain unchanged from the initial study.

Also, the contingency FLT 17, listed in the scope of work was not included in the restudy, since it comprises non exiting network elements.

Table 3-2: Disturbances for Stability Analysis

Cont. #	Fault Location	Fault Type	Fault Clearing
1	At Hitchland end of 345 kV line to GEN-2003-013	3PH	trip Hitchland – GEN-2003-013 345 kV
2	At Hitchland end of 345 kV line to GEN-2003-013	SLG	trip Hitchland – GEN-2003-013 345 kV
3	At Hitchland end of 345 kV line to GEN-2005-017	3PH	trip Hitchland – GEN-2005-017 345 kV

Cont. #	Fault Location	Fault Type	Fault Clearing
4	At Hitchland end of 345 kV line to GEN-2005-017	SLG	trip Hitchland – GEN-2005-017 345 kV
5	At Hitchland end of 345 kV line to Woodward	3PH	trip Hitchland – Woodward 345 kV
6	At Hitchland end of 345 kV line to Woodward	SLG	trip Hitchland – Woodward 345 kV
7	At Hitchland 345 kV end of 345/230 kV transformer	3PH	trip Hitchland 345/230 kV transformer
8	At Hitchland 345 kV end of 345/230 kV transformer	SLG	trip Hitchland 345/230 kV transformer
9	At Hitchland 230 kV end of 345/230 kV transformer	3PH	trip Hitchland 345/230 kV transformer
10	At Hitchland 230 kV end of 345/230 kV transformer	SLG	trip Hitchland 345/230 kV transformer
11	At Hitchland end of 230 kV line to Pringle	3PH	trip Hitchland – Pringle 345 kV
12	At Hitchland end of 230 kV line to Pringle	SLG	trip Hitchland – Pringle 345 kV
13	At Hitchland end of 230 kV line to Moore Co	3PH	trip Hitchland – Moore Co 345 kV
14	At Hitchland end of 230 kV line to Moore Co	SLG	trip Hitchland – Moore Co 345 kV
15	At GEN-2005-017 end of 345 kV line to Potter Co	3PH	trip GEN-2005-017 – Potter Co 345 kV
16	At GEN-2005-017 end of 345 kV line to Potter Co	SLG	trip GEN-2005-017 – Potter Co 345 kV
19	At Moore Co end of 230 kV line to Hitchland	3PH	trip Moore Co – Hitchland 230 kV
20	At Moore Co end of 230 kV line to Hitchland	SLG	trip Moore Co – Hitchland 230 kV
21	At Moore Co end of 230 kV line to Potter Co	3PH	trip Moore Co – Potter Co 230 kV
22	At Moore Co end of 230 kV line to Potter Co	SLG	trip Moore Co – Potter Co 230 kV
23	At Pringle end of 230 kV line to Hitchland	3PH	trip Pringle – Hitchland 230 kV
24	At Pringle end of 230 kV line to Hitchland	SLG	trip Pringle – Hitchland 230 kV

Cont. #	Fault Location	Fault Type	Fault Clearing
25	At Pringle end of 230 kV line to GEN-2007-033	3PH	trip Pringle – GEN-2007-033 230 kV
26	At Pringle end of 230 kV line to GEN-2007-033	SLG	trip Pringle – GEN-2007-033 230 kV
31	At GEN-2007-013 end of 345 kV line to Finney	3PH	trip GEN-2007-013 – Finney 345 kV
32	At GEN-2007-013 end of 345 kV line to Finney	SLG	trip GEN-2007-013 – Finney 345 kV
35	At Holocomb end of 345 kV line to Setab	3PH	trip Holocomb – Setab 345 kV
36	At Holocomb end of 345 kV line to Setab	SLG	trip Holocomb – Setab 345 kV
37	At Holocomb end of 345 kV line to GEN-2007-040	3PH	trip Holocomb – GEN-2007-040 345 kV
38	At Holocomb end of 345 kV line to GEN-2007-040	SLG	trip Holocomb – GEN-2007-040 345 kV
49	At Woodward end of 345 kV line to Tatonga	3PH	trip Woodward – Tatonga 345 kV
50	At Woodward end of 345 kV line to Tatonga	SLG	trip Woodward – Tatonga 345 kV
65	At Hitchland end of 115 kV line to Texas Co	3PH	trip Hitchland – Texas Co 115 kV
66	At Hitchland end of 115 kV line to Texas Co	SLG	trip Hitchland – Texas Co 115 kV
67	At Hitchland end of 115 kV line to Sherman	3PH	trip Hitchland - GEN-2006-020 - Sherman Tap-Moore Co East - Sherman 115 kV
68	At Hitchland end of 115 kV line to Sherman	SLG	trip Hitchland - GEN-2006-020 - Sherman Tap-Moore Co East - Sherman 115 kV
69	At Hitchland end of 115 kV line to Hansford	3PH	trip Hitchland – Hansford 115 kV
70	At Hitchland end of 115 kV line to Hansford	SLG	trip Hitchland – Hansford 115 kV
71	At Hitchland 115 kV end of 230/115 kV transformer	3PH	trip Hitchland 230/115 kV transformer
72	At Hitchland 115 kV end of 230/115 kV transformer	SLG	trip Hitchland 230/115 kV transformer
73	At Pringle end of 115 kV line to Spearman	3PH	trip Pringle – Spearman 115 kV

Cont. #	Fault Location	Fault Type	Fault Clearing
74	At Pringle end of 115 kV line to Spearman	SLG	trip Pringle – Spearman 115 kV
75	At Pringle end of 115 kV line to Blackhawk	3PH	trip Pringle – Blackhawk 115 kV
76	At Pringle end of 115 kV line to Blackhawk	SLG	trip Pringle – Blackhawk 115 kV
77	At Pringle end of 115 kV line to GEN-2005-002	3PH	trip Pringle – GEN-2005-002 115 kV
78	At Pringle end of 115 kV line to GEN-2005-002	SLG	trip Pringle – GEN-2005-002 115 kV
79	At Pringle 115 kV end of 115/230 kV transformer	3PH	trip Pringle 115/230 kV transformer
80	At Pringle 115 kV end of 115/230 kV transformer	SLG	trip Pringle 115/230 kV transformer
81	At Moore Co East of 115 kV line to Sherman	3PH	trip Moore Co East – Sherman Tap – GEN-2006-020 – Hitchland – Sherman 115 kV
82	At Moore Co East of 115 kV line to Sherman	SLG	trip Moore Co East – Sherman Tap – GEN-2006-020 – Hitchland – Sherman 115 kV
83	At Moore Co East of 115 kV line to RB Hogu	3PH	trip Moore Co East – RB Hogu 115 kV
84	At Moore Co East of 115 kV line to RB Hogu	SLG	trip Moore Co East – RB Hogu 115 kV
85	At Moore Co West of 115 kV line to Dumas	3PH	trip Moore Co West – Dumas 115 kV
86	At Moore Co West of 115 kV line to Dumas	SLG	trip Moore Co West – Dumas 115 kV
87	At Moore Co West of 115 kV line to RB Sneed	3PH	trip Moore Co West – RB Sneed 115 kV
88	At Moore Co West of 115 kV line to RB Sneed	SLG	trip Moore Co West – RB Sneed 115 kV
89	At Moore Co East 115 kV end of 230/115 kV transformer	3PH	trip Moore Co East 230/115 kV transformer
90	At Moore Co East 115 kV end of 230/115 kV transformer	SLG	trip Moore Co East 230/115 kV transformer
91	At Blackhawk North of 115 kV line to Pringle	3PH	trip Blackhawk North – Pringle 115 kV
92	At Blackhawk North of 115 kV line to Pringle	SLG	trip Blackhawk North – Pringle 115 kV

Cont. #	Fault Location	Fault Type	Fault Clearing
93	At Blackhawk South of 115 kV line to Hutchinson	3PH	trip Blackhawk South – Hutchinson 115 kV
94	At Blackhawk South of 115 kV line to Hutchinson	SLG	trip Blackhawk South – Hutchinson 115 kV
95	At Spearman of 115 kV line to Spearman Sub	3PH	trip Spearman – Spearman Sub 115 kV
96	At Spearman of 115 kV line to Spearman Sub	SLG	trip Spearman – Spearman Sub 115 kV
97	At Perryton 115 kV end of 230/115 kV transformer	3PH	trip Perryton 230/115 kV transformer
98	At Perryton 115 kV end of 230/115 kV transformer	SLG	trip Perryton 230/115 kV transformer
99	At Texas Co of 115 kV line to TC-MMRY3	3PH	trip Texas Co – TC-MMRY3 115 kV
100	At Texas Co of 115 kV line to TC-MMRY3	SLG	trip Texas Co – TC-MMRY3 115 kV
101	At Texas Co 115 kV end of 115 kV phase shift transformer	3PH	trip Texas Co 115 kV phase shift transformer
102	At Texas Co 115 kV end of 115 kV phase shift transformer	SLG	trip Texas Co 115 kV phase shift transformer
103	At Dalhart of 115 kV line to Sherman	3PH	trip Dalhart – Sherman 115 kV
104	At Dalhart of 115 kV line to Sherman	SLG	trip Dalhart – Sherman 115 kV

In order to simulate single line to ground faults, equivalent reactances were calculated. Table 3-3 presents the reactances applied to the buses in the stability simulations:

Table 3-3: Equivalent Reactances – Line to Ground Faults

Bus Number	Name	Equivalent Reactance (Mvar)
523097	Hitchland 345 kV	3300
523095	Hitchland 230 kV	2600
51700	Gen 05-017 345 kV	2400
523961	Potter Co. 345 kV	2600
523309	Moore Co. 230 kV	1700
523267	Pringle 230 kV	1800

Bus Number	Name	Equivalent Reactance (Mvar)
560029	Gen-03-013	2700
531449	Holcomb 345 kV	3800
515375	Woodward 345 kV	5000
523093	Hitchland 115 kV	1300
523266	Pringle 115 kV	1500
523308	Moore Co East 115 kV	1200
523304	Moore Co West 115 kV	1200
523344	Blackhawk North 115 kV	1400
523346	Blackhawk South 115 kV	1400
523186	Spearman 115 kV	1000
523158	Perryton 115 kV	700
523090	Texas Co 115 kV	800
523246	Dalhart 115 kV	400

The following Figures 3-1 and 3-2 present the most of fault locations within the study area.

Figure 3-1 – Fault Locations in the Study Area – *Diagram1, 345 and 230 kV Systems*

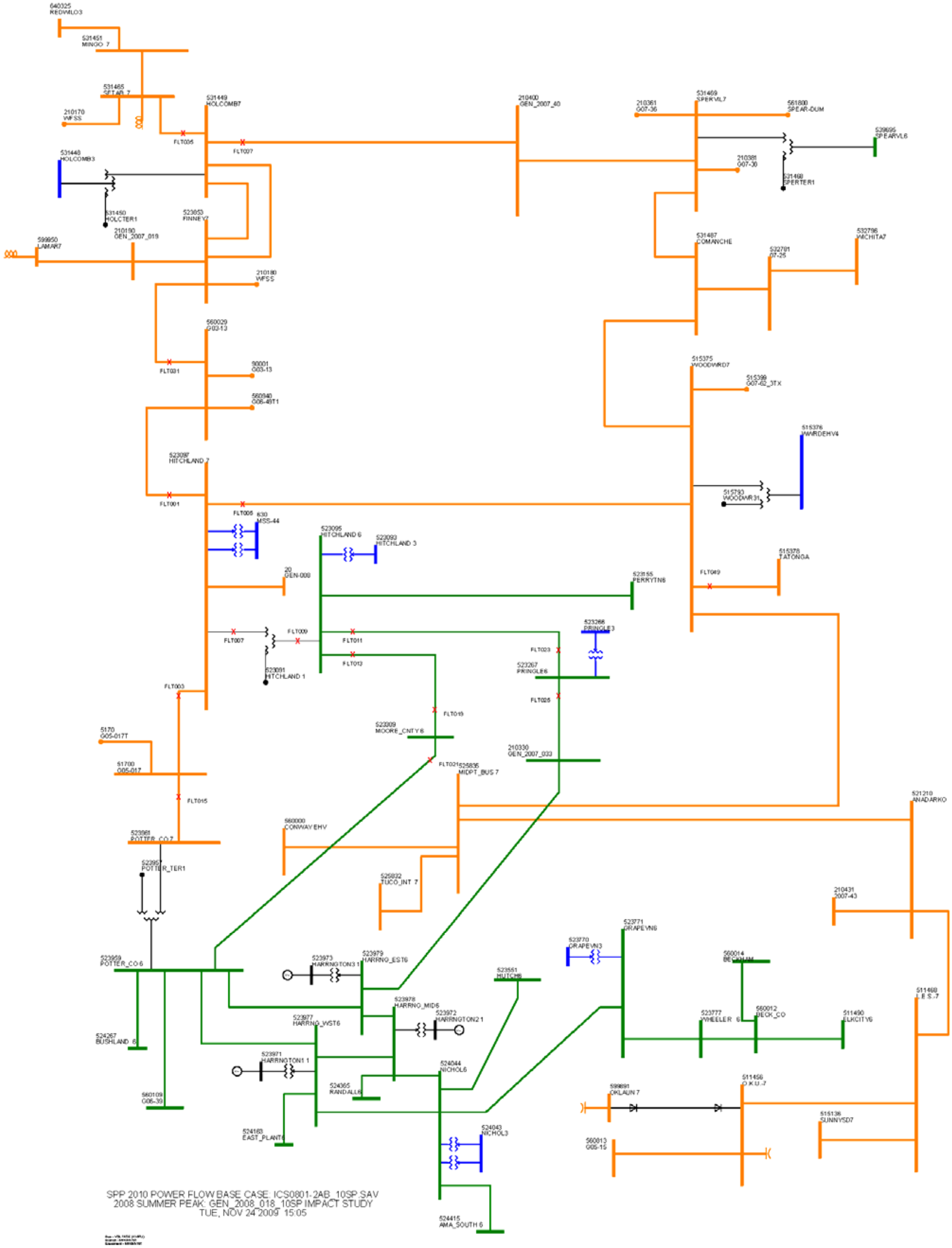
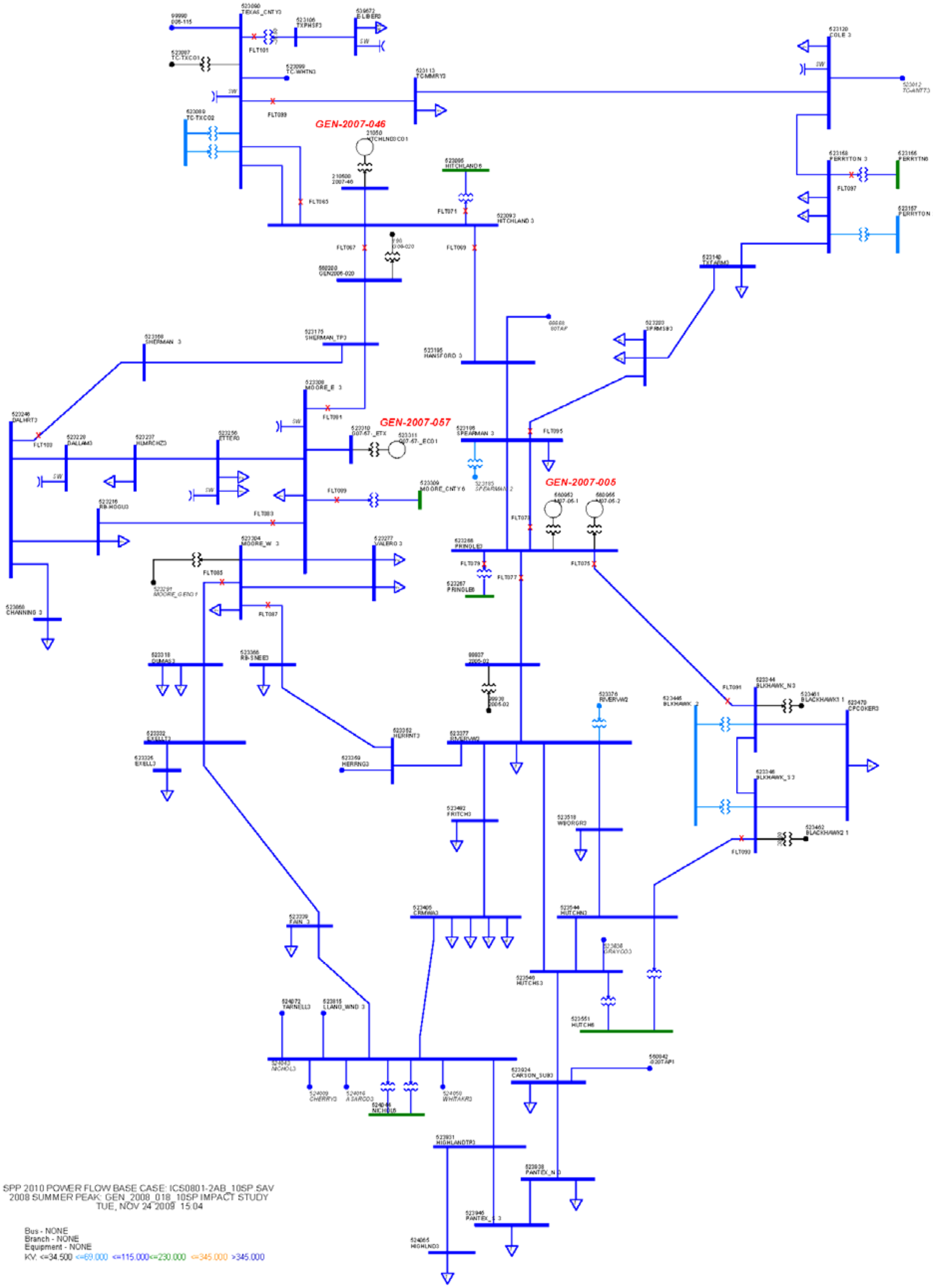


Figure 3-2 – Fault Locations in the Study Area – *Diagram2, 115 kV*



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Section

4

Analysis Performed

4.1 Steady State Performance

Tables 4-1 and 4-2 summarize the results obtained from the steady state analysis for Summer Peak and Winter Peak base cases, respectively. The tables list the voltage deviations at the Points of Interconnection of the proposed study projects of Group 2, as well as the prior queued projects. Note that only the contingencies that cause a voltage criterion violation or have an impact of at least 1% in the POI's voltages are listed.

The complete set of results for both summer peak and winter peak scenarios are presented in Appendix C.

Table 4-1: Results Obtained – Steady State Analysis – Summer Peak Base Case

Bus #	Bus Name	Base kV	Contingency Voltage	Base Voltage	% Deviation
Base Case					
51700	G05-017	345.0	-	1.0260	-
99937	2005-02	115.0	-	1.0375	-
210330	GEN_2007_03	230.0	-	1.0095	-
523090	TEXAS_CNTY3	115.0	-	1.0286	-
523093	HITCHLAND 3	115.0	-	1.0276	-
523095	HITCHLAND 6	230.0	-	1.0188	-
523097	HITCHLAND 7	345.0	-	1.0240	-
523195	HANSFORD 3	115.0	-	1.0333	-
523266	PRINGLE3	115.0	-	1.0451	-
523308	MOORE_E 3	115.0	-	1.0200	-
523924	CARSON_SUB3	115.0	-	1.0201	-
560029	G03-13	345.0	-	1.0320	-
560200	GEN2006-020	115.0	-	1.0201	-
FLT 01					
523095	HITCHLAND 6	230.0	1.009	1.019	-1.00
523097	HITCHLAND 7	345.0	1.007	1.024	-1.64
FLT 05					
560029	G03-13	345.0	1.009	1.032	-2.23
FLT 31					
51700	G05-017	345	0.983	1.026	-4.21
99937	2005-02	115	1.026	1.038	-1.08
210330	GEN_2007_033	230	0.996	1.010	-1.34
523090	TEXAS_CNTY3	115	1.007	1.029	-2.08
523093	HITCHLAND 3	115	1.006	1.028	-2.08
523095	HITCHLAND 6	230	0.974	1.019	-4.40

Bus #	Bus Name	Base kV	Contingency Voltage	Base Voltage	% Deviation
523097	HITCHLAND 7	345	0.954	1.024	-6.86
523195	HANSFORD 3	115	1.013	1.033	-1.98
523266	PRINGLE3	115	1.032	1.045	-1.26
560029	G03-13	345	0.998	1.032	-3.25
560200	GEN2006-020	115	1.004	1.020	-1.54
FLT 37					
523097	HITCHLAND 7	345	1.009	1.024	-1.42
FLT 69					
523195	HANSFORD 3	115	1.053	1.033	1.93
FLT 79					
523266	PRINGLE3	115	1.050	1.045	0.47
FLT 89					
523308	MOORE_E 3	115	1.008	1.020	-1.21

Table 4-2: Results Obtained – Steady State Analysis – Winter Peak Base Case

Bus #	Bus Name	Base kV	Contingency Voltage	Base Voltage	% Deviation
Base Case					
51700	G05-017	345.0	-	1.020	-
99937	2005-02	115.0	-	1.038	-
210330	GEN_2007_03	230.0	-	1.009	-
523090	TEXAS_CNTY3	115.0	-	1.035	-
523093	HITCHLAND 3	115.0	-	1.026	-
523095	HITCHLAND 6	230.0	-	1.011	-
523097	HITCHLAND 7	345.0	-	1.012	-
523195	HANSFORD 3	115.0	-	1.032	-
523266	PRINGLE3	115.0	-	1.042	-
523308	MOORE_E 3	115.0	-	1.027	-
523924	CARSON_SUB3	115.0	-	1.026	-
560029	G03-13	345.0	-	1.017	-
560200	GEN2006-020	115.0	-	1.022	-
FLT 01					
51700	G05-017	345	1.006	1.020	-1.39
523095	HITCHLAND 6	230	0.998	1.011	-1.33
523097	HITCHLAND 7	345	0.990	1.012	-2.13
FLT 05					
560029	G03-13	345	0.988	1.017	-2.82
FLT 31					
Voltage Collapse in the 345 kV System near Hitchland					
FLT 37					
51700	G05-017	345	1.008	1.020	-1.22
523090	TEXAS_CNTY3	115	1.025	1.035	-0.98
523095	HITCHLAND 6	230	0.999	1.011	-1.22
523097	HITCHLAND 7	345	0.993	1.012	-1.86
FLT 69					
523195	HANSFORD 3	115	1.052	1.032	1.99

Bus #	Bus Name	Base kV	Contingency Voltage	Base Voltage	% Deviation
FLT 71					
523090	TEXAS_CNTY3	115	1.045	1.035	1.02
523093	HITCHLAND 3	115	1.042	1.026	1.59
FLT 79					
523266	PRINGLE3	115	1.052	1.042	1.01
FLT 89					
523308	MOORE_E 3	115	0.995	1.027	-3.09
560200	GEN2006-020	115	1.012	1.022	-1.01

Both scenarios, summer and winter peak, some contingencies cause voltage rise or drop equal to or greater than 0.01 p.u. However, the voltage profile of the POI's surrounding area remains within the limits. The exceptions are:

- The outage of the 345 kV line between GEN-2003-013 and Finney substations (FLT 31) is severe. In summer peak it was identified voltage drop of approximately 7% at Hitchland 115 kV. In winter peak, it requires large reactive support at Hitchland 345 kV substation to prevent voltage collapse.

- The outage of 115 kV line between Hitchland and Hansford (FLT 69) substations leads to a minor voltage violation (0.3% - summer peak and 0.2 % - winter peak) in Hansford 115 kV. The identified violation can be mitigated using the existing system resources to control the voltages.

- The outage of Pringle 230/115 kV transformer (FLT 79) causes a voltage rise of approximately 1% in Pringle 115 kV substation. However the 0.2 % violation (winter peak) can be mitigated using the existing voltage control resources.

- The loss of the Moore Co East 230/115 kV transformer (FLT 89) causes 3.0% voltage drop in the winter peak case, without causing criterion violation. In the summer peak case, this contingency is not severe.

As shown in Table 4-2 and mentioned in bullet 1 above, in winter peak case, the outage of the 345 kV line between GEN-2003-013 and Finney substations (FLT 31) is severe and cause voltage collapse.

A sensitivity analysis was performed to assess the impact of each project in the Hitchland 345 kV voltage profile, for contingency FLT 31, when each project is modeled, one at a time.

The system was tested under the contingency, for each project individually, to determine the cause of the reactive power deficiency and system performance.

The results showed that:

- GEN-2007-05
  the post-contingency voltage near Hitchland drops to as low as 0.89 p.u. (at MSS -44 115 kV substation) with 0.924 p.u. at Hitchland 345 kV substation.

- GEN-2007-46
  the case with only this project modeled the contingency is much more severe, as the system experience voltage collapse near Hitchland 345 kV.

- GEN -2007-57
  the post-contingency voltage near Hitchland drops to as low as 0.928 (at MSS - 44 115 kV substation) with 0.962 p.u. at Hitchland 345 kV substation.

Based on the sensitivity analysis results, both GEN-2007-05 and GEN-2007-57 aggravate the reactive power deficiency at Hitchland 345 kV a little, but the foremost cause of reactive power deficiency is GEN-2007-46.

Table 4-3 shows the reactive support required, for each project when modeled individually, to maintain post-contingency voltage of 1.0 p.u at Hitchland 345 kV.

Table 4-3: Mvar Requirements at Hitchland 345 kV for the Proposed Projects Interconnection

Project	Point of Interconnection	Mvar Requirement at Hitchland 345 kV	Contingency
GEN-2007-05	Pringle 115 kV	224 Mvar	FLT31
GEN-2007-46	Hitchland 115 kV	286 Mvar	FLT31
GEN-2007-57	Moore Co. 115 kV	165 Mvar	FLT31

When the three projects are modeled in the winter peak base case at same time, the reactive support requirement to maintain post-contingency voltage of 1.0 p.u at Hitchland 345 kV is approximately 450 Mvar at this substation.

The electrical one- line diagram, shown in Appendix D, presents the voltage profile near Hitchland 345 kV substation for these three scenarios where the projects are modeled one at a time.

Overall, the Group 2 interconnection requests have significant impact on the voltages of the buses monitored in the study system, either in base case conditions or under contingencies, such that reactive support is required to prevent voltage collapse.

4.2 Power Factor Analysis

A QV analysis was performed to determine the amount of reactive support required from the projects to maintain the scheduled voltages at the respective points of interconnection. The contingencies described in Table 3-2 were evaluated in steady state conditions for summer and winter peak base cases, with variable Mvar injection at the POIs.

Table 4-4 presents for each one of the proposed wind facilities in Group 2, the Mvar requirements and the associated power factor that the projects must be able to provide under contingencies. It should be noted that the results shown in the table are based on the assumption that proper reactive support is provided for the contingency related to outage of 345 kV line GEN-2003-13 to Finney substations (FLT 31), to prevent voltage collapse in the 345 kV system in the Hitchland vicinity.

The maximum amount of Mvar required for the GEN-2007-057 (POI: Moore Co East 115 kV substation) is 55 Mvar for the contingency related to loss of Moore Co East 230/115 kV transformer (FLT 89). However, the requirement could be reduced to 15 Mvar if the POI could be operated at a voltage of 1.0 p.u. during contingency as oppose to scheduled voltage of 1.027 p.u.. Since Gen-2007-057 has a total capacity of 34.5 MW, the results shown in the Table 4-4 are based on this assumption.

Table 4-4: Mvar Requirements and Power Factor at the POI for the Proposed Projects Interconnection

Project	Point of Interconnection	V Scheduled (p.u)	Mvar Requirement at POI	Contingency	Power Factor at POI (lagging)
GEN-2007-005	Pringle 115 kV	1.045	25 Mvar	FLT 71(WP)	0.992
GEN-2007-046	Hitchland 115 kV	1.027	20 Mvar	FLT 37,67,81 (WP)	0.995
GEN-2007-057	Moore Co. 115 kV	1.000	15 Mvar	FLT 89 (WP)	0.917

Tables showing the injected Mvar for each voltage level in base case and contingencies are presented in Appendix E for both summer peak and winter peak scenarios. The values chosen are the highest between the two scenarios.

4.3 Stability Results

The stability analysis was carried out for both summer and winter peak load flow models.

In order to determine the impact of the project on the overall system dynamics as well as to determine the requirements to meet the FERC Order 661-A Guidelines, 74 contingencies listed by Table 3-2 were simulated. The results obtained are described in this sub-section.

Tables 4-5 and 4-6 summarize the results obtained from the stability simulations for both summer and winter peak base cases, respectively. The table lists the dynamic performance of the proposed study projects of Group 2, as well as the prior queued projects. Note that only the critical contingencies that lead to trips due to LVRT, frequency protection or loss of synchronism are listed.

Table 4-5: Results Obtained – Summer Peak Base Case

Name	Wind Projects Dynamic Performance
FLT067-3PH	GEN-2006-020 (90201) tripped for overfrequency at 0.7250 s
FLT068-1PH	GEN-2006-020 (90201) tripped for overfrequency at 0.7333 s
FLT081-3PH	GEN-2006-020 (90201) tripped for overfrequency at 0.7292 s
FLT082-1PH	GEN-2006-020 (90201) tripped for overfrequency at 0.7333 s

Table 4-6: Results Obtained – Winter Peak Base Case

Name	Wind Projects Dynamic Performance
FLT067-3PH	GEN-2006-020 (90201) tripped for overfrequency at 0.7250 s
FLT068-1PH	GEN-2006-020 (90201) tripped for overfrequency at 0.7292 s
FLT081-3PH	GEN-2006-020 (90201) tripped for overfrequency at 0.7292 s
FLT082-1PH	GEN-2006-020 (90201) tripped for overfrequency at 0.7333 s

The outage of Hitchland – Gen-2006-020 – Sherman Tap – Moore Co – Sherman 115 kV (FLTs 67, 68, 81 and 82) isolates the wind facility Gen-2006-020, causing trips due to overfrequency protection in both summer and winter peak scenarios.

Besides the Gen-2006-020 trip due to overfrequency, the results obtained show:

- The new proposed projects, did not trip during any of the contingencies tested, that is, no trips occurred due to LVRT or frequency protection.
- Furthermore, trips were not identified in the prior queued wind projects.
- All synchronous generators in the monitored areas were stable and remained in synchronism during all contingencies and the system conditions considered.
- Acceptable damping and voltage recovery was observed, within applicable standards.

Stability plots of the main contingencies evaluated for both summer peak and winter peak scenarios are presented in Appendix F.

Section

5

Conclusions

The three projects of ICS-2008-001 Group 2 have been evaluated to determine the system requirements to meet the FERC Order 661-A Guidelines for Low Voltage Ride Through (LVRT) and therefore, for them to deliver their full power to the SPP transmission system.

Steady state and stability analysis were carried out to evaluate the system performance under contingencies. In general, the Group 2 interconnection requests have more than 1% impact on the voltage profile of the monitored system, under contingencies. Significant voltage criteria violations, caused by the projects, were identified through the simulations performed. The main voltage deviations were:

- About 3% in FLT 89 (winter peak)
- Approximately 7% in FLT 31 (summer peak).

Reactive support is required to prevent voltage collapse in the winter peak scenario, under the outage of the 345 kV line between GEN-2003-013 and Finney substations (FLT 31). In order to maintain post-contingency voltage of 1.0 p.u at Hitchland 345 kV, approximately 450 Mvar is required at this substation.

The power factor analysis determined the amount of reactive support required to maintain the scheduled voltages at each one of the points of interconnection. The amount of reactive support indicated by Table 4-4 must be provided by each interconnection request using the wind turbine generator (WTG) reactive capabilities and/or adding capacitor banks to the system.

The stability results indicate that none of the Group 2 projects trip during the contingencies tested, that is, no trips occurred due to LVRT or frequency protection. Moreover, the new interconnection requests have no adverse impact on the stability of the SPP system, for system conditions tested.

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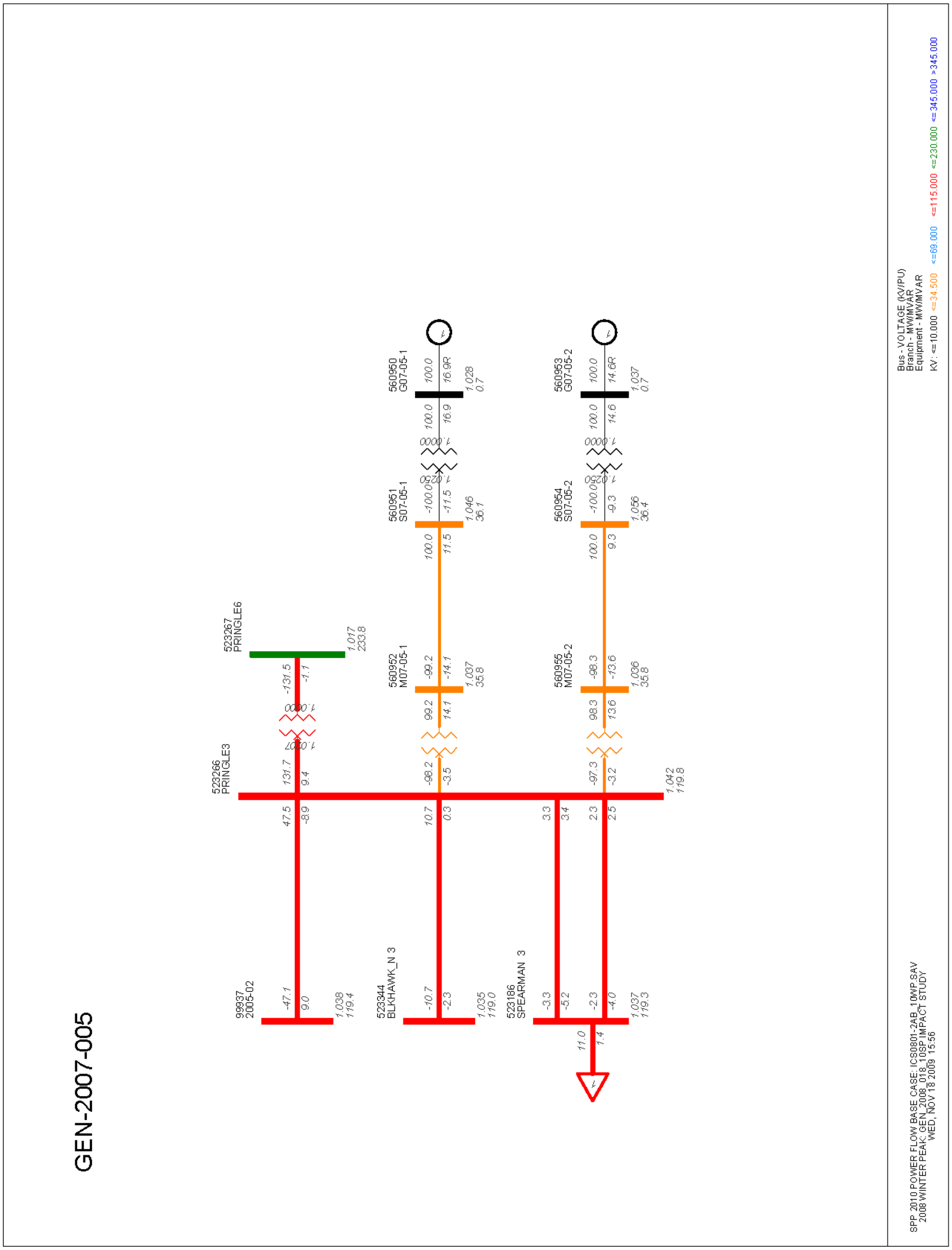
Appendix

A

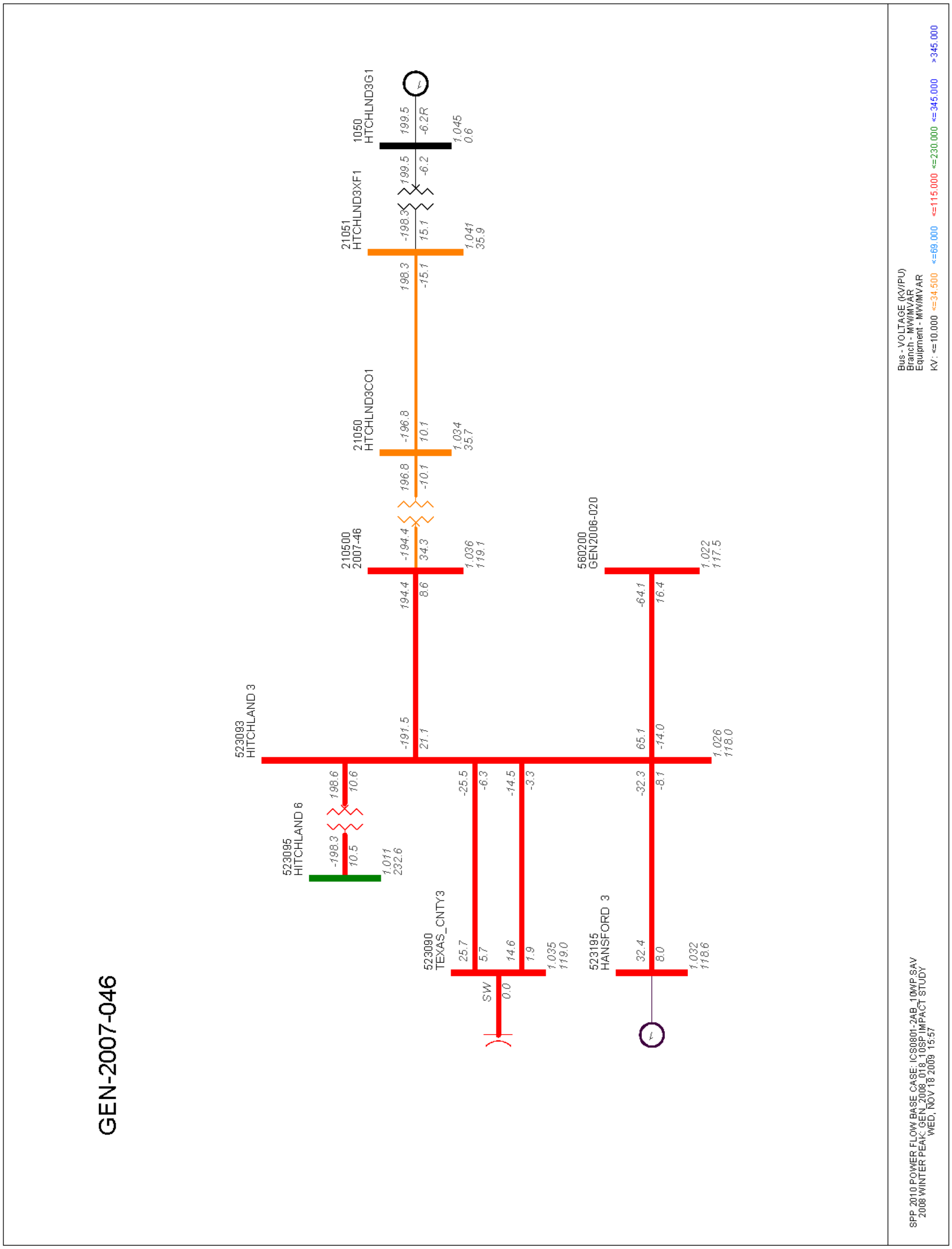
WTG Single Line Diagrams

This appendix contains the single line diagrams, showing the modeling details of each Group 2 project.

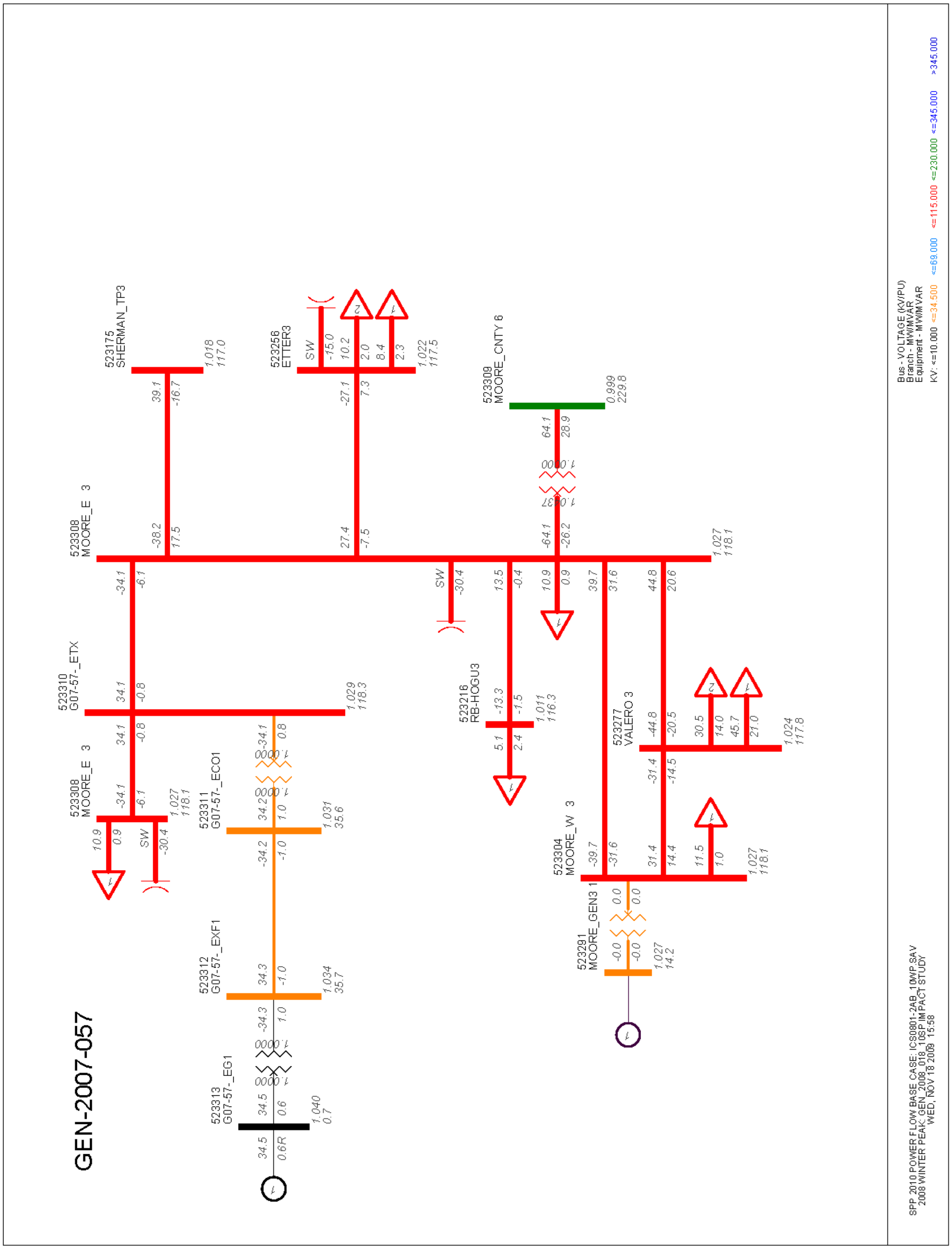
A.1 Gen -2007-005 – Furhlander 1.5 MW



A.2 GEN-2007-046 – GE 1.5 MW



A.3 GEN-2007-057-- GE 1.5 MW



Appendix

B

WTG Dynamic Models

This appendix shows the model data used to represent the turbines in the simulations.

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Appendix

C

Steady State Results

This Appendix shows the voltage analysis results. The voltages at each POI were monitored and documented for deviations from the base case voltages greater than 0.1%.

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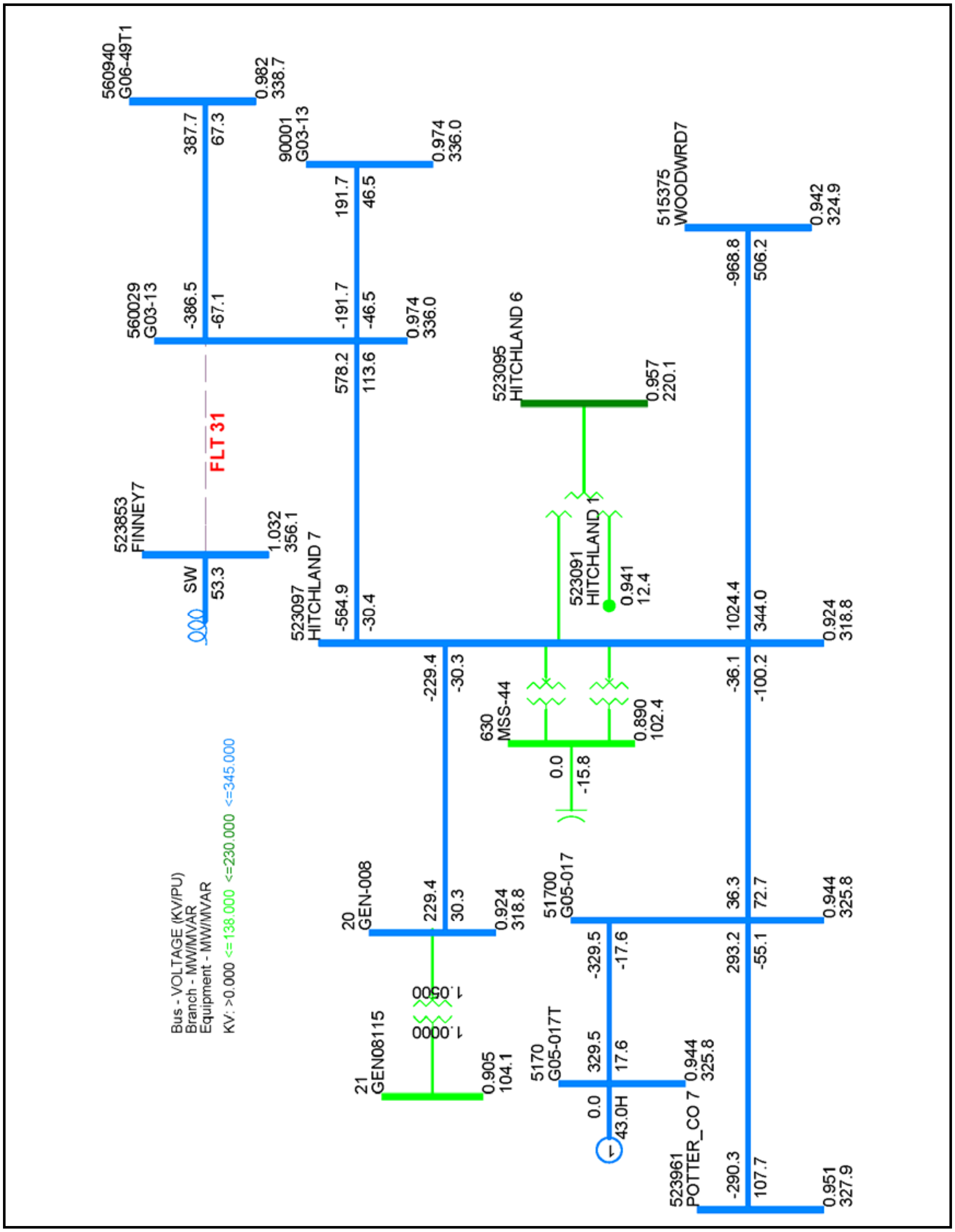
Appendix

D

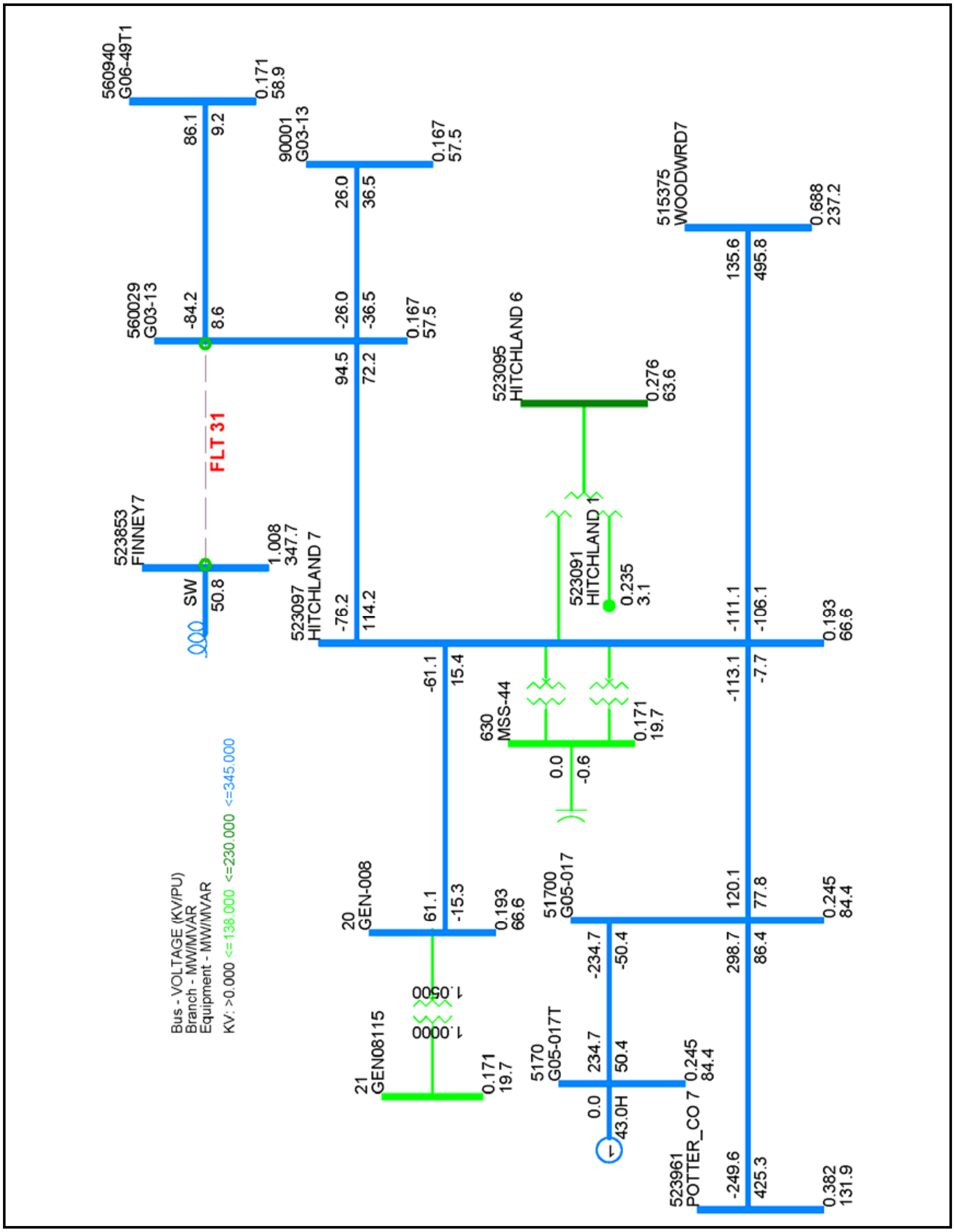
Voltage Profile near Hitchland 345 kV for FLT 31

This appendix presents post - contingency (FLT31) voltage profile at and near Hitchland 345 kV when each project was modeled individually in the winter peak case.

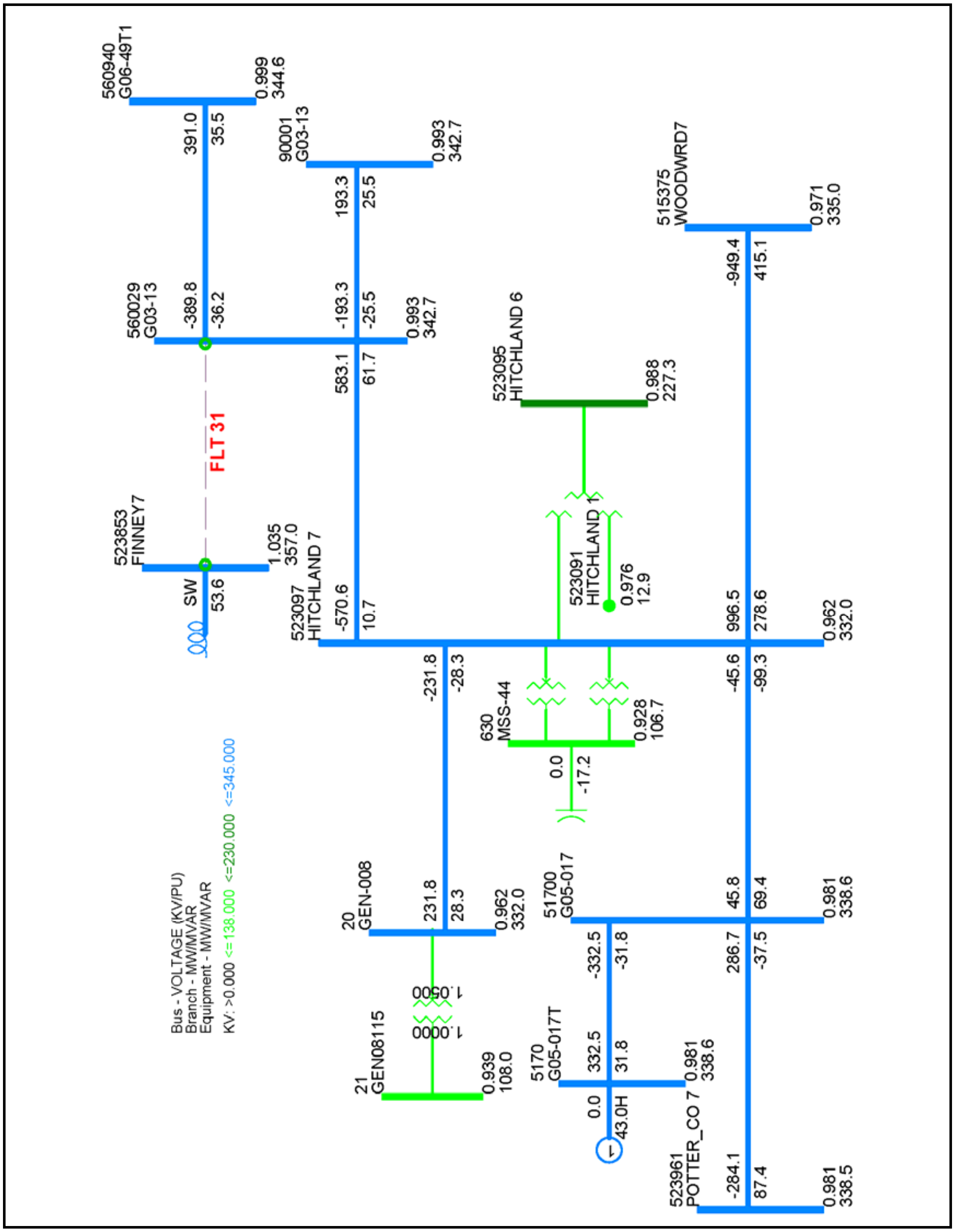
D.1 Post – contingency (FLT31) Voltage Profile near Hitchland 345 kV for GEN-2007-05



D.2 Post – contingency (FLT31) Voltage Profile near Hitchland 345 kV for GEN-2007- 46



D.3 Post – contingency (FLT31) Voltage Profile near Hitchland 345 kV for GEN-2007-57



Appendix

E

QV Tables – Power Factor Analysis

This appendix shows tables presenting the injected Mvar for each voltage level in base case and contingencies for both summer peak and winter peak scenarios.

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Appendix

F

Stability Results

The stability plots of the main contingencies evaluated are shown in this appendix. There are 4 plots for each interconnection request, which include the following channels:

- Bus Voltages.
- Speed Deviation.
- Synchronous Machine Rotor Angles.
- Electric Power of the Proposed WTGs (in Per Unit on 100 MVA Base)

F.1 Summer Peak Stability Results

F.2 Winter Peak Stability Results

L: Stability Study for Group 3

Pterra Consulting

Technical Report R134-09

Impact Study for Generation Interconnection Request ICS 2008-001 (Group 3)

Submitted to

Southwest Power Pool

November 2009

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Contents

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Executive Summary

This report presents the results of impact study comprising of power factor and stability analyses of the proposed interconnectionwind farm projects under ICS-2008-001 Group 3, namely Gen-2006-006, Gen-2007-038, and Gen-2008-018. These projects are described in Section 1.

The analysis was conducted through the Southwest Power Pool ("SPP") Tariff. Power factor analysis and transient stability simulations were conducted with all three projects in service at their full output.

Two base cases for 2010, summer and winter conditions, each comprising of a power flow and corresponding dynamics database, were provided by SPP. The three projects are already modeled in the base cases.

The results of the Power Factor analysis showed that with the MVAR capability of the three projects and without reactive compensation, each wind farm will not be able to keep the voltage schedule at the POI consistent with the voltage schedule in the provided power flow cases for summer and winter. Additional VAR compensating devices need to be installed for the customer to maintain a power factor at the point of interconnection in the ±-0.95 range.

Sixty-eight (68) faults were considered for the transient stability simulations which included 3-phase faults, as well as 1-phase to ground faults, at the locations defined by SPP. The results of the simulations showed no angular or voltage instability problems for the forty faults. The study finds that the interconnection of the three proposed projects does not impact stability performance of the SPP system for the contingencies tested on the supplied base cases.

Section 1. Introduction

1.1. Project Overview

This report presents the results of impact study comprising of power factor and stability analyses of the proposed interconnection projects under ICS-2008-001 Group 3 as described in Table 1-1:

Table 1-1 Projects Included Under ICS-2008-001

Request	Size (MW)	Wind Turbine Model	Point of Interconnection
GEN-2006-006	205	GE 1.5 MW	Spearville 230kV (539695)
GEN-2007-038	200	Clipper 2.5MW	Spearville 345kV (531469)
GEN-2008-018	405	GE 1.5 MW	Finney 345kV (523853)

Figures 1-1, 1-2, and 1-3 show the interconnection diagrams of the Project to SPP's system as modeled in the power flow cases.

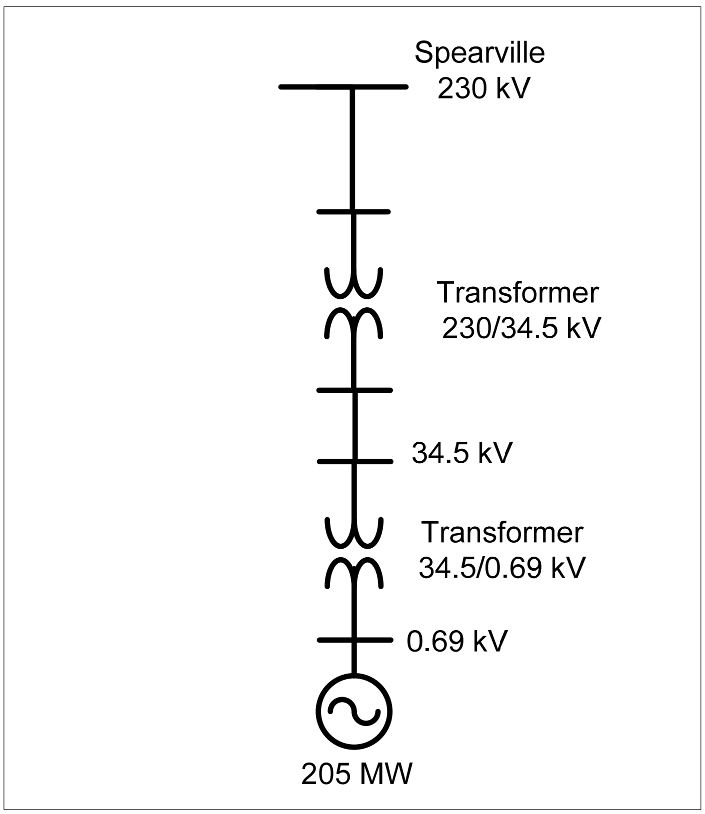

Figure 1-1 Power Flow Model for Gen-2006-006

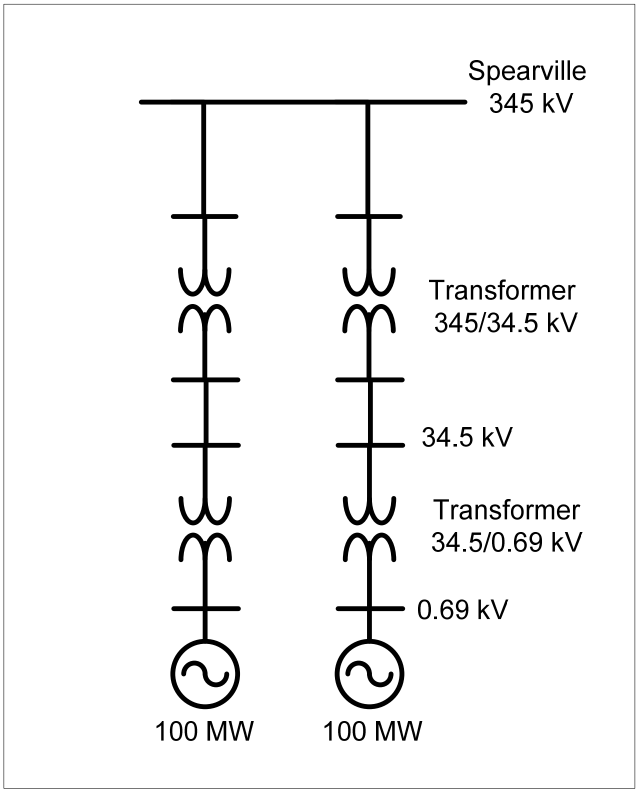

Figure 1-2 Power Flow Model for Gen-2007-038

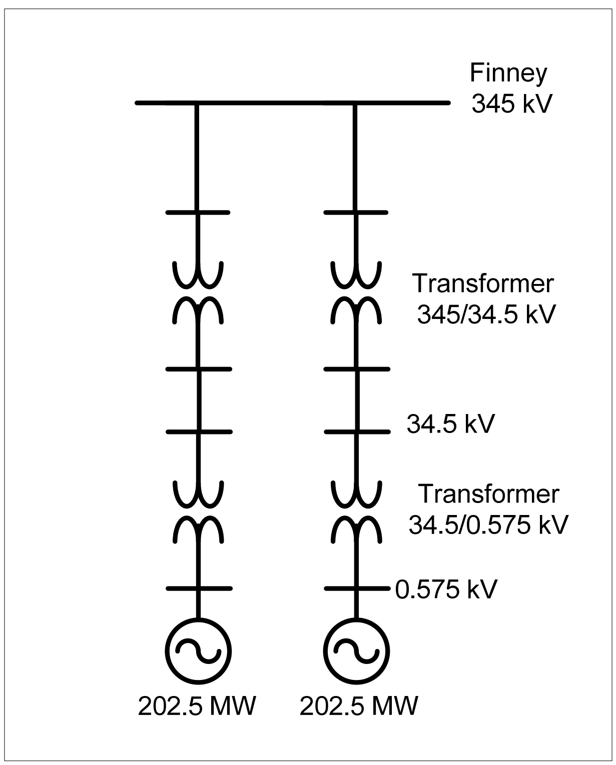

Figure 1-3 Power Flow Model for Gen-2008-018

Table 1-2 shows the list of prior queued projects modeled in the base case.

Table 1-2 List of Prior Queued Projects

Request	Size MW	Wind Turbine Model	Point of Interconnection
GEN-2001-039A	105	Clipper 2.5MW	Judson Large – Greensburg 115 kV 103)
GEN-2002-025A	150	GE 1.5 MW	Spearville 230 kV (539695)
GEN-2004-014	154.5	GE 1.5 MW	Spearville 230 kV (539695)
GEN-2005-012	250	Vestas V90 3.0MW	Spearville 345 kV (531469)

1.2. Objectives

The objectives of the study are to conduct power factor analysis and to determine the impact on system stability of interconnecting the proposed wind farms to SPP's transmission system.

Section 2. Power Factor Analysis

2.1. Methodology

Power factor analysis was conducted for the Project using a methodology which is summarized as follows:

1. Model a VAR generator at the Project's 345 or 230 kV bus, whichever is applicable. The VAR generator is set to hold a voltage schedule at the POI consistent with the voltage schedule in the provided power flow cases for summer and winter or 1.0 pu voltage, whichever is higher.

2. Steady state contingency analysis is conducted to determine the power factor necessary at the POI for each contingency.

3. According to the contingency analysis results, determine whether capacitors are required for the Project or not.

4. If the required power factor at the POI is beyond the capability of the studied wind turbines to meet (at the POI) capacitor banks are considered. The preference is to locate the capacitance banks is on the 34.5 kV Customer side. Factors to sizing capacitor banks include:

    4.1. The ability of the wind farm to meet FERC Order 661A (low voltage ride through) with and without capacitor banks.

    4.2. The ability of the wind farm to meet FERC Order 661A (wind farm recovery to pre-fault voltage).

    4.3. If wind farms trips on high voltage, power factor lower than unity may be required.

2.2. Analysis

Analysis was performed for each proposed project with all three projects in service. A VAR generator was modeled at each point of interconnection and was set to hold a voltage schedule at the POI consistent with the voltage schedule in the provided power flow cases. These voltages are summarized in the Table 2-1.

No changes were made in the base cases provided other than the addition of the VAR generators. Contingency analysis was run for twenty contingencies.

Table 2-1 Pre-contingency Voltages at POI

Request	Point of Interconnection	Size (MW)	Base Case Voltage (p.u.)	
			Summer Peak	Winter Peak
GEN-2006-006	Spearville 230kV (539695)	205	1.03	1.024
GEN-2007-038	Spearville 345kV (531469)	200	1.035	1.025

Request	Point of Interconnection	Size (MW)	Base Case Voltage (p.u.)	
			Summer Peak	Winter Peak
GEN-2008-018	Finney 345kV (523853)	405	1.021	1.017

2.2.1. Gen-2006-006

The VAR generator either supplies or absorbs reactive power at different contingencies as summarized in Table 2-1. The highest values obtained are as follows:

1. For the summer case, the VAR generator supplies 101.9 MVar for the outage of Spearville-Comanche 345 kV line and absorbs 24.4 MVar for the loss of Holcomb-Gen_2007_040 345 kV line.
2. For the winter case, the VAR generator supplies 152.7 MVar for the outage of Spearville-Comanche 345 kV line and absorbs 57.3 MVar for the loss of Holcomb-Gen_2007_040 345 kV line.

Table 2-2 VAR Generator Output in Summer and Winter Peak Cases for GEN-2006-006

CASE	CONTINGENCY	PF @ POI	PF	MW @ POI	MVAR @ POI
SP	BASE CASE	1.000	Lag	198.4	0.7
	523853 FINNEY7 345 210190 GEN_2007_019 345 1	1.000	Lead	198.4	3.6
	523853 FINNEY7 345 560029 G03-13 345 1	0.997	Lead	198.4	16.4
	523853 FINNEY7 345 531449 HOLCOMB7 345 1	1.000	Lag	198.4	0.6
	531449 HOLCOMB7 345 531465 SETAB 7 345 1	0.999	Lead	198.4	8.9
	531449 HOLCOMB7 345 210400 GEN_2007_040 345 1	0.993	Lag	198.4	24.4
	531449 HOLCOMB7 345 531448 HOLCOMB3 115 531450 HOLCTER1 13.8 1	0.999	Lag	198.4	6.3
	531469 SPERVIL7 345 210400 GEN_2007_040 345 1	0.997	Lag	198.4	14.2
	531469 SPERVIL7 345 531487 COMANCHE 345 1	0.890	Lead	198.4	101.9
	531469 SPERVIL7 345 539695 SPEARVL6 230 531468 SPERTER1 13.8 1	0.951	Lead	198.4	64.2
	539695 SPEARVL6 230 539694 SPEARVL3 115 2	1.000	Lag	198.4	3.1
	539695 SPEARVL6 230 539679 MULGREN6 230 1	0.995	Lead	198.4	20.0
	539679 MULGREN6 230 530582 S HAYS6 230 1	1.000	Lead	198.4	1.0
	539679 MULGREN6 230 532871 CIRCLE 6 230 1	1.000	Lead	198.4	2.8
	531487 COMANCHE 345 532781 07-25 345 1	0.999	Lead	198.4	8.5
	531487 COMANCHE 345 515375 WOODWRD7 345 1	1.000	Lead	198.4	3.7
	560029 G03-13 345 523097 HITCHLAND 7 345 1	0.995	Lead	198.4	20.4
	51700 G05-017 345 523961 POTTER_CO 7 345 1	1.000	Lead	198.4	3.5
	523961 POTTER_CO 7 345 523959 POTTER_CO 6 230 523957 POTTER_TER1 13.2 1	1.000	Lag	198.4	2.3
	531469 SPERVIL7 345 530700 KNOLL 345 1	0.987	Lead	198.4	32.5
	530558 KNOLL 6 230 530592 SMOKYHLLS6 230 1	1.000	Lead	198.4	3.2

CASE	CONTINGENCY	PF @ POI	PF	MW @ POI	MVAR @ POI
WP	BASE CASE	1.000	Lag	198.5	3.3
	523853 FINNEY7 345 210190 GEN_2007_019 345 1	1.000	Lag	198.5	3.0
	523853 FINNEY7 345 560029 G03-13 345 1	0.994	Lead	198.5	22.4
	523853 FINNEY7 345 531449 HOLCOMB7 345 1	1.000	Lag	198.5	3.4
	531449 HOLCOMB7 345 531465 SETAB 7 345 1	1.000	Lead	198.5	2.0
	531449 HOLCOMB7 345 210400 GEN_2007_040 345 1	0.961	Lag	198.5	57.3
	531449 HOLCOMB7 345 531448 HOLCOMB3 115 531450 HOLCTER1 13.8 1	0.998	Lag	198.5	12.3
	531469 SPERVIL7 345 210400 GEN_2007_040 345 1	0.982	Lag	198.5	37.7
	531469 SPERVIL7 345 531487 COMANCHE 345 1	0.793	Lead	198.5	152.7
	531469 SPERVIL7 345 539695 SPEARVL6 230 531468 SPERTER1 13.8 1	0.883	Lead	198.5	105.7
	539695 SPEARVL6 230 539694 SPEARVL3 115 2	0.999	Lag	198.5	9.6
	539695 SPEARVL6 230 539679 MULGREN6 230 1	0.973	Lead	198.5	47.1
	539679 MULGREN6 230 530582 S HAYS6 230 1	1.000	Lead	198.5	0.2
	539679 MULGREN6 230 532871 CIRCLE 6 230 1	1.000	Lead	198.5	2.3
	531487 COMANCHE 345 532781 07-25 345 1	1.000	Lead	198.5	5.6
	531487 COMANCHE 345 515375 WOODWRD7 345 1	0.989	Lead	198.5	29.9
	560029 G03-13 345 523097 HITCHLAND 7 345 1	0.988	Lead	198.5	31.0
	51700 G05-017 345 523961 POTTER_CO 7 345 1	1.000	Lead	198.5	4.2
	523961 POTTER_CO 7 345 523959 POTTER_CO 6 230 523957 POTTER_TER1 13.2 1	0.999	Lag	198.5	7.5
	531469 SPERVIL7 345 530700 KNOLL 345 1	0.944	Lead	198.5	69.1
	530558 KNOLL 6 230 530592 SMOKYHLLS6 230 1	1.000	Lead	198.5	1.5

2.2.2. Gen-2007-038

The VAR generator either supplies or absorbs reactive power at different contingencies as summarized in Table 2-2. The highest values obtained are as follows:

1. For the summer case, the VAR generator supplies 161.5 MVar for the outage of Spearville-Comanche 345 kV line and absorbs 115 MVar for the loss of Spearville 345/230/13.8 kV transformer.
2. For the winter case, the VAR generator supplies 182.2 MVar for the outage of Spearville-Comanche 345 kV line and absorbs 85.1 MVar for the loss of Holcomb-Gen_2007_040 345 kV line.

Table 2-2 VAR Generator Output in Summer and Winter Peak Cases for GEN-2007-036

CASE	CONTINGENCY	PF @ POI	PF	MW @ POI	MVAR @ POI
SP	BASE CASE	1.000	Lead	393.0	4.5
	523853 FINNEY7 345 210190 GEN_2007_019 345 1	0.999	Lead	393.0	20.5
	523853 FINNEY7 345 560029 G03-13 345 1	0.989	Lead	393.0	59.4
	523853 FINNEY7 345 531449 HOLCOMB7 345 1	1.000	Lead	393.0	4.7

CASE	CONTINGENCY	PF @ POI	PF	MW @ POI	MVAR @ POI
	531449 HOLCOMB7 345 531465 SETAB 7 345 1	0.995	Lead	393.0	37.5
	531449 HOLCOMB7 345 210400 GEN_2007_040 345 1	0.974	Lag	393.0	91.2
	531449 HOLCOMB7 345 531448 HOLCOMB3 115 531450 HOLCTER1 13.8 1	0.999	Lag	393.0	19.5
	531469 SPERVIL7 345 210400 GEN_2007_040 345 1	0.988	Lag	393.0	60.6
	531469 SPERVIL7 345 531487 COMANCHE 345 1	0.925	Lead	393.0	161.5
	531469 SPERVIL7 345 539695 SPEARVL6 230 531468 SPERTER1 13.8 1	0.960	Lag	393.0	115.0
	539695 SPEARVL6 230 539694 SPEARVL3 115 2	1.000	Lead	393.0	4.5
	539695 SPEARVL6 230 539679 MULGREN6 230 1	0.981	Lead	393.0	76.7
	539679 MULGREN6 230 530582 S HAYS6 230 1	1.000	Lag	393.0	7.0
	539679 MULGREN6 230 532871 CIRCLE 6 230 1	0.998	Lead	393.0	24.8
	531487 COMANCHE 345 532781 07-25 345 1	1.000	Lead	393.0	7.2
	531487 COMANCHE 345 515375 WOODWRD7 345 1	1.000	Lead	393.0	7.7
	560029 G03-13 345 523097 HITCHLAND 7 345 1	0.984	Lead	393.0	71.5
	51700 G05-017 345 523961 POTTER_CO 7 345 1	0.999	Lead	393.0	16.6
	523961 POTTER_CO 7 345 523959 POTTER_CO 6 230 523957 POTTER_TER1 13.2 1	1.000	Lag	393.0	0.6
	531469 SPERVIL7 345 530700 KNOLL 345 1	0.988	Lead	393.0	61.4
	530558 KNOLL 6 230 530592 SMOKYHLLS6 230 1	1.000	Lead	393.0	11.4
WP	BASE CASE	1.000	Lead	392.7	0.2
	523853 FINNEY7 345 210190 GEN_2007_019 345 1	1.000	Lead	392.7	1.2
	523853 FINNEY7 345 560029 G03-13 345 1	0.994	Lead	392.7	43.8
	523853 FINNEY7 345 531449 HOLCOMB7 345 1	1.000	Lead	392.7	0.4
	531449 HOLCOMB7 345 531465 SETAB 7 345 1	1.000	Lead	392.7	9.8
	531449 HOLCOMB7 345 210400 GEN_2007_040 345 1	0.977	Lag	392.7	85.1
	531449 HOLCOMB7 345 531448 HOLCOMB3 115 531450 HOLCTER1 13.8 1	0.999	Lag	392.7	15.8
	531469 SPERVIL7 345 210400 GEN_2007_040 345 1	0.990	Lag	392.7	55.2
	531469 SPERVIL7 345 531487 COMANCHE 345 1	0.907	Lead	392.7	182.2
	531469 SPERVIL7 345 539695 SPEARVL6 230 531468 SPERTER1 13.8 1	0.979	Lag	392.7	80.8
	539695 SPEARVL6 230 539694 SPEARVL3 115 2	1.000	Lag	392.7	3.9
	539695 SPEARVL6 230 539679 MULGREN6 230 1	0.981	Lead	392.7	77.0
	539679 MULGREN6 230 530582 S HAYS6 230 1	1.000	Lag	392.7	4.2
	539679 MULGREN6 230 532871 CIRCLE 6 230 1	0.999	Lead	392.7	20.1
	531487 COMANCHE 345 532781 07-25 345 1	1.000	Lag	392.7	2.3
	531487 COMANCHE 345 515375 WOODWRD7 345 1	0.993	Lead	392.7	48.0
	560029 G03-13 345 523097 HITCHLAND 7 345 1	0.989	Lead	392.7	58.4
	51700 G05-017 345 523961 POTTER_CO 7 345 1	1.000	Lead	392.7	11.4
	523961 POTTER_CO 7 345 523959 POTTER_CO 6 230 523957 POTTER_TER1 13.2 1	1.000	Lag	392.7	6.8
	531469 SPERVIL7 345 530700 KNOLL 345 1	0.968	Lead	392.7	102.3

CASE	CONTINGENCY	PF @ POI	PF	MW @ POI	MVAR @ POI
	530558 KNOLL 6 230 530592 SMOKYHLLS6 230 1	1.000	Lead	392.7	5.9

2.2.3. Gen-2008-018

The VAR generator absorbs reactive power for all specified contingencies as summarized in Table 2-3. The highest values are 65.7 MVar in the summer case for the loss of Spearville 345/230/13.8 kV three-winding transformer and 59.5 MVar in the winter case for the same contingency.

Table 2-3 VAR Generator Output in Summer and Winter Peak Cases for GEN-2008-018

CASE	CONTINGENCY	PF @ POI	PF	MW @ POI	MVAR @ POI
SP	BASE CASE	0.992	Lag	396.0	51.0
	523853 FINNEY7 345 210190 GEN_2007_019 345 1	0.998	Lag	396.0	22.0
	523853 FINNEY7 345 560029 G03-13 345 1	0.997	Lag	396.0	30.8
	523853 FINNEY7 345 531449 HOLCOMB7 345 1	0.992	Lag	396.0	50.5
	531449 HOLCOMB7 345 531465 SETAB 7 345 1	0.995	Lag	396.0	39.5
	531449 HOLCOMB7 345 210400 GEN_2007_040 345 1	0.999	Lag	396.0	20.6
	531449 HOLCOMB7 345 531448 HOLCOMB3 115 531450 HOLCTER1 13.8 1	0.988	Lag	396.0	61.0
	531469 SPERVIL7 345 210400 GEN_2007_040 345 1	0.997	Lag	396.0	30.1
	531469 SPERVIL7 345 531487 COMANCHE 345 1	1.000	Lag	396.0	10.7
	531469 SPERVIL7 345 539695 SPEARVL6 230 531468 SPERTER1 13.8 1	0.987	Lag	396.0	65.7
	539695 SPEARVL6 230 539694 SPEARVL3 115 2	0.992	Lag	396.0	50.9
	539695 SPEARVL6 230 539679 MULGREN6 230 1	0.994	Lag	396.0	44.0
	539679 MULGREN6 230 530582 S HAYS6 230 1	0.992	Lag	396.0	51.5
	539679 MULGREN6 230 532871 CIRCLE 6 230 1	0.992	Lag	396.0	49.2
	531487 COMANCHE 345 532781 07-25 345 1	0.992	Lag	396.0	49.4
	531487 COMANCHE 345 515375 WOODWRD7 345 1	0.993	Lag	396.0	47.5
	560029 G03-13 345 523097 HITCHLAND 7 345 1	0.997	Lag	396.0	32.0
	51700 G05-017 345 523961 POTTER_CO 7 345 1	0.992	Lag	396.0	51.8
	523961 POTTER_CO 7 345 523959 POTTER_CO 6 230 523957 POTTER_TER1 13.2 1	0.991	Lag	396.0	53.5
	531469 SPERVIL7 345 530700 KNOLL 345 1	0.994	Lag	396.0	43.2
	530558 KNOLL 6 230 530592 SMOKYHLLS6 230 1	0.992	Lag	396.0	50.1
WP	BASE CASE	0.992	Lag	395.9	51.0
	523853 FINNEY7 345 210190 GEN_2007_019 345 1	0.995	Lag	395.9	39.1
	523853 FINNEY7 345 560029 G03-13 345 1	0.998	Lag	395.9	27.8
	523853 FINNEY7 345 531449 HOLCOMB7 345 1	0.992	Lag	395.9	50.4
	531449 HOLCOMB7 345 531465 SETAB 7 345 1	0.998	Lag	395.9	22.8
	531449 HOLCOMB7 345 210400 GEN_2007_040 345 1	0.998	Lag	395.9	26.7
	531449 HOLCOMB7 345 531448 HOLCOMB3 115 531450 HOLCTER1 13.8 1	0.989	Lag	395.9	58.7

CASE	CONTINGENCY	PF @ POI	PF	MW @ POI	MVAR @ POI
	531469 SPERVIL7 345 210400 GEN_2007_040 345 1	0.996	Lag	395.9	36.0
	531469 SPERVIL7 345 531487 COMANCHE 345 1	1.000	Lag	395.9	6.1
	531469 SPERVIL7 345 539695 SPEARVL6 230 531468 SPERTER1 13.8 1	0.989	Lag	395.9	59.5
	539695 SPEARVL6 230 539694 SPEARVL3 115 2	0.992	Lag	395.9	51.3
	539695 SPEARVL6 230 539679 MULGREN6 230 1	0.994	Lag	395.9	42.3
	539679 MULGREN6 230 530582 S HAYS6 230 1	0.992	Lag	395.9	51.3
	539679 MULGREN6 230 532871 CIRCLE 6 230 1	0.993	Lag	395.9	48.6
	531487 COMANCHE 345 532781 07-25 345 1	0.992	Lag	395.9	50.3
	531487 COMANCHE 345 515375 WOODWRD7 345 1	0.994	Lag	395.9	41.8
	560029 G03-13 345 523097 HITCHLAND 7 345 1	0.997	Lag	395.9	28.2
	51700 G05-017 345 523961 POTTER_CO 7 345 1	0.991	Lag	395.9	54.9
	523961 POTTER_CO 7 345 523959 POTTER_CO 6 230 523957 POTTER_TER1 13.2 1	0.991	Lag	395.9	54.5
	531469 SPERVIL7 345 530700 KNOLL 345 1	0.995	Lag	395.9	38.2
	530558 KNOLL 6 230 530592 SMOKYHLLS6 230 1	0.992	Lag	395.9	50.0

2.3. Conclusions

In order to hold a voltage schedule at the POI's of the three projects consistent with the voltage schedule in the provided power flow cases, the wind farm should control the power factor at the POI to be within the ± 0.95 range. Additional VAR compensating devices need to be installed for the customer to maintain a power factor at the point of interconnection in the ±-0.95 range.

3.1. Assumptions

The following assumptions were adopted for the dynamic simulations:

1. Constant maximum and uniform wind speed for the entire period of study.
2. Wind turbine control models with their default values.
3. Under/over voltage/frequency protection use manufacturer settings.

3.2. Faults Simulated

Sixty-eight (68) faults were considered for the transient stability simulations which included three phase faults, as well as single phase line faults, at the locations defined by SPP. Single-phase line faults were simulated by applying a 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. Prior queued projects shown in Table 1-2 and units in areas 520, 524, 525, 526, 531, and 534, and 536 were monitored in the simulations.

Table 3-1 shows the list of simulated faults. It also shows the fault clearing time and the time delay before re-closing for all the study contingencies.

Table 3-1 List of Simulated Faults

Cont. No.	Cont. Name	Description
5	FLT05-3PH	3 phase fault on the Finney (523853) to GEN-2007-019 (210190) 345kV line, near Finney. a. Apply fault at the Finney 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.
6	FLT06-1PH	Single phase fault and sequence like previous
7	FLT07-3PH	3 phase fault on the Finney (523853) to GEN-2003-013 (560029) 345kV line, near Finney. a. Apply fault at the Finney 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.

Cont. No.	Cont. Name	Description
8	FLT08-1PH	Single phase fault and sequence like previous
9	FLT09-3PH	3 phase fault on one of the Finney (523853) to Holcomb (531449) 345kV lines, near Finney. a. Apply fault at the Finney 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.
10	FLT10-1PH	Single phase fault and sequence like previous
13	FLT13-3PH	3 phase fault on the Holcomb (531449) to Setab (531465) 345kV line, near Holcomb. a. Apply fault at the Holcomb 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	FLT14-1PH	Single phase fault and sequence like previous
15	FLT15-3PH	3 phase fault on the Holcomb (531449) to GEN-2007-040 (210400) 345kV line, near Holcomb. a. Apply fault at the Holcomb 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.
16	FLT16-1PH	Single phase fault and sequence like previous
17	FLT17-3PH	3 phase fault on the Holcomb 345kV (531449) to 115kV (531448) transformer, near the 345 kV bus. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
18	FLT18-1PH	Single phase fault and sequence like previous
23	FLT23-3PH	3 phase fault on the Spearville (531469) to GEN-2007-040 (210400) 345kV line, near Spearville. a. Apply fault at the Spearville 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.
24	FLT24-1PH	Single phase fault and sequence like previous

Cont. No.	Cont. Name	Description
25	FLT25-3PH	3 phase fault on the Spearville (531469) to Comanche (531487) 345kV line, near Spearville. a. Apply fault at the Spearville 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.
26	FLT26-1PH	Single phase fault and sequence like previous
27	FLT27-3PH	3 phase fault on the Spearville 345kV (531469) to 230kV (539695) transformer, near the 345 kV bus. a. Apply fault at the Spearville 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
28	FLT28-1PH	Single phase fault and sequence like previous
31	FLT31-3PH	3 phase fault on the Spearville 230kV (539695) to 115kV (539694) transformer #2, near the 230 kV bus. a. Apply fault at the Spearville 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
32	FLT32-1PH	Single phase fault and sequence like previous
33	FLT33-3PH	3 phase fault on the Spearville (539695) to Mullergren (539679) 230kV line, near Spearville. a. Apply fault at the Spearville 230kV 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.
34	FLT34-1PH	Single phase fault and sequence like previous
35	FLT35-3PH	3 phase fault on the Mullergren (539679) to South Hays (530582) 230kV line, near Mullergren. a. Apply fault at the Mullergren 230kV 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.
36	FLT36-1PH	Single phase fault and sequence like previous

Cont. No.	Cont. Name	Description
37	FLT37-3PH	3 phase fault on the Mullergren (539679) to Circle (532871) 230kV line, near Mullergren. a. Apply fault at the Mullergren 230kV 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.
38	FLT38-1PH	Single phase fault and sequence like previous
41	FLT41-3PH	3 phase fault on the Comanche (531487) to GEN-2007-025 (532781) 345kV line, near Comanche. a. Apply fault at the Comanche 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.
42	FLT42-1PH	Single phase fault and sequence like previous
45	FLT45-3PH	3 phase fault on the Comanche (531487) to Woodward (515375) 345kV line, near Comanche. a. Apply fault at the Comanche 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.
46	FLT46-1PH	Single phase fault and sequence like previous
51	FLT51-3PH	3 phase fault on the GEN-2003-013 (560029) to Hitchland (523097) 345kV line, near GEN-2003-013. a. Apply fault at the GEN-2003-013 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.
52	FLT52-1PH	Single phase fault and sequence like previous
57	FLT57-3PH	3 phase fault on the GEN-2005-017 (51700) to Potter Co. (523961) 345kV line, near GEN-2005-017. a. Apply fault at the GEN-2005-017 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.

Cont. No.	Cont. Name	Description
58	FLT58-1PH	Single phase fault and sequence like previous
61	FLT61-3PH	3 phase fault on the Potter Co. 345kV (523961) to 230kV (523959) transformer, near the 345 kV bus. a. Apply fault at the Potter Co. 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
62	FLT62-1PH	Single phase fault and sequence like previous
67	FLT67-3PH	3 phase fault on the Knoll (530558) to Smoky Hills (530592) 230kV line, near Knoll. a. Apply fault at the Knoll 230kV 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.
68	FLT68-1PH	Single phase fault and sequence like previous

Simulations were performed with a 0.1-second steady-state run followed by the appropriate disturbance as described in Table 3-1. Simulations were run for a minimum 10-second duration to confirm proper machine damping.

3.3. Simulation Results

The simulations conducted in the study did not find any angular or voltage instability problems for the 68 faults. The study finds that the interconnection of the three proposed projects does not impact stability performance of the SPP system for the contingencies tested on the supplied base cases.

Section 4. Conclusions

The findings of the impact study for the proposed interconnection projects under ICS-2008-001 (Group 3), namely Gen-2006-006, Gen-2007-038, and Gen-2008-018, considered at 100% of their proposed installed capacities are as follows:

1. The results of the Power Factor analysis showed that with the MVAR capability of the three projects and without reactive compensation, each wind farm will not be able to keep the voltage schedule at the POI consistent with the voltage schedule in the provided power flow cases for summer and winter. . Additional VAR compensating devices need to be installed for the customer to maintain a power factor at the point of interconnection in the ±-0.95 range.
2. For the three proposed projects, the stability simulations with 68 specified faults did not show any angular or voltage instability problems in the SPP system. The study finds that these interconnections do not impact stability performance of the SPP system for the contingencies tested on the base cases provided.

M: Stability Study for Group 4

POWER SYSTEMS DIVISION
GRID SYSTEMS CONSULTING

System Impact Re-Study for SPP ICS-2008-001 Group 4

FINAL REPORT

REPORT NO.: 2009-E3685-R2
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ABB Inc – Grid Systems Consulting

Technical Report

Southwest Power Pool, Inc.	**No.** 2009-E3685-R2	
System Impact Re-Study for SPP IC-2008-001 Group 4	Date: 11/17/2009	# Pages 43

Author(s):	**Reviewed by:**	**Approved by:**
Trinadh Dwibhashyam	Amit Kekare	Willie Wong

Executive Summary

Southwest Power Pool, Inc. (SPP) has commissioned ABB Inc. to perform a system impact study for 300 MW of wind-based generation on the SPP system. The proposed windfarm is located in Northwest Kansas. Below are the details of the Group 4 wind farm project:

Request	Size	Wind Turbine Technology	Point of Interconnection	County
GEN-2008-017	300	GE 1.5 MW	Setab 345kV (#531465)	Scott, Kansas

The main objectives of this study were
1) To determine the need of reactive power compensation, if any, for the proposed wind farm
2) To determine the impact of proposed GEN-2008-017 (300 MW) generation on system stability and the nearby transmission system and generating stations.
3) To validate the compliance with FERC LVRT requirement for wind farm.

To achieve these objectives the following analyses were performed on the 2010 Summer Peak and 2010 Winter Peak system conditions with GEN-2008-017 in-service
- o Power factor analysis for the selected contingencies.
- o Transient stability analysis under various local and regional contingencies.
- o LVRT performance under selected contingencies near POI.

Following is the summary of study findings:

Power factor analysis

The power factor analysis was performed to determine the need of additional reactive power compensation, if any, for the Group4 wind farm project GEN-2008-017. The results of power factor analysis indicated that project has the adequate reactive power capability to meet the power factor requirement at the POI.

Stability Analysis

After initial issues were discovered, consultation with SPP resulted in the following changes to the provided base for faults FLT13-3PH, FLT14-1PH, FLT19-3PH, FLT21-3PH, FLT_57_3PH & FLT_59_3PH.

Per SPP input following changes were made to the base cases:

- A fictitious generator of 76 MW at Colby 115 kV (Bus #530555) was switched OFF
- Incorrect representation of NPPD (area 640) loads during dynamic simulations was rectified.
- 7 MW windfarm connected at Spearville 230 kV (Bus 543116) was switched OFF. The windfarm has been already modeled at KCPL Wind (Bus #562102) connected at Spearville 230 kV

Following are the conclusions of the sensitivity analysis.

- No oscillations were observed in the Mingo 115 kV (Bus #531429) voltage following Fault 13 and 14 involving loss of Mingo 345/115/13.5 kV transformer.
- Per SPP input, the Faults 19 and 21 at Gentleman susbstation were repeated with faster clearing time of 4 cycles and without reclosing. The system was found to be stable following these faults.
- No wind farm tripping was observed following Fault_57_and 59

Hence proposed Group 4 project GEN-08-017 does not have any adverse impact on the stability of SPP transmission system.

FERC Order 661A Compliance

Selected faults were simulated at the Point of Interconnection (POI) of the proposed GEN-2008-017 wind farm to determine the compliance with FERC 661 – A post-transition period LVRT standard. The results indicated that the proposed project meets the FERC LVRT requirement for windfarms.

The results of this analysis are based on available data and assumptions made at the time of conducting this study. If any of the data and/or assumptions made in developing the study model change, the results provided in this report may not apply.

Rev No.	Revision Description	Date	Authored by	Reviewed by	Approved by
0	Draft Report	11/17/09	Trinadh	A. Kekare	W. Wong
1	Sensitivity Analysis	12/11/09	Trinadh	A. Kekare	W. Wong
DISTRIBUTION: Charles Hendrix – Southwest Power Pool, Inc. Ray Offenbacker – Southwest Power Pool, Inc.					

TABLE OF CONTENTS

1 INTRODUCTION

Southwest Power Pool, Inc. (SPP) has commissioned ABB Inc. to perform a system impact study for 300 MW of wind-based generation (GEN-2008-017: Group 4 project) on the SPP system. The proposed wind farm is located in Northwest Kansas. Figure 1-1 shows the locations of the project.

The study evaluated the impact of the Group 4 generation project GEN-2008-017 on the stability of the SPP system. The scope of this study was limited to the transient stability analysis.

The main objectives of this study were

1) To determine the need of reactive power compensation, if any, for the proposed wind farm.
2) To determine the impact of proposed GEN-2008-017 (300 MW) generation on system stability and the nearby transmission system and generating stations.
3) To validate the compliance with FERC LVRT requirement for wind farms.

To achieve these objectives the following analyses were performed on the 2010 Summer Peak and 2010 Winter Peak system conditions with GEN-2008-017 in-service

- Power factor analysis for the selected contingencies.
- Transient stability analysis under various local and regional contingencies.
- LVRT performance under selected contingencies near POI.

The study was performed on 2010 Summer Peak and winter peak cases, provided by SPP. This report documents the methods, analysis and results of the system impact study.

Table 1-1: List of Group 4 Projects

Request	Size	Wind Turbine Model	Point of Interconnection	County
GEN-2008-017	300	GE 1.5 MW	Setab 345kV (#531465)	Scott, Kansas

1.1 REPORT ORGANIZATION

This report is organized as follows:

Section 2: Description of GEN-2008-017
Section 3: Study methodology
Section 4: Model Development
Section 5: Power Factor Analysis Results
Section 6: Stability Analysis Results
Section 7: Conclusions

The detailed study results are compiled in separate Appendices.

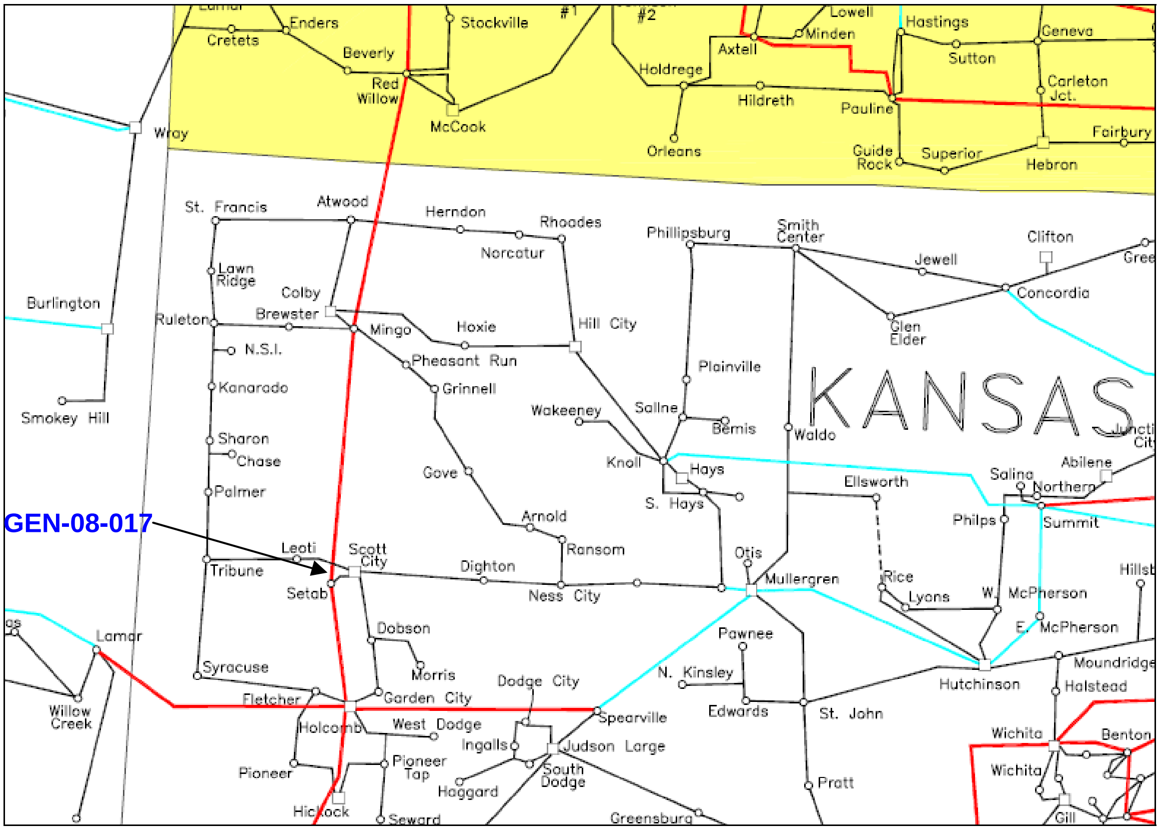

Figure 1-1 Group 4 Project GEN-08-017 location

2 DESCRIPTION OF GEN-2008-017

The details of load flow and dynamic data for the wind farm project are included in the Appendix A.

Gen-2008-017

- Wind farm rating: 300 MW
- Interconnection:

  Voltage: 345 kV

  Location: Existing Setab 345 kV substation; owned by Sunflower Electric Corporation (SUNC). The windfarm was assumed to be connected to Setab 345 kV substation via 15 miles of 345 kV line.

  Transformer: Three (3) step-up transformers connecting to the 345 kV

  MVA: 100/133/167 MVA

  Voltage: 345/34.5

  Z: 7.5 % on 100 MVA

- Wind Turbines:

  Number: Two hundred (200)

  Manufacturer: GE

  Type: Doubly-fed induction generator (DFIG)

  Machine Terminal voltage: 575 V

  Rated Power: 1.5 MW

  Frequency: 60 Hz

  Generator Step-up Transformer

  MVA: 1.75
  High voltage: 34.5 kV,
  Low voltage: 0.575 kV
  Z: 5.75% on 1.7 MVA

- Fault Ride-through: Zero voltage rid through (ZVRT) capability was assumed.
- Frequency tolerance: 57.0 – 63.0 Hz, a continuous operation
- Project protection: Overvoltage

  Undervoltage

  Overfrequency

  Underfrequency

- PSSE Model Used psse_gewt_w5

No additional reactive power compensation (e.g. shunt capacitor bank) was modeled for the proposed GEN-2008-017 Windfarm.

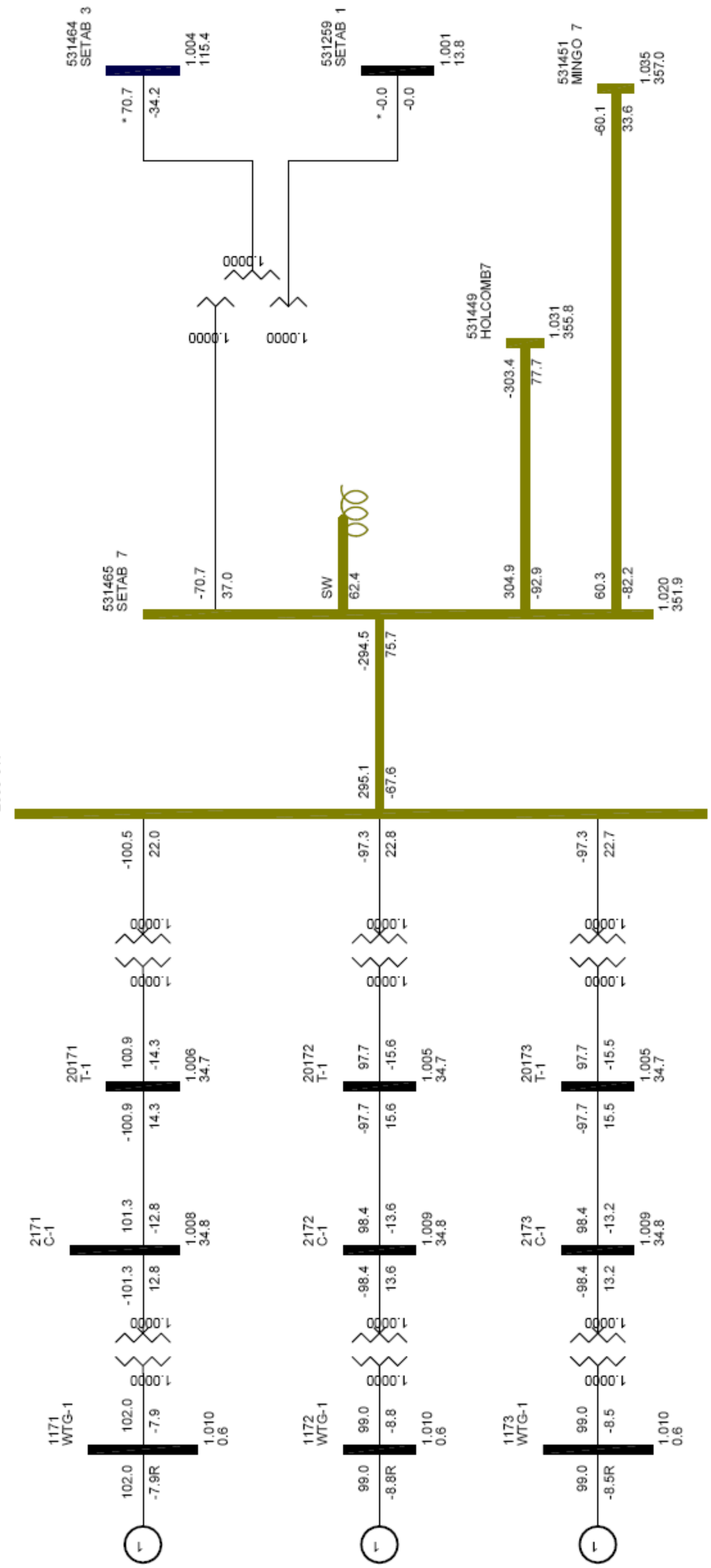

Figure 2-1: one-line diagram for GEN-2008-017 Project

3 STUDY METHODOLOGY

3.1 POWER FACTOR ANALYSIS

SPP transmission planning criteria[1] requires the generation interconnection projects

a. To maintain the power factor at the Point of Interconnection (POI) to near-unity for system intact conditions and within lag/lead 0.95 p.f. range for post-contingency conditions ,and
b. To maintain the voltage at the POI in 0.95 – 1.05 p.u. range in post-contingency conditions.

If the reactive power capability of the proposed project is not adequate to meet the above-mentioned requirements then additional reactive power compensation (e.g. shunt capacitors) need to be added.

The purpose of the power factor analysis was to determine whether the proposed wind farm project will meet the power factor requirement at the Point of Interconnection (POI) in system intact and contingency conditions.

Following steps were taken to perform the power factor analysis:

- A VAR generator with large capacity (+/- 9999 Mvar) was modeled at the POI of the subject wind farm. The VAR generator was set to hold the POI voltage consistent with the voltage schedule in the provided base case or 1.00 p.u. (whichever was higher). The reactive power capability of the wind farm was set to zero.
- A list of selected contingencies in the vicinity of the subject windfarm project was simulated. The results were used to identify the most-limiting contingency from steady state voltage and power factor perspective.
- If the required reactive power support, to maintain an acceptable power factor at the POI, was found to be beyond the capability of proposed windfarm then the additional reactive power compensation (e.g. shunt capacitor banks) was considered.

It is important to note that the reactive power compensation identified in this analysis was primarily to meet steady state criteria. The need for dynamic reactive power support, if any, will be determined during transient stability analysis.

3.2 TRANSIENT STABILITY ANALYSIS

The purpose of the transient stability analysis was to determine the impact, if any, of the GEN-2008-017 wind farm project on the system stability and the nearby transmission system and generating stations.

Using Planning Standards approved by NERC, the following stability definition was applied in the Transient Stability Analysis:

[1] The SPP transmission planning criteria was provided for the purpose of this study.

“Power system stability is defined as that condition in which the differences of the angular positions of synchronous machine rotors become constant following an aperiodic system disturbance.”

Stability analysis was performed using Siemens-PTI’s PSS/E^{TM} dynamics program V30.3.2. Three-phase and single-line-to-ground (SLG) faults were simulated for the specified duration and synchronous machine rotor angles and wind turbine generator speeds were monitored to check whether synchronism is maintained following fault removal.

For three-phase faults, a fault admittance of –j2E9 was used (essentially infinite admittance or zero impedance). The PSS/E dynamics program only simulates the positive sequence network. Unbalanced faults (like single-phase line faults) involve the positive, negative, and zero sequence networks. For unbalanced faults, the equivalent fault admittance was inserted in the PSS/E positive sequence model between the faulted bus and ground to simulate the effect of the negative and zero sequence networks. For a single-line-to-ground (SLG) fault, the fault admittance equals the inverse of the sum of the positive, negative and zero sequence Thevenin impedances at the faulted bus. Since PSS/E inherently models the positive sequence fault impedance, the sum of the negative and zero sequence Thevenin impedances needs to be added and entered as the fault impedance at the faulted bus. The fault impedance was estimated to give a positive sequence voltage at the fault location of approximately 60% of pre-fault voltage, which is a typical value.

Another important aspect of the stability analysis was to determine the ability of the wind generators to stay connected to the grid during disturbances. This is primarily determined by their low-voltage ride-through capabilities – or lack thereof – as represented in the models by low-voltage trip settings. The Federal Energy Regulatory Commission (FERC) Post-transition period LVRT standard for Interconnection of Wind generating plants includes a Low Voltage Ride Through (LVRT) requirement. The key features of LVRT requirements are:

- A wind generating plant must remain in-service during three-phase faults with normal clearing (maximum 9 cycles) and single-line-to-ground faults with delayed clearing, and have subsequent post-fault recovery to pre-fault voltage unless the clearing of the fault effectively disconnects the generator from the system.
- The maximum clearing time the wind generating plant shall be required to withstand a three-phase fault shall be 9 cycles after which, if the fault remains following the location-specific normal clearing time for three-phase faults, the wind generating plant may disconnect from the transmission system. A wind generating plant shall remain interconnected during such a fault on transmission system for a voltage level as low as zero volts, as measured at the high voltage side of the GSU connected at POI.

These criteria were used to evaluate the LVRT capabilities of the GEN-2008-017 Project.

4 MODEL DEVELOPMENT

Two power flow cases – “ICS08-01_G4_10SP_Restudy.sav” and “ICS08-01_G4_10WP_Restudy.sav” –representing the 2010 Summer Peak and Winter Peak system conditions were provided by SPP. The base cases included the GEN-2008-017 (300 MW) wind farm project. These cases were used for performing the studies.

Figure 4-1 and Figure 4-2 show the one-line diagram in the local area of GEN-2008-017 project for 2010 summer peak and 2010 winter peak system conditions respectively.

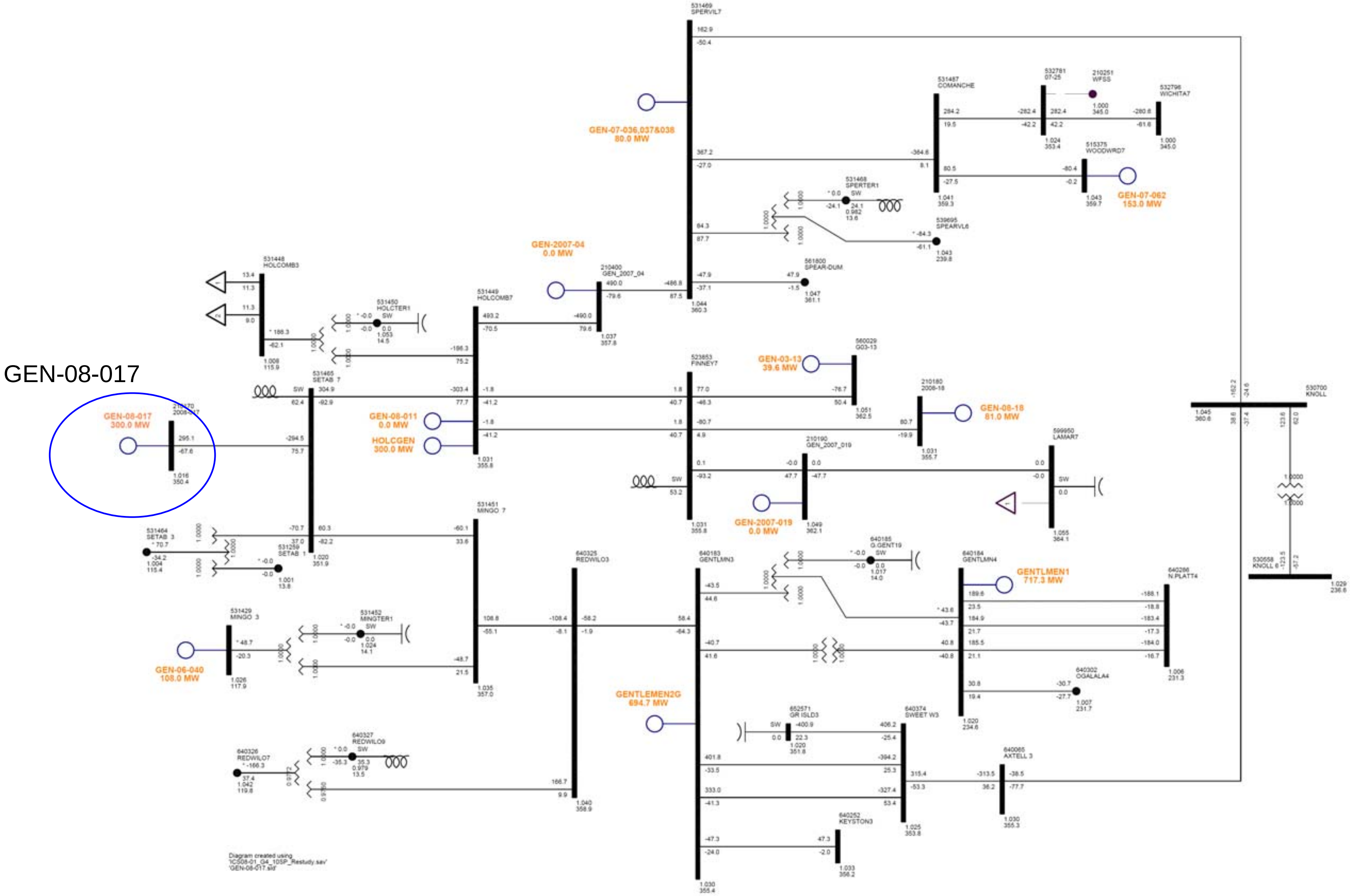

Figure 4-1 One-line Diagram of the local area with GEN-2008-017 (2010 Summer Peak)

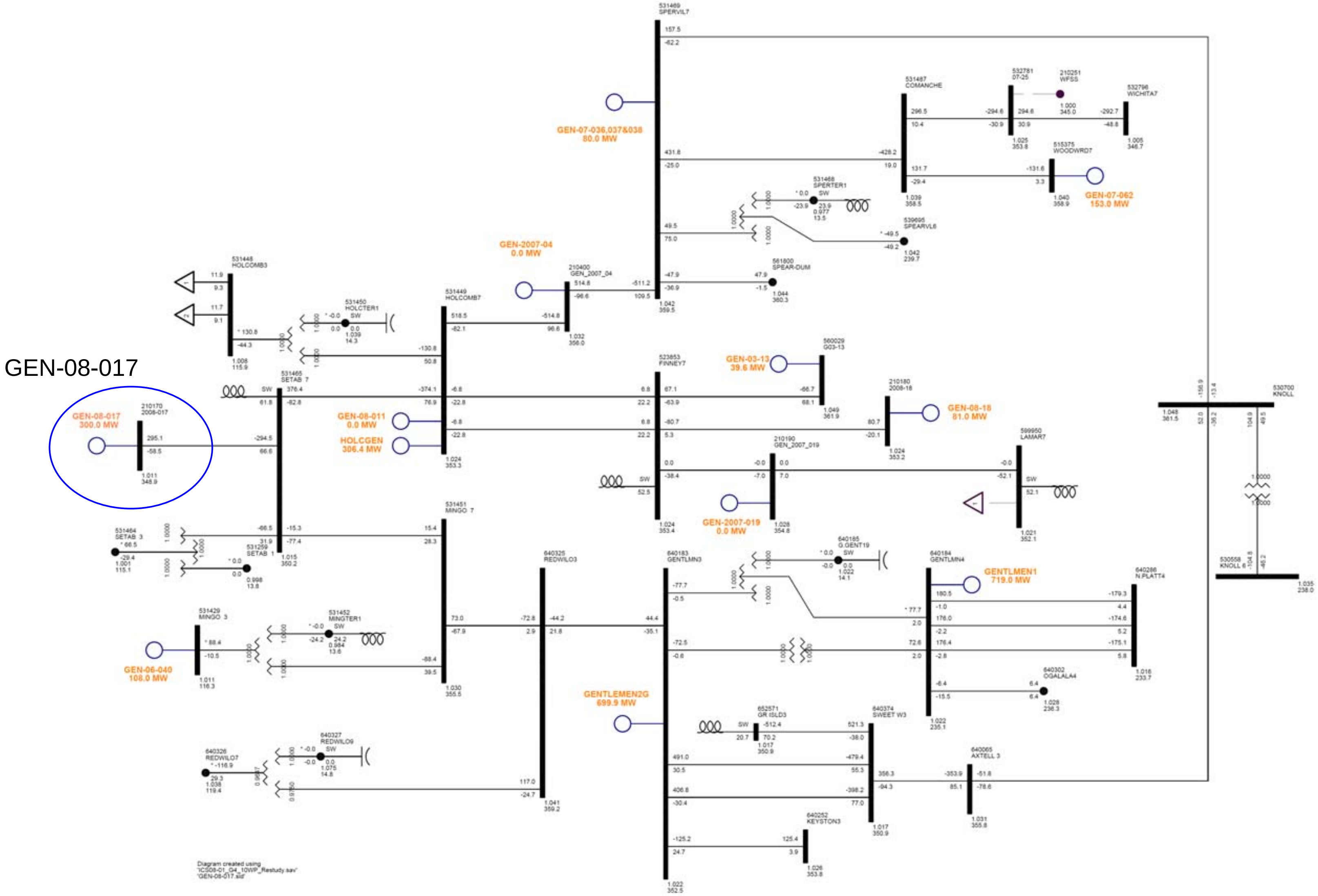

Figure 4-2 One-line Diagram of the local area with GEN-2008-017 (2010 Winter Peak)

5 POWER FACTOR ANALYSIS RESULTS

Table 5-1 lists the contingencies simulated for Power Factor analysis.

Table 5-1: List of contingencies simulated for Power Factor Analysis

Contingency	Contingency Description
CONT_01	531465 SETAB 7 345 - 531449 HOLCOMB7 345 ckt 1
CONT_02	531465 SETAB 7 345 - 531451 MINGO 7 345 ckt 1
CONT_03	531465 SETAB 7 345 - 531464 SETAB 3 115 ckt 1
CONT_04	531451 MINGO 7 345 - 640325 REDWILO3 345 ckt 1
CONT_05	531451 MINGO 7 345 - 531429 MINGO 3 115 ckt 1
CONT_06	640183 GENTLMN3 345 - 640252 KEYSTON3 345 ckt 1
CONT_07	640183 GENTLMN3 345 - 640374 SWEET W3 345 ckt 1
CONT_08	531449 HOLCOMB7 345 - 210400 GEN_2007_04 345 ckt 1
CONT_09	531449 HOLCOMB7 345 - 531448 HOLCOMB3 115 ckt 1
CONT_10	523853 FINNEY7 345 - 560029 G03-13 345 ckt 1
CONT_11	531469 SPERVIL7 345 - 530700 KNOLL 345 ckt 1
CONT_12	531469 SPERVIL7 345 - 531487 COMANCHE 345 ckt 1
CONT_13	640374 SWEET W3 345 - 640065 AXTELL 3 345 ckt 1

5.1 POWER FACTOR ANALYSIS RESULTS FOR GEN-2008-017

The proposed GEN-2008-017 windfarm (300 MW) will be comprised of GE 1.5 MW wind turbine generators. These wind turbine generators are doubly fed induction generators (DFIG) with a reactive power capability of +/- 0.95 p.f. The wind turbine generators were modeled in voltage control mode.

Next, as described in section 3.1 a VAR generator was modeled at the POI (Setab 345 kV). The VAR generator was set to hold the 345 kV POI voltage consistent with the pre-contingency voltage schedule in the provided base cases. The reactive power capability of the wind farm was set to zero.

The contingencies from Table 5-1 were repeated on 2010 summer peak and 2010 winter peak system conditions. Table 5-2 lists the VARs provided by the VAR generator at POI following the simulated contingencies.

Table 5-2 VAR generator output at the GEN-08-017 POI

Contingency	2010 summer peak	2010 winter peak
SYSTEM INTACT (ALL LINES IN-SERVICE)	26.9**	17.3**
CONT_01	**68.5**	**76.4**
CONT_02	57.6	58.6
CONT_03	61.9	46.4
CONT_04	25.7	50.3
CONT_05	37.2	35
CONT_06	25.7	19
CONT_07	9.5	7.8
CONT_08	35.8	48
CONT_09	32.4	22
CONT_10	1.6	19.8
CONT_11	18.9	8.7
CONT_12	21.9	12.8
CONT_13	16.7	1.4

**The reactive power capability of the wind farm was set to unity p.f at machine terminal (i.e Qmax=Qmin=Qgen= 0 Mvar).

The results indicated that the *CONT_01*: loss of Setab – Holocomb 345 kV line will yield the maximum reactive power output for GEN-2008-017 in summer peak and winter peak conditions.

In addition to the above analysis, the list of contingencies was repeated without the VAR generator at the POI. The voltage at the POI was monitored. The results of the contingency analysis are included in Appendix B. The *CONT_01*: loss of Setab – Holocomb 345 kV line resulted in lowest voltage at POI in post-contingency conditions in both summer peak and winter peak system conditions.

Hence, the '*CONT_01*' was repeated without the VAR generator. The Table 5-3 summarizes the results of the post-contingency voltage and p.f. at the POI. The results indicated that the GEN-2008-017 wind farm has adequate reactive power capability to maintain the acceptable p.f. at the POI in system intact and in post-contingency conditions for simulated contingencies. Hence, GEN-2008-017 wind farm does not require any additional reactive power support (e.g. shunt capacitor banks etc.).

Table 5-3 Voltage & p.f. at POI without VAR generator: GEN-2008-017

System condition		Voltage (in p.u.)	P.F.
2010 summer peak	System Intact	1.02003	0.9685
	Post-cotingency (1)	0.99435	0.9948
2010 winter peak	System Intact	1.01500	0.9753
	Post-cotingency (1)	0.98780	0.9979

(1)'*CONT_01*': Loss of Setab – Holocomb 345 kV line

6 STABILITY ANALYSIS RESULTS

Stability simulations were performed to examine the transient behavior of the Group 4 project GEN-2008-017 and its impact on the SPP system. A number of three-phase and single phase faults with re-closing were simulated. The fault clearing times and re-closing times used for the simulations are given in Table 6-1.

Table 6-1: Fault Clearing Times

Faulted bus kV level	Normal Clearing	Time before reclosing
345	5 cycles	20 cycles

Table 6-2 lists all the faults simulated for transient stability analysis.

Thirteen (13) three phase and thirteen (13) single-line-to-ground faults with re-closing were simulated. For all cases analyzed, the initial disturbance was applied at t = 0.1 seconds. The breaker clearing was applied at the appropriate time following this fault inception.

Table 6-2 List of Simulated Faults for Group 4 SIS

Cont.No	Cont.Name	Description
1	FLT01-3PH	3 phase fault on the Setab (531465) to Holcomb (531449) 345kV line, near Setab. a. Apply fault at the Setab 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.
2	FLT02-1PH	Single phase fault and sequence like previous
3	FLT03-3PH	3 phase fault on the Setab (531465) to Mingo (531451) 345kV line, near Setab. a. Apply fault at the Setab 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.
4	FLT04-1PH	Single phase fault and sequence like previous
5	FLT05-3PH	3 phase fault on the Setab 345kV (531465) to 115kV (531464) transformer, near the 345 kV bus. a. Apply fault at the Setab 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
6	FLT06-1PH	Single phase fault and sequence like previous
9	FLT09-3PH	3 phase fault on the Mingo (531451) to Red Willow (640325) 345kV line, near Mingo. a. Apply fault at the Mingo 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.
10	FLT10-1PH	Single phase fault and sequence like previous
13	FLT13-3PH	3 phase fault on the Mingo 345kV (531451) to 115kV (531429) transformer, near the 345 kV bus. a. Apply fault at the Mingo 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
14	FLT14-1PH	Single phase fault and sequence like previous

Cont.No	Cont.Name	Description
19	FLT19-3PH	3 phase fault on the Gentleman (640183) to Keystone (640252) 345kV line, near Gentleman. a. Apply fault at the Gentleman 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.
20	FLT20-1PH	Single phase fault and sequence like previous
21	FLT21-3PH	3 phase fault on the Gentleman (640183) to Sweetwater (640374) 345kV line, near Gentleman. a. Apply fault at the Gentleman 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.
22	FLT22-1PH	Single phase fault and sequence like previous
27	FLT27-3PH	3 phase fault on the Holcomb (531449) to GEN-2007-040 (210400) 345kV line, near Holcomb. a. Apply fault at the Holcomb 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.
28	FLT28-1PH	Single phase fault and sequence like previous
29	FLT29-3PH	3 phase fault on the Holcomb 345kV (531449) to 115kV (531448) transformer, near the 345 kV bus. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
30	FLT30-1PH	Single phase fault and sequence like previous
33	FLT33-3PH	3 phase fault on the Finney (523853) to GEN-2003-013 (560029) 345kV line, near Finney. a. Apply fault at the Finney 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.
34	FLT34-1PH	Single phase fault and sequence like previous
57	**FLT57-3PH	3 phase fault on the Spearville (531469) to Knoll (530700) 345kV line, near Spearville. a. Apply fault at the Spearville 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.
58	FLT58-1PH	Single phase fault and sequence like previous
59	**FLT59-3PH	3 phase fault on the Spearville (531469) to Comanche (531487) 345kV line, near Spearville. a. Apply fault at the Spearville 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.
60	FLT60-1PH	Single phase fault and sequence like previous
61	FLT61-3PH	3 phase fault on the Sweetwater (640374) to Axtell (640065) 345kV line, near Sweetwater. a. Apply fault at the Sweetwater 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.
62	FLT62-1PH	Single phase fault and sequence like previous

** Following 3 phase fault at Spearville, 7 MW unit connected at #543116 got tripped.

Table 6-3 and Table 6-4 summarize the stability analysis results for 2010 summer peak and 2010 winter peak system conditions.

The system was stable following all simulated 3-Phase and single-phase faults ***except*** for two (2) faults. Also, no undervoltage tripping of any other windfarms in the system was observed following the simulated faults ***except*** following the Fault_57_3PH, Fault_59_3PH and the UNSTABLE faults. The stability plots for the transient stability analysis are included in Appendix C for reference.

Faults at Gentleman 345 kV substation:
Following 3 Phase faults at Gentleman 345 kV substation (FLT19-3PH and FLT21-3PH) the system was found to be unstable.

Voltage Oscillations at 115 kV Mingo (#531429):
Following faults at Mingo 345 kV substation (FLT13-3PH and FLT14-1PH) involving loss of Mingo 345/115/13.8 kV transformer, undamped oscillations were observed in the Mingo 115 kV (#531429) voltage for both summer and winter peak system conditions. The faults were repeated on the case WITHOUT proposed Group 4 Project GEN-08-017. The undamped oscillations were observed in WITHOUT GEN-2008-017 case. Figure 6-3 shows the variation of voltage at Mingo 115 kV bus following Fault_13_3PH.

Faults at Spearville 345 kV with loss of Spearville-Knoll, Spearville-Comanche lines:
Following the three phase faults at Spearville 345 kV bus (FLT_57_3PH, FLT_59_3PH), a unit of 7 MW (Bus# 543116) connected to Spearville 230 kV was tripped due to undervoltage protection in WITH and WITHOUT Group 4 Project GEN-2008-017 cases.

Table 6-3 Results of stability analysis – summer peak 2010

	2010 Summer Peak	
FAULT	**Without GEN-08-017**	**With GEN-08-017**
FLT_01_3PH	---	STABLE
FLT_02_1PH	---	STABLE
FLT_03_3PH	---	STABLE
FLT_04_1PH	---	STABLE
FLT_05_3PH	---	STABLE
FLT_06_1PH	---	STABLE
FLT_09_3PH	---	STABLE
FLT_10_1PH	---	STABLE
FLT_13_3PH	---	STABLE
FLT_14_1PH	---	STABLE
FLT_19_3PH	UNSTABLE	UNSTABLE
FLT_20_1PH	---	STABLE
FLT_21_3PH	UNSTABLE	UNSTABLE
FLT_22_1PH	---	STABLE
FLT_27_3PH	---	STABLE

FAULT	2010 Summer Peak Without GEN-08-017	2010 Summer Peak With GEN-08-017
FLT_28_1PH	---	STABLE
FLT_29_3PH	---	STABLE
FLT_30_1PH	---	STABLE
FLT_33_3PH	---	STABLE
FLT_34_1PH	---	STABLE
FLT_57_3PH	---	STABLE
FLT_58_1PH	---	STABLE
FLT_59_3PH	---	STABLE
FLT_60_1PH	---	STABLE
FLT_61_3PH	---	STABLE
FLT_62_1PH	---	STABLE

Table 6-4 Results of stability analysis – winter peak 2010

FAULT	2010 Winter Peak Without GEN-08-017	2010 Winter Peak With GEN-08-017
FLT_01_3PH	---	STABLE
FLT_02_1PH	---	STABLE
FLT_03_3PH	---	STABLE
FLT_04_1PH	---	STABLE
FLT_05_3PH	---	STABLE
FLT_06_1PH	---	STABLE
FLT_09_3PH	---	STABLE
FLT_10_1PH	---	STABLE
FLT_13_3PH	---	STABLE
FLT_14_1PH	---	STABLE
FLT_19_3PH	UNSTABLE	UNSTABLE
FLT_20_1PH	---	STABLE
FLT_21_3PH	UNSTABLE	UNSTABLE
FLT_22_1PH	---	STABLE
FLT_27_3PH	---	STABLE
FLT_28_1PH	---	STABLE
FLT_29_3PH	---	STABLE
FLT_30_1PH	---	STABLE
FLT_33_3PH	---	STABLE
FLT_34_1PH	---	STABLE
FLT_57_3PH	---	STABLE
FLT_58_1PH	---	STABLE
FLT_59_3PH	---	STABLE
FLT_60_1PH	---	STABLE

FAULT	2010 Winter Peak	
	Without GEN-08-017	With GEN-08-017
FLT_61_3PH	---	STABLE
FLT_62_1PH	---	STABLE

ABB

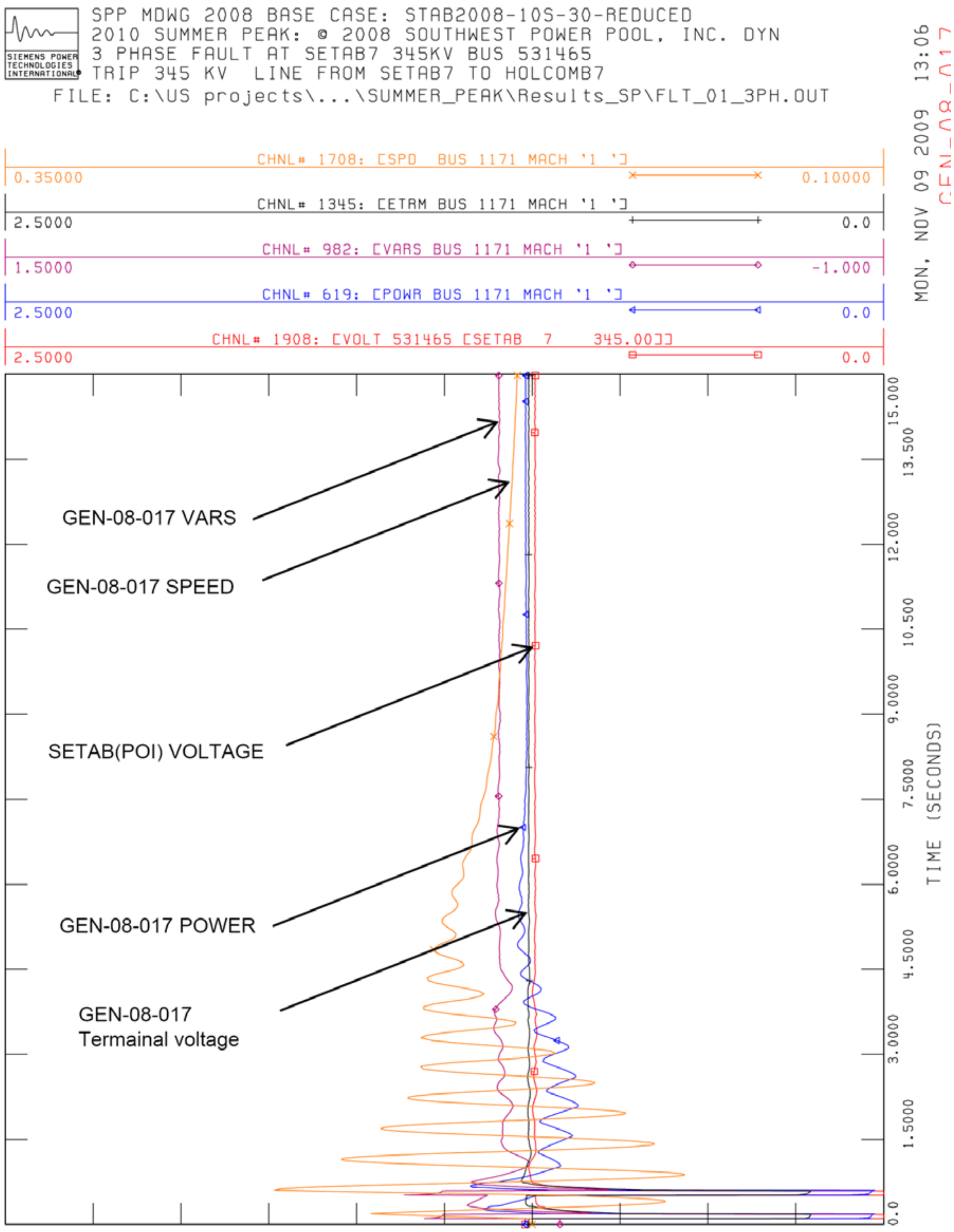

Figure 6-1 GEN-08-017 Machine parameters for FAULT_1_3PH

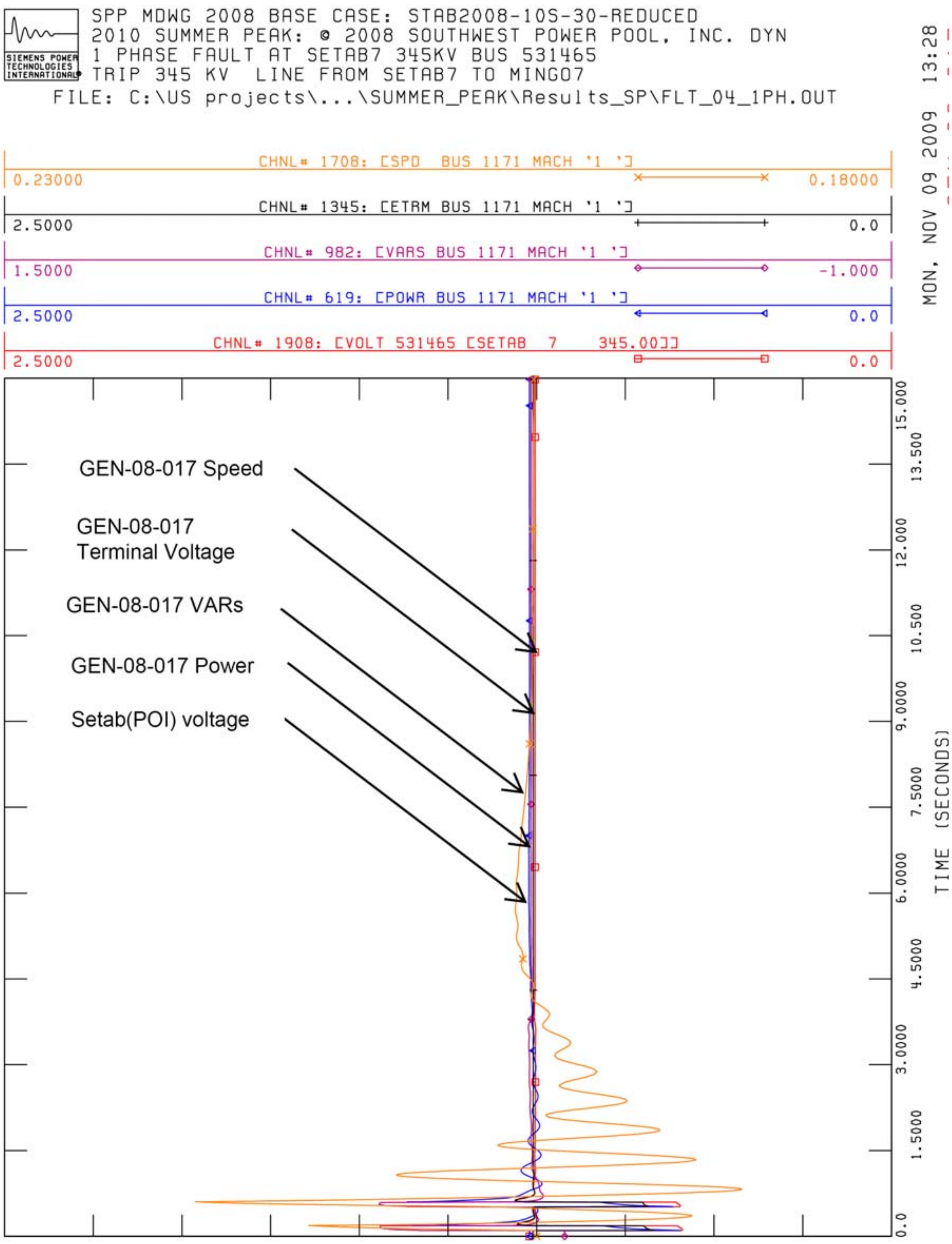

Figure 6-2 GEN-08-017 Machine parameters for FAULT_4_1PH

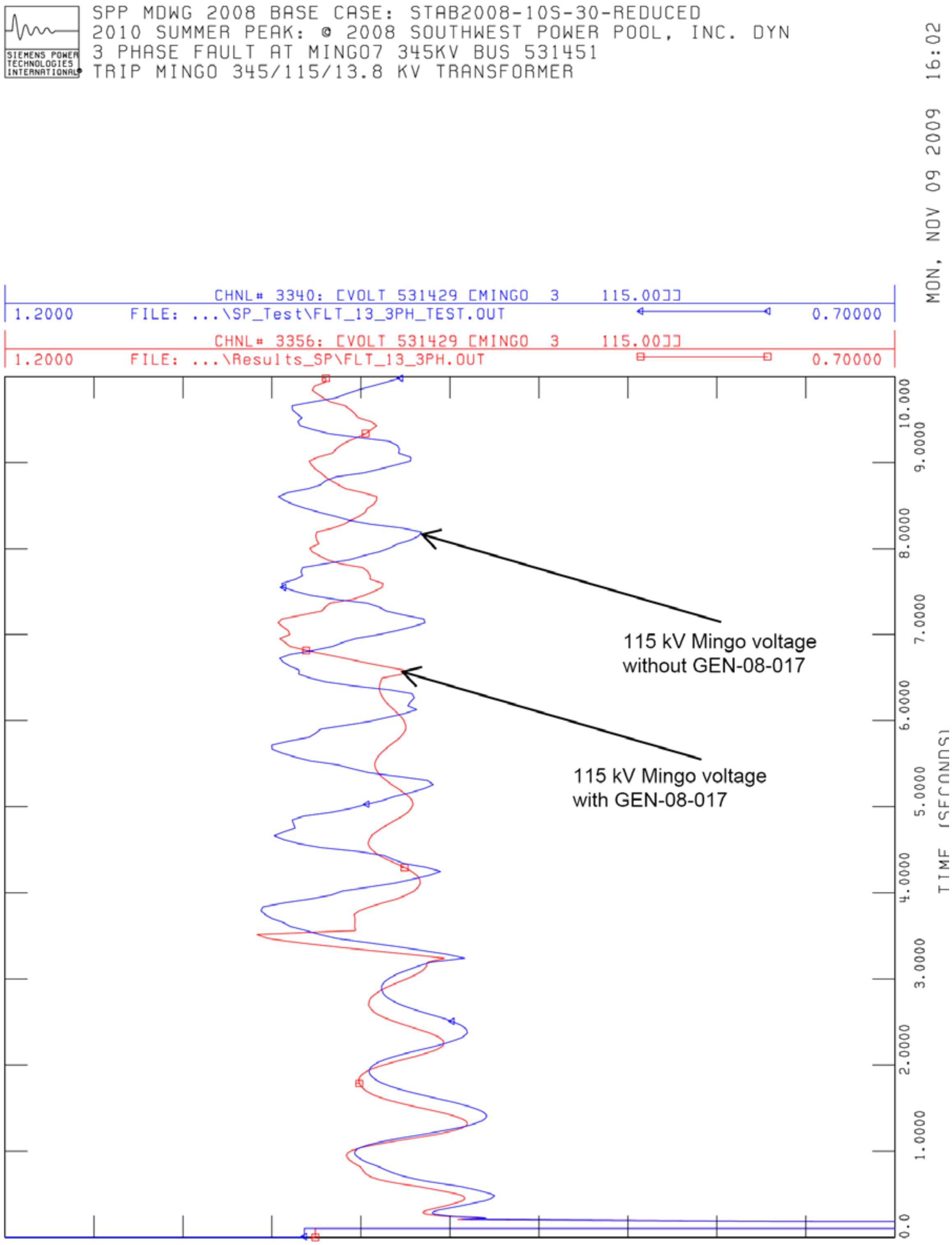

Figure 6-3 Mingo 115 kV Bus voltage with&without GEN-08-017 following FLT_13_3PH

6.1 SENSITIVITY ANALYSIS

A sensitivity analysis was performed for the faults FLT13-3PH, FLT14-1PH, FLT19-3PH, FLT21-3PH, FLT_57_3PH & FLT_59_3PH.. These faults were either unstable or had caused tripping of other wind farms.

Per SPP input following changes were made to the base cases:

- A fictitious generator of 76 MW at Colby 115 kV (Bus #530555) was switched OFF
- Incorrect representation of NPPD (area 640) loads during dynamic simulations was rectified.
- 7 MW windfarm connected at Spearville 230 kV (Bus 543116) was switched OFF. The windfarm has been already modeled at KCPL Wind (Bus #562102) connected to Spearville 230 kV

<u>Faults at Gentleman 345 kV substation:</u>
Faults 19 and 21 at the Gentleman 345 kV substation were repeated with faster clearing time of 4 cycles without reclosing of the line.

The system would be stable following Fault 19 and 21.

<u>Voltage Oscillations at Mingo 115 kV (#531429):</u>
Faults FLT13-3PH and FLT14-1PH were repeated. The faults were stable and no oscillations were observed in the Mingo 115 kV (#531429) voltage for both summer and winter peak system conditions.

<u>Faults at Spearville 345 kV (FLT_57_3PH and FLT_59_3PH):</u>
The faults FLT_57_3PH and FLT_59_3PH were repeated. The results indicated that no other wind farm tripping following the fault 57 and 50.

The plots for the sensitivity analysis simulations are included in Appendix E. The results of sensitivity analysis indicated that the Group 4 project GEN-2008-017 doesn't have any adverse impact on the stability of SPP transmission system.

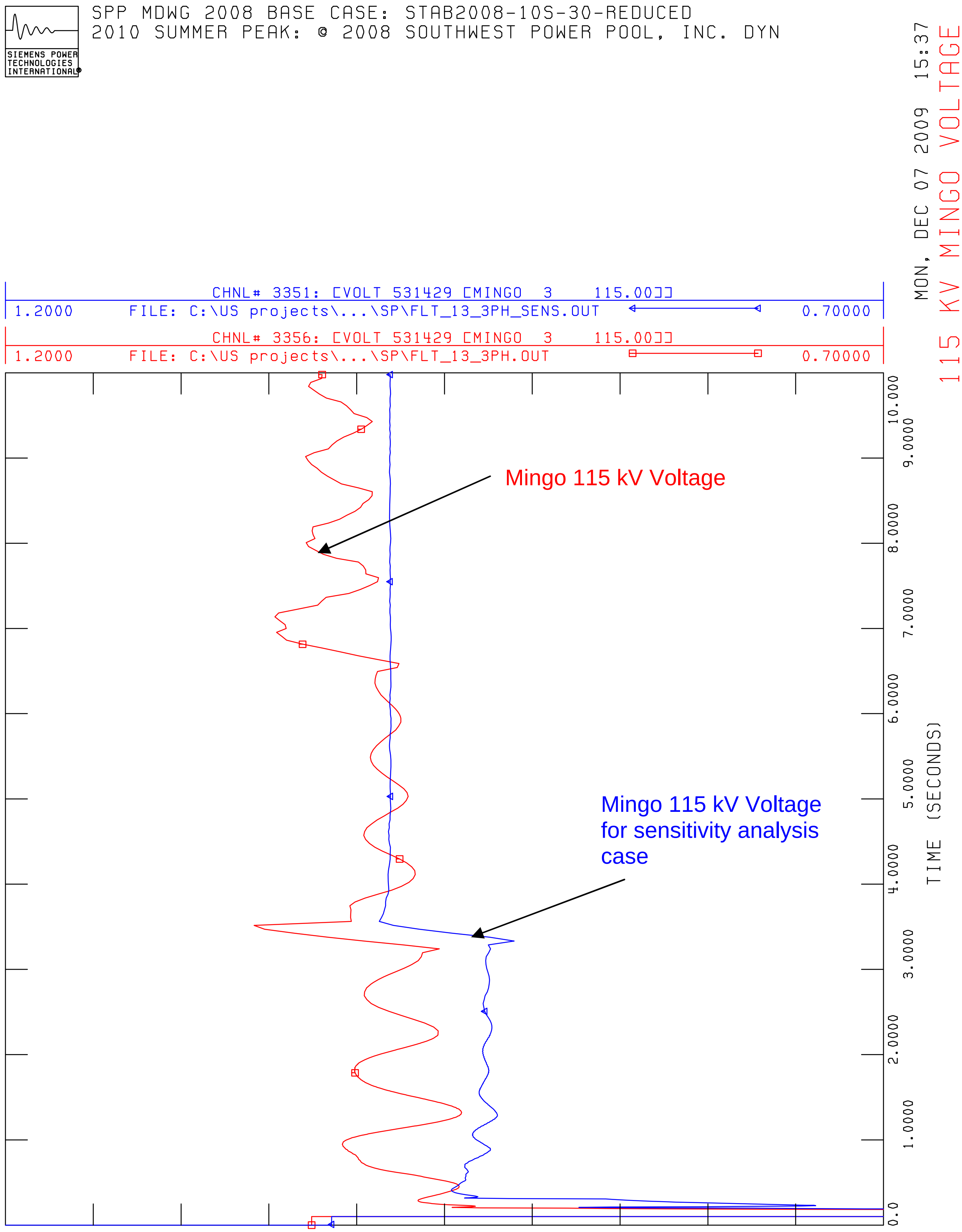

Figure 6-4 Mingo 115 kV Bus voltage with GEN-08-017 following FLT_13_3PH for Base and Sensitivity cases

6.2 FERC LVRT COMPLIANCE

As explained in section 2, the proposed Group 4 windfarm project GEN-08-017 was modeled with the low voltage ride through capacity. To determine the compliance of the wind farm projects total of three (3) faults were simulated. Faults were simulated at the POI of the wind farm project and normally cleared by tripping one transmission element..Table 6-5 lists the faults simulated for LVRT analysis.

Table 6-5: List of faults for FERC LVRT compliance

Fault Name	Description
FLT01-3PH_LVRT	3 phase fault on the Setab (531465) to Holcomb (531449) 345kV line, near Setab. a. Apply fault at the Setab 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT03-3PH_LVRT	3 phase fault on the Setab (531465) to Mingo (531451) 345kV line, near Setab. a. Apply fault at the Setab 345kV bus. b. Clear fault after 5 cycles by tripping the faulted line.
FLT05-3PH_LVRT	3 phase fault on the Setab 345kV (531465) to 115kV (531464) transformer, near the 345 kV bus. a. Apply fault at the Setab 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.

The results of the simulations indicated that the wind farm project GEN-08-017 meet the FERC LVRT criteria for the interconnection of the wind farm generation (FERC Order 661 – A).

The results of the FERC LVRT compliance are included in Appendix D for reference.

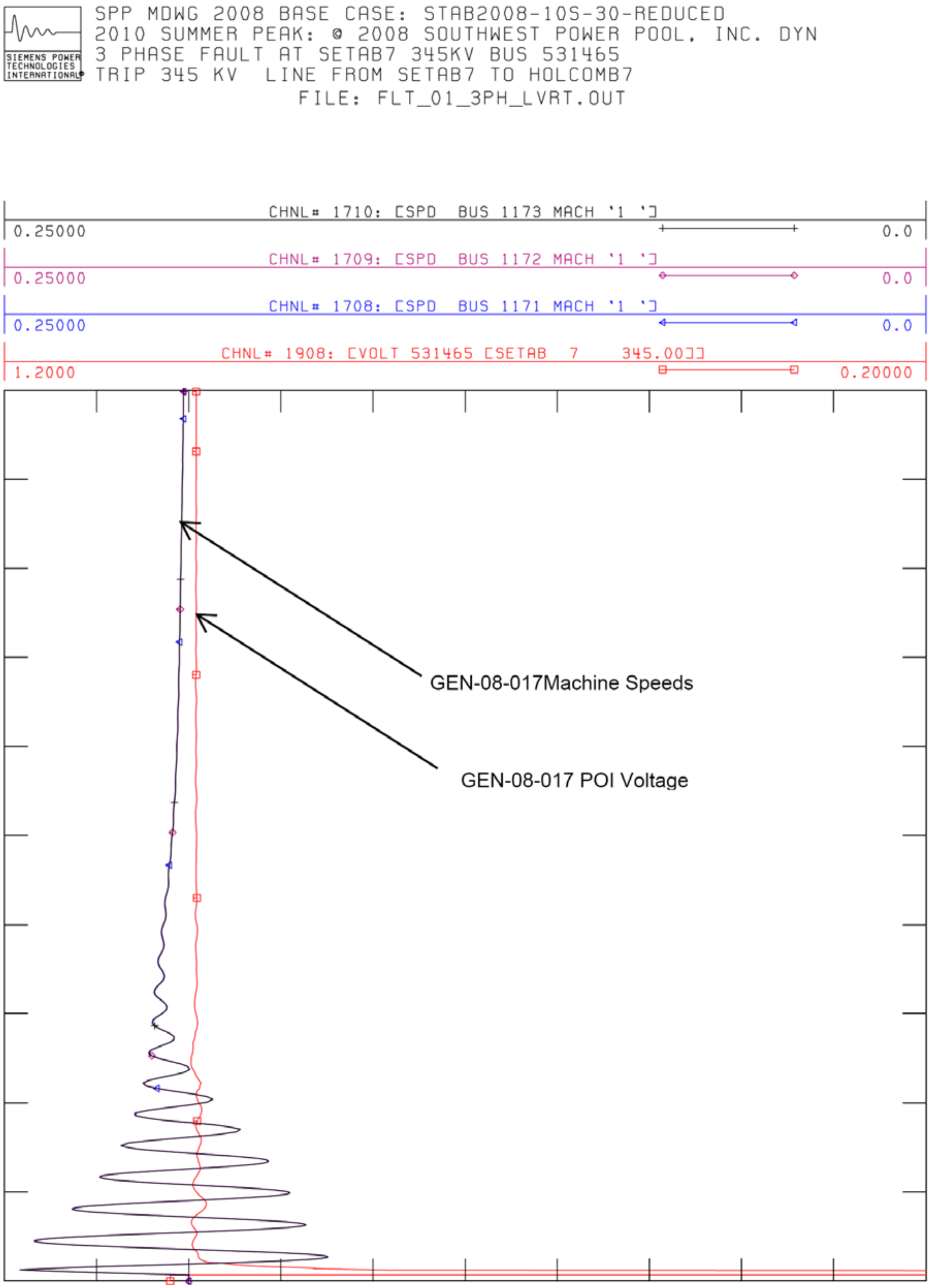

Figure 6-5 GEN-08-017 Machine Speed and POI Voltage for FLT_01_3PH_LVRT

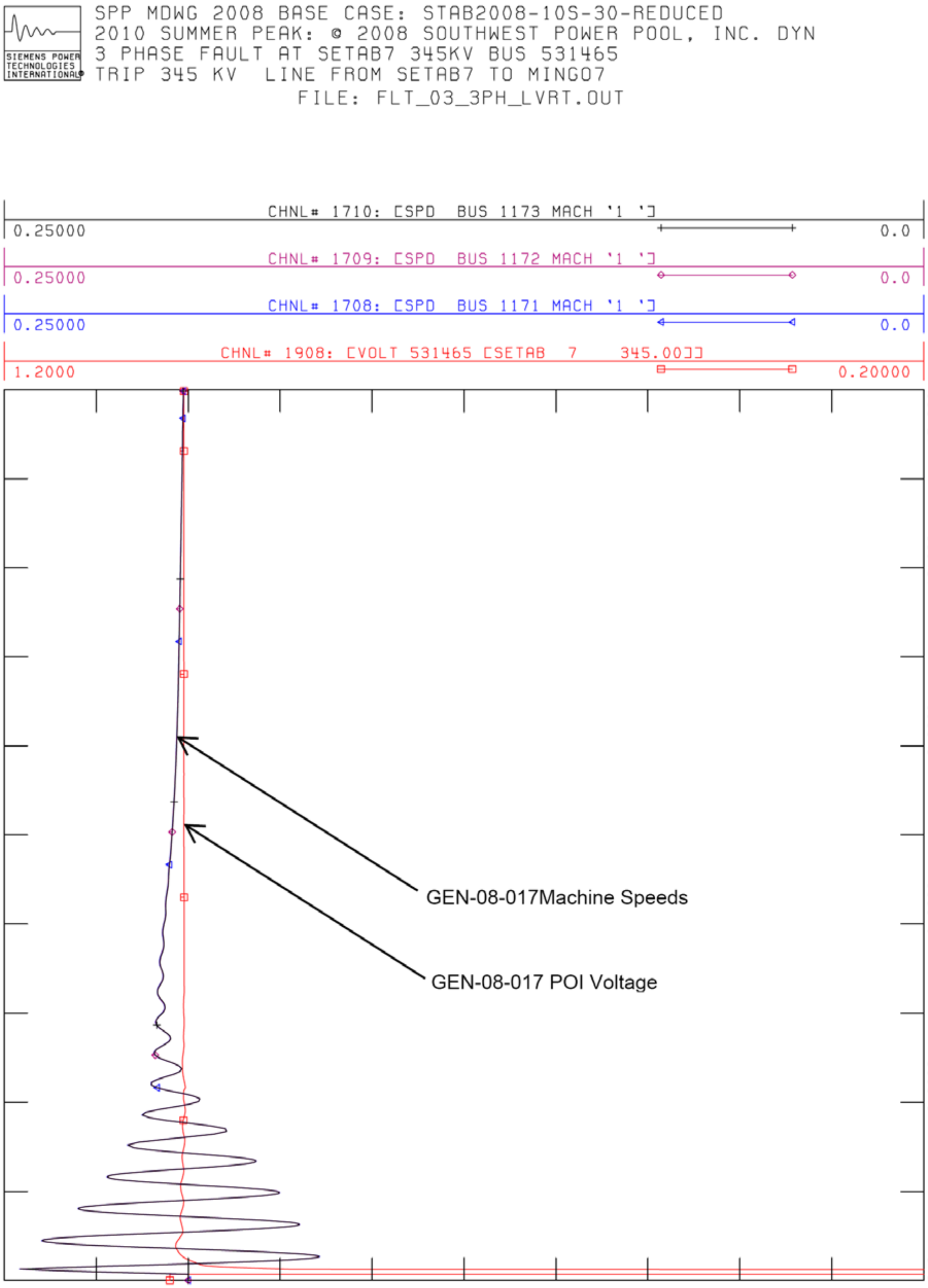

Figure 6-6 GEN-08-017 Machine Speed and POI Voltage for FLT_03_3PH_LVRT

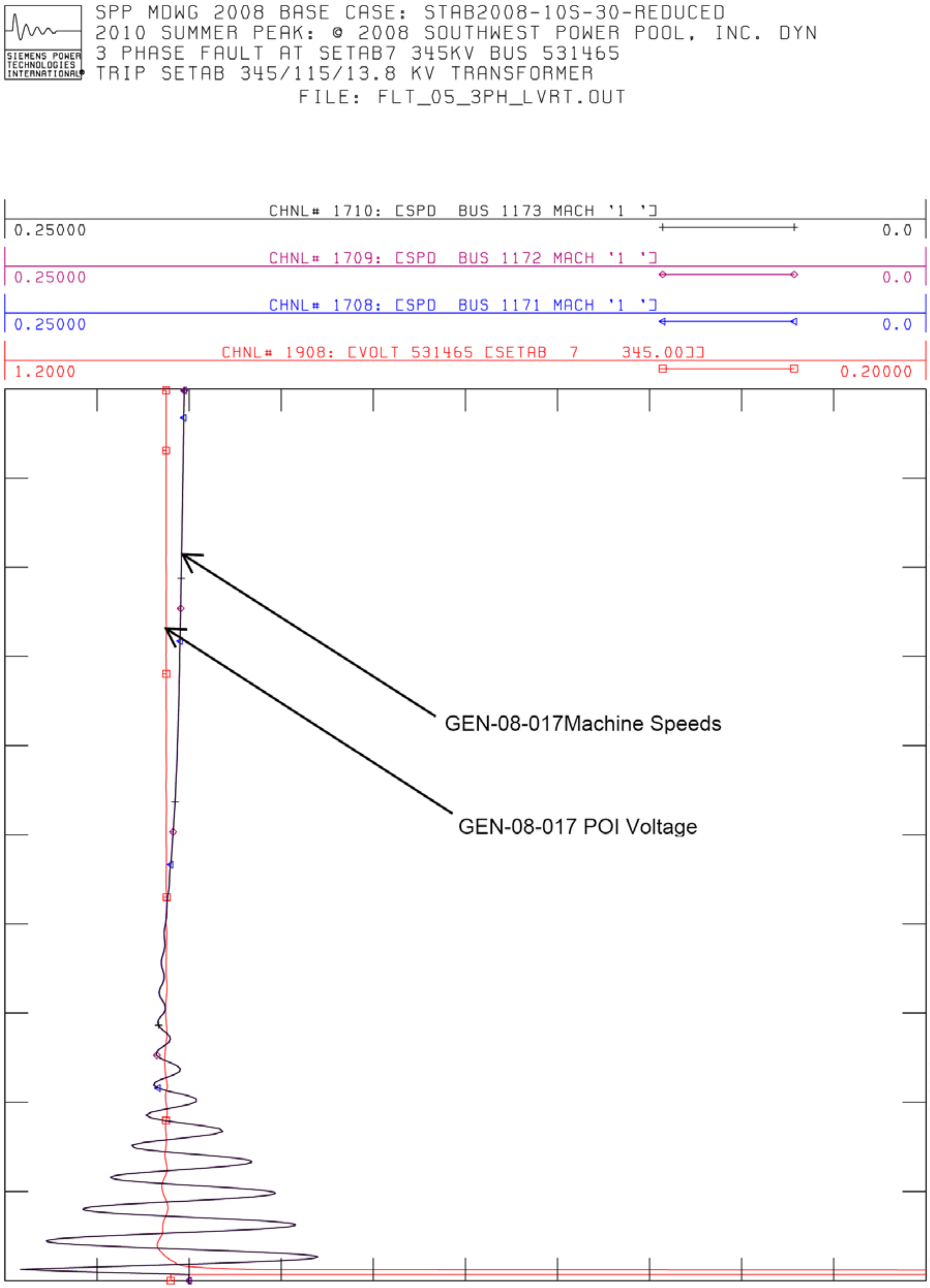

Figure 6-7 GEN-08-017 Machine Speed and POI Voltage for FLT_05_3PH_LVRT

7 CONCLUSIONS

The main objectives of this study were

1) To determine the need of reactive power compensation, if any, for the proposed wind farms
2) To determine the impact of proposed GEN-08-017 (300 MW) generation on system stability and the nearby transmission system and generating stations.
3) To validate the compliance with FERC LVRT requirement.

The study was performed on 2010 Summer Peak and winter peak cases, provided by SPP.

To achieve these objective the following analyses were performed on the 2010 Summer Peak and 2010 winter peak system conditions

- Power factor Analysis for the selected contingencies.
- Transient Stability analysis under various local and regional contingencies.
- LVRT performance under selected contingencies near POI.

Following is the summary of study findings:

Power factor analysis

The power factor analysis was performed to determine the need of additional reactive power compensation, if any, for the Group4 wind farm project GEN-2008-017. The results of power factor analysis indicated that project has the adequate reactive power capability to meet the power factor requirement at the POI.

Stability Analysis

The stability analysis was performed to determine the impact, if any, of the proposed Group 4 project GEN-2008-017 on the stability of the SPP system. After initial issues were discovered the following sensitivity was made.

A sensitivity analysis was performed for the faults FLT13-3PH, FLT14-1PH, FLT19-3PH, FLT21-3PH, FLT_57_3PH & FLT_59_3PH.

Per SPP input following changes were made to the base cases:

- A fictitious generator of 76 MW at Colby 115 kV (Bus #530555) was switched OFF
- Incorrect representation of NPPD (area 640) loads during dynamic simulations was rectified.
- 7 MW windfarm connected at Spearville 230 kV (Bus 543116) was switched OFF. The windfarm has been already modeled at KCPL Wind (Bus #562102) connected at Spearville 230 kV

Following are the conclusions of the sensitivity analysis.

- No oscillations were observed in the Mingo 115 kV (Bus #531429) voltage following Fault 13 and 14 involving loss of Mingo 345/115/13.5 kV transformer.
- Per SPP input, the Faults 19 and 21 at Gentleman susbstation were repeated with faster clearing time of 4 cycles and without reclosing. The system was found to be stable following these faults.
- No wind farm tripping was observed following Fault_57_and 59

Hence proposed Group 4 project GEN-08-017 does not have any adverse impact on the stability of SPP transmission system.

<u>FERC Order 661A Compliance</u>

Selected faults were simulated at the Point of Interconnection (POI) of the proposed GEN-2008-017 wind farm to determine the compliance with FERC 661 – A post-transition period LVRT standard. The results indicated that the proposed project meets the FERC LVRT requirement for windfarms.

The results of this analysis are based on available data and assumptions made at the time of conducting this study. If any of the data and/or assumptions made in developing the study model change, the results provided in this report may not apply.

APPENDIX B Results of Power Factor Analysis

APPENDIX B.1 GEN-08-017 POI voltage without VAR generator

Contingency	Contingency Description	GEN-08-017 POI VOLTAGE SETAB(#531465)	
		SUMMER PEAK	WINTER PEAK
CONT_01	531465 SETAB 7 345 - 531449 HOLCOMB7 345 ckt 1	**0.99464**	**0.98843**
CONT_02	531465 SETAB 7 345 - 531451 MINGO 7 345 ckt 1	1.0036	1.00017
CONT_03	531465 SETAB 7 345 - 531464 SETAB 3 115 ckt 1	1.02594	1.0201
CONT_04	531451 MINGO 7 345 - 640325 REDWILO3 345 ckt 1	1.01109	1.00281
CONT_05	531451 MINGO 7 345 - 531429 MINGO 3 115 ckt 1	1.02173	1.01795
CONT_06	640183 GENTLMN3 345 - 640252 KEYSTON3 345 ckt 1	1.01984	1.01527
CONT_07	640183 GENTLMN3 345 - 640374 SWEET W3 345 ckt 1	1.01735	1.01099
CONT_08	531449 HOLCOMB7 345 - 210400 GEN_2007_04 345 ckt 1	1.00951	1.00464
CONT_09	531449 HOLCOMB7 345 - 531448 HOLCOMB3 115 ckt 1	1.02103	1.01588
CONT_10	523853 FINNEY7 345 - 560029 G03-13 345 ckt 1	1.01546	1.00924
CONT_11	531469 SPERVIL7 345 - 530700 KNOLL 345 ckt 1	1.0188	1.01362
CONT_12	531469 SPERVIL7 345 - 531487 COMANCHE 345 ckt 1	1.01926	1.01427
CONT_13	640374 SWEET W3 345 - 640065 AXTELL 3 345 ckt 1	1.01846	1.01246

APPENDIX B.2 GEN-08-017 VAR generator output to maintain pre-contingency POI voltage

SUMMER PEAK		
Contingency	**Pre-Cont**	**Post-Cont**
BASECASE	26.9	26.9
CONT_01	26.9	**68.5**
CONT_02	26.9	57.6
CONT_03	26.9	61.9
CONT_04	26.9	25.7
CONT_05	26.9	37.2
CONT_06	26.9	25.7
CONT_07	26.9	9.5
CONT_08	26.9	35.8
CONT_09	26.9	32.4
CONT_10	26.9	1.6
CONT_11	26.9	18.9
CONT_12	26.9	21.9
CONT_13	26.9	16.7

WINTER PEAK		
Contingency	**Pre-Cont**	**Post-Cont**
BASECASE	17.3	17.3
CONT_01	17.3	**76.4**
CONT_02	17.3	58.6
CONT_03	17.3	46.4
CONT_04	17.3	50.3
CONT_05	17.3	35
CONT_06	17.3	19
CONT_07	17.3	7.8
CONT_08	17.3	48
CONT_09	17.3	22
CONT_10	17.3	19.8
CONT_11	17.3	8.7
CONT_12	17.3	12.8
CONT_13	17.3	1.4

APPENDIX C PLOTS FOR STABILITY SIMULATIONS

APPENDIX D PLOTS FOR LVRT SIMULATIONS

APPENDIX E PLOTS FOR SENSITIVITY ANALYSIS

N: Stability Study for Group 5

SPP Cluster #1 Group #5 Impact Study

Restudy

Report for

Southwest Power Pool

Prepared by:
Excel Engineering, Inc.

November 3, 2009

Principal Contributor:

William Quaintance, P.E.

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0. Certification

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the Laws of the State of **Arkansas**.

William Quaintance
Arkansas Registration Number 13865

1. Background and Scope

The Cluster #1 Group #5 Impact Study Restudy is a generation interconnection study performed by Excel Engineering, Inc. for its non-affiliated client, Southwest Power Pool (SPP). Its purpose is to study the impacts of interconnecting each of the three projects shown in Table 1-1. The in-service date assumed for the generation additions was 2010.

After the first Cluster #1 Impact Studies were completed, a number of projects dropped out of the SPP interconnection queue. This change resulted in a scaling back and adjustment of the needed transmission upgrades for Cluster #1. Because of the canceled projects and transmission changes, all Cluster #1 Impact Studies were repeated, including Group 5 described in this report.

Table 1-1. Interconnection Requests to be Evaluated

Request	Size	Wind Turbine Model	Point of Interconnection
GEN-2007-008	300	Suzlon 2.1 MW	Grapevine 230kV (523771)
GEN-2007-045	171	G.E. 1.5MW	Conway 115kV (524079)
GEN-2007-048	400	Fuhrlaender	Amarillo South – Swisher 230kV line (525228)

The previously-queued requests shown in Table 1-2 were included in this study.

Table 1-2. Nearby Interconnection Requests Already in the Queue

Request	Size	Wind Turbine Model	Point of Interconnection
GEN-2002-022	240	Siemens 2.3MW	Bushland 230kV (524267)
GEN-2004-003	240	GE 1.5MW	Conway 115kV (524079)
GEN-2005-021	85.5	GE 1.5MW	Kirby 115kV (524088)
GEN-2006-039	400	Clipper 2.5MW	Potter – Plant X 230kV line (560109)
GEN-2006-045	240	Suzlon 2.1MW	Potter – Plant X 230kV line (560109)
GEN-2006-047	240	Suzlon 2.1 MW	Bushland – Deaf Smith 230kV line (560109)
GEN-2007-002	160	Steam Turbine	Grapevine 115kV (523770)

The study included a stability analysis for each proposed 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 disabled. Since three of the interconnection requests in this group are wind projects, a power factor analysis was performed.

ATC (Available Transfer Capability) studies were not performed as part of this study. These studies will be required at the time transmission service is actually requested. Additional transmission upgrades may be required based on that analysis.

Study assumptions in general have been based on Excel's knowledge of the electric power system and on the specific information and data provided by SPP. The accuracy of the conclusions contained within this study is sensitive to the assumptions made with respect to other generation additions and transmission improvements being contemplated by other entities. Changes in the assumptions of the timing of other generation additions or transmission improvements will affect this study's conclusions.

2. Executive Summary

The Cluster #1 Group #5 Impact Study Restudy evaluated the impacts of interconnecting projects GEN-2007-008, GEN-2007-045, and GEN-2007-048 to the SPP transmission system.

One stability problem was found in the summer peak model after the addition of these generators. GEN-2007-008 is unstable following a fault on the Grapevine-Wheeler 230 kV line. The solution is for GEN-2007-008 to add reactive power resources to meet the power factor requirements listed in Table 4-2 and to use those resources to maintain a voltage schedule of at least 1.0 per unit at the Grapevine 230 kV bus. Dynamically controlled reactive power devices are not required as long as the voltage schedule can be maintained.

Power factor requirements were determined, and all study plants must install sufficient reactive power resources to meet these requirements listed in Table 4-2. The reactive power resources need not be dynamically controlled. However, any change in wind turbine model or controls could change the stability results, possibly resulting in a need for a dynamically controlled reactive power supply.

Some generator tripping occurred during Fault 39 (3-phase fault on the Tolk-Tuco 230 kV line). In this instance, the two GEN-2005-010 Gamesa generators tripped due to undervoltage in both summer and winter peak conditions. As specified by SPP standards, this fault was retested with tripping turned off to check for instability. With tripping disabled, no stability problems were found in either summer or winter peak conditions.

All Suzlon wind turbines have rather oscillatory machine speeds, with low but positive damping. The oscillations die out within 30 seconds. These speed oscillations have minimal impact on the electric system. The turbine manufacturer should review the PSS/E dynamic model for accuracy.

The Fuhrlaender models are slow to recover to steady state. The Fuhrlaender model documentation indicates that this is normal for these wind turbines.

3. Study Development and Assumptions

3.1 Simulation Tools

The Siemens Power Technologies, Inc. PSS/E digital computer power flow simulation program Version 30.3.3 was used in this study.

3.2 Models Used

SPP provided its latest stability database cases for both summer and winter peak seasons. The power flow cases from the previous Group 5 study were updated by removing cancelled projects and adjusting transmission plans accordingly. Each plant's PSS/E model had been developed prior to this study and was included in the power flow case and the dynamics database. As a result, no additional generator modeling was required. Power flow one-line diagrams of the study projects are shown in Figure 3-1, Figure 3-2, and Figure 3-3. As the figures show, each plant model includes explicit representation of the radial transmission line, if any; the substation transformer(s) from transmission voltage to 34.5 kV; and the substation reactive power device(s), if any. The remainder of each wind farm is represented by one or more lumped equivalents including a generator, a step-up transformer, and a collector system impedance.

No special modeling is required of line relays in these cases, except for the special modeling related to the wind-turbine tripping.

Figure 3-4 shows the locations of these projects on the SPP transmission system. The green ellipses indicate the study project points of interconnection (POI), and the yellow ellipses indicate the prior-queued project POIs. The red X's indicate the fault locations examined in this study. Orange transmission lines are nominally 345 kV, blue lines are 230 kV, and black lines are 115 kV and below.

3.3 Monitored Facilities

All generators in Areas 520, 524, 525, 526, 531, 534, and 536 were monitored.

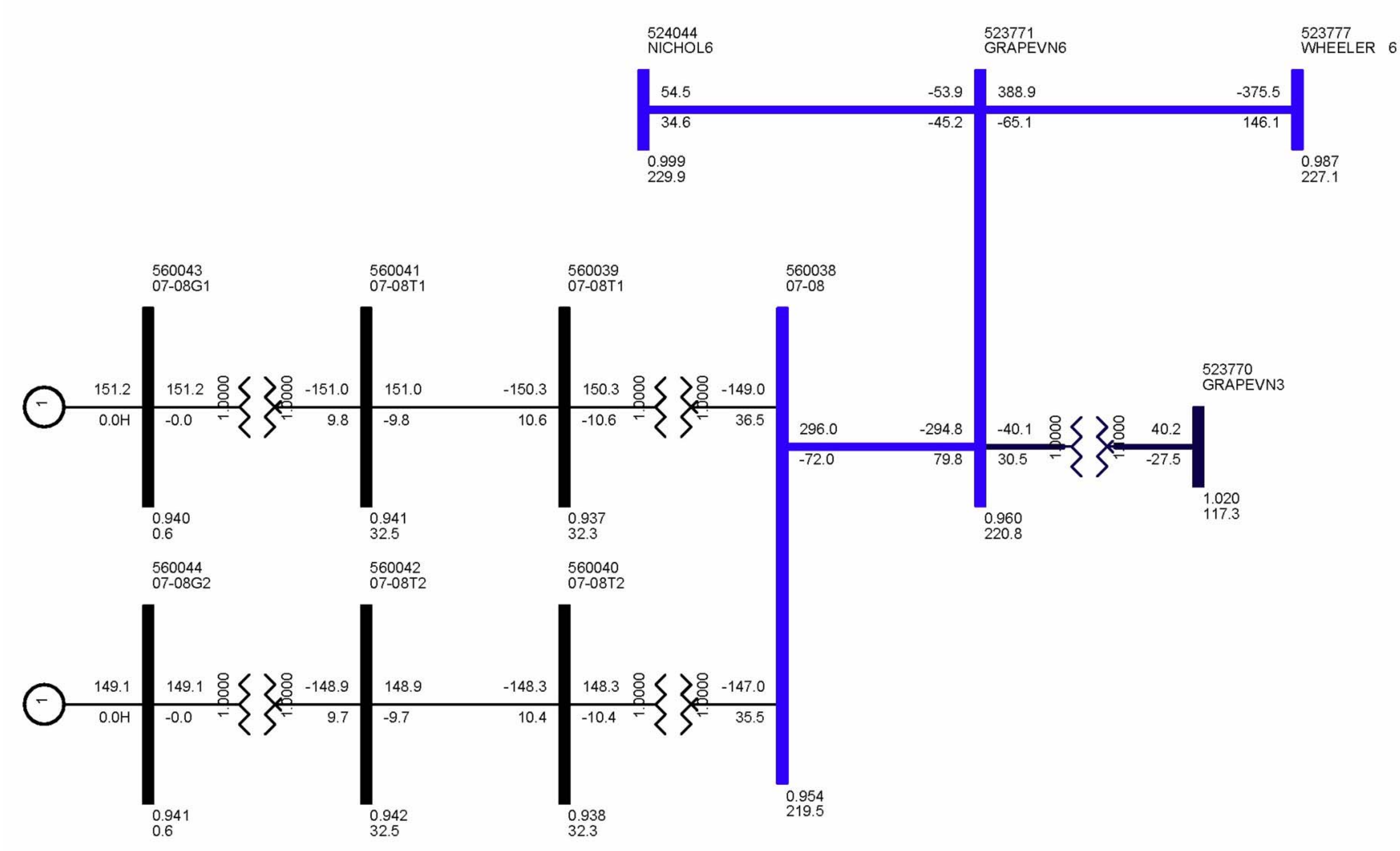

Figure 3-1. **Power Flow One-line for GEN-2007-008**

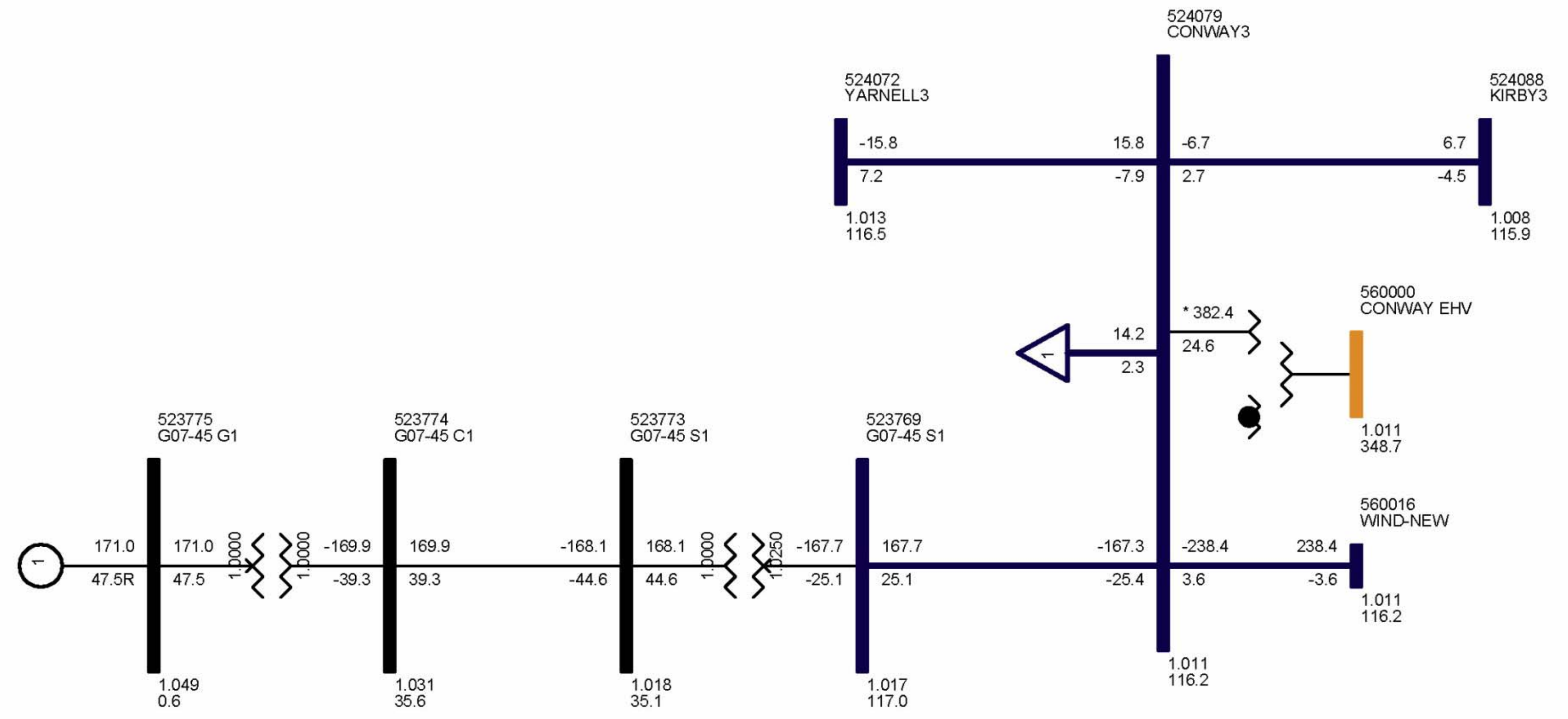

Figure 3-2. Power Flow One-line for GEN-2007-045

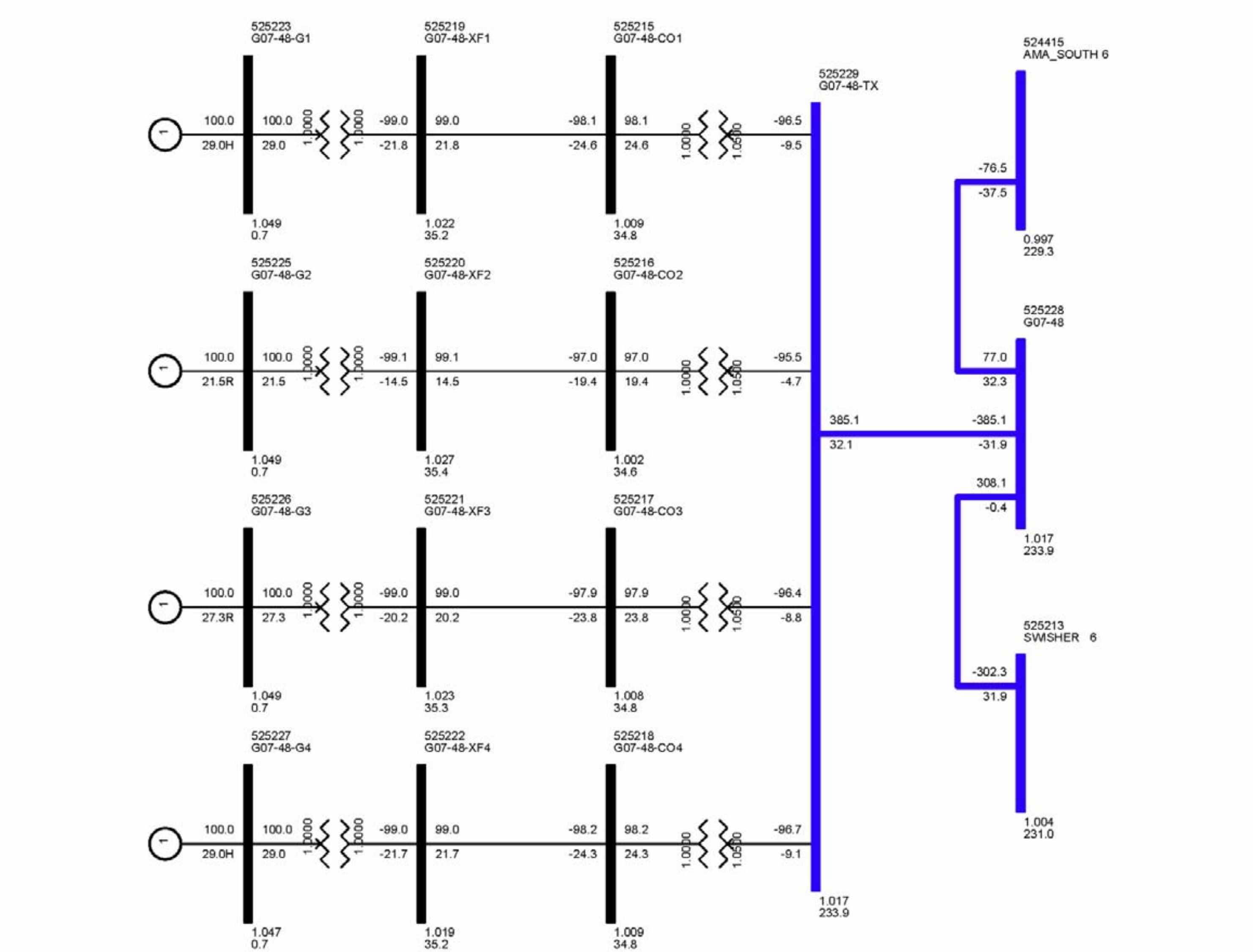

Figure 3-3. Power Flow One-line for GEN-2007-048

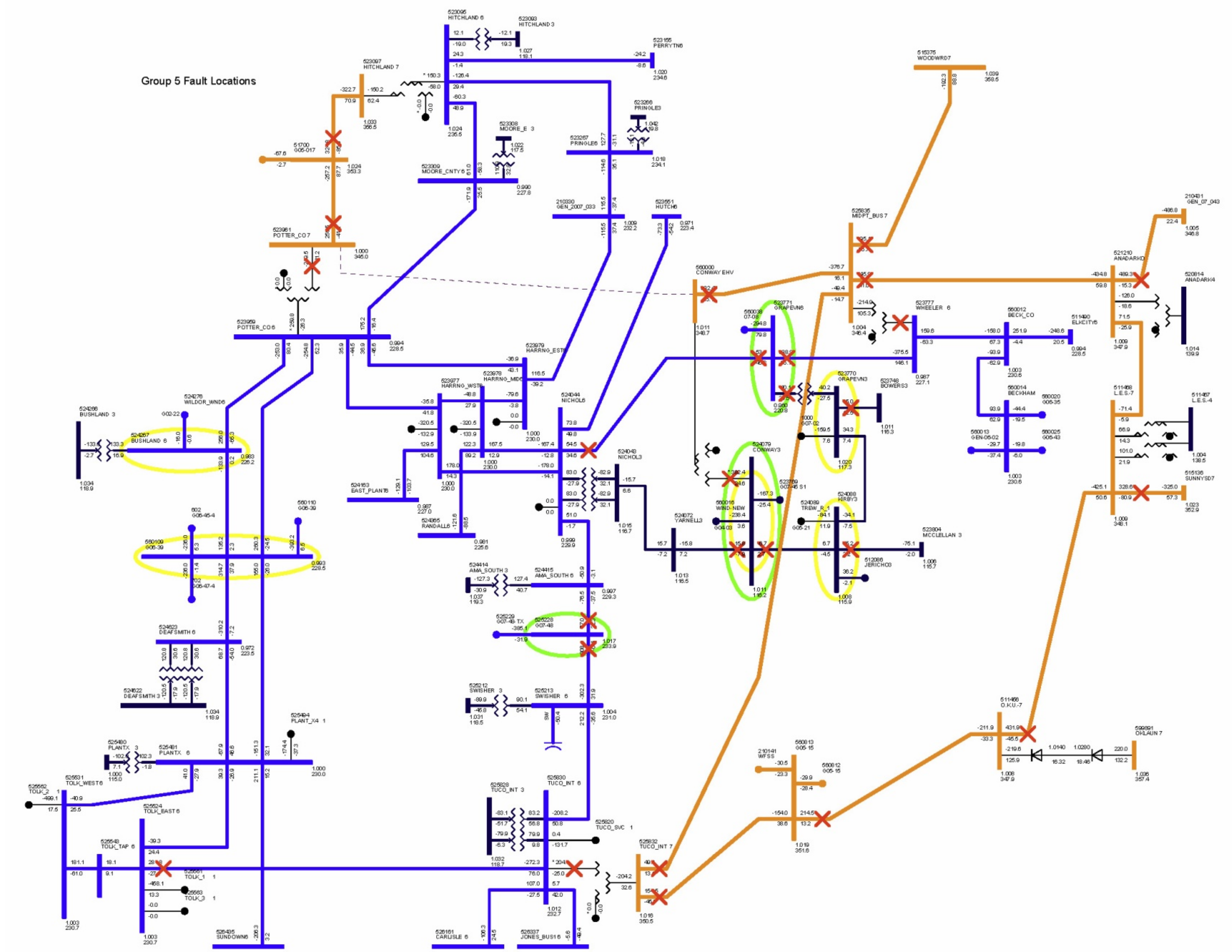

Figure 3-4. SPP Transmission System in the Group 5 Area

3.4 Performance Criteria

The wind generators must comply with FERC Order 661A on low voltage ride through for wind farms. Therefore, the wind generators should not trip off line for faults for under voltage relay actuation. If a wind generator trips off line, an appropriately sized SVC or STATCOM device may need to be specified to keep the wind generator on-line for the fault. SPP was consulted to determine if the addition of an SVC or STATCOM is warranted for the specific condition.

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 disabled to check for stability issues.

3.5 Performance Evaluation Methods

Since all of the interconnection requests are wind projects, a power factor analysis was performed. The power factor analysis consisted of modeling a var generator in each wind farm holding a voltage schedule at the POI. The voltage schedule was set equal to the higher of the voltage with the wind farm off-line or 1.0 per unit.

If the required power factor at the POI is beyond the capability of the studied wind turbines, then capacitor banks would be considered. Factors used in sizing capacitor banks would include two requirements of FERC Order 661A: the ability of the wind farm to ride through low voltage with and without capacitor banks and the ability of the wind farm to recover to pre-fault voltage. If a wind generator trips on high voltage, a leading power factor may be required.

ATC studies were not performed as part of this study. These studies will be required at the time transmission service is actually requested. Additional transmission facilities may be required based on subsequent ATC analysis.

Stability analysis was performed for each proposed interconnection request. Faults were simulated on transmission lines at the POIs and on other nearby transmission equipment. The faults in Table 3-1 were run for each case (three phase and single phase as noted). The fault numbers from the previous Group 5 study were maintained for consistency. Faults no longer applicable were removed, and new faults were added at the end as necessary.

Table 3-1. Fault Definitions for Group 5

Cont. No.	Contingency Name	Description
7	FLT07-3PH	3 phase fault on the Potter Co. (523961) to GEN-2005-017 (51700) 345kV line, near Potter Co. a. Apply fault at the Potter Co. 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.
8	FLT08-1PH	*Single phase fault and sequence like previous*
9	FLT09-3PH	3 phase fault on the GEN-2005-017 (51700) to Hitchland (523097) 345kV line, near GEN-2005-017. a. Apply fault at the GEN-2005-017 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.
10	FLT10-1PH	*Single phase fault and sequence like previous*
11	FLT11-3PH	3 phase fault on the Potter Co. 345kV (523961) to 230kV (523959) transformer, near the 345kV kV bus. a. Apply fault at the Potter Co. 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
12	FLT12-1PH	*Single phase fault and sequence like previous*
17	FLT17-3PH	3 phase fault on the Anadarko (521210) to GEN-2007-043 (210431) 345kV line, near Anadarko. a. Apply fault at the Anadarko 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.
18	FLT18-1PH	*Single phase fault and sequence like previous*
19	FLT19-3PH	3 phase fault on the Lawton Eastside (511468) to Sunnyside (515136) 345kV line, near Lawton Eastside. a. Apply fault at the Lawton Eastside 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.
20	FLT20-1PH	*Single phase fault and sequence like previous*
21	FLT21-3PH	3 phase fault on the GEN-2007-048 (525228) to Amarillo South (524415) 230kV line, near GEN-2007-048. a. Apply fault at the GEN-2007-048 230kV 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.
22	FLT22-1PH	*Single phase fault and sequence like previous*
23	FLT23-3PH	3 phase fault on the GEN-2007-048 (525228) to Swisher (525213) 230kV line, near GEN-2007-048. a. Apply fault at the GEN-2007-048 230kV 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.

Cont. No.	Contingency Name	Description
24	FLT24-1PH	*Single phase fault and sequence like previous*
25	FLT25-3PH	3 phase fault on the Nichols (524044) to Grapevine (523771) 230kV line, near Nichols. a. Apply fault at the Nichols 230kV 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.
26	FLT26-1PH	*Single phase fault and sequence like previous*
27	FLT27-3PH	3 phase fault on the Grapevine (523771) to Wheeler (523777) 230kV line, near Grapevine. a. Apply fault at the Grapevine 230kV 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.
28	FLT28-1PH	*Single phase fault and sequence like previous*
39	FLT39-3PH	3 phase fault on the Tolk (525524) to Tuco (525830) 230kV line, near Tolk. a. Apply fault at the Tolk 230kV 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.
40	FLT40-1PH	*Single phase fault and sequence like previous*
41	FLT41-3PH	3 phase fault on the Tuco 230kV (525830) to 345kV (525832) transformer, near the 230kV bus. a. Apply fault at the Tuco 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
42	FLT42-1PH	*Single phase fault and sequence like previous*
43	FLT43-3PH	3 phase fault on the GEN-2005-015 (560813) to Oklaunion (511456) 345kV line, near GEN-2005-015. a. Apply fault at the GEN-2005-015 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.
44	FLT44-1PH	*Single phase fault and sequence like previous*
45	FLT45-3PH	3 phase fault on the Oklaunion (511456) to Lawton Eastside (511468) 345kV line, near Oklaunion. a. Apply fault at the Oklaunion 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.
46	FLT46-1PH	*Single phase fault and sequence like previous*
51	FLT51-3PH	3 phase fault on the Grapevine (523771) to Nichols (524044) 230kV line, near Grapevine. a. Apply fault at the Grapevine 230kV 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.
52	FLT52-1PH	*Single phase fault and sequence like previous*
53	FLT53-3PH	3 phase fault on the Conway (524079) to Yarnell (524072) 115kV line, near Conway. a. Apply fault at the Conway 115kV 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.

Cont. No.	Contingency Name	Description
54	FLT54-1PH	*Single phase fault and sequence like previous*
55	FLT55-3PH	3 phase fault on the Conway (524079) to Kirby (524088) 115kV line, near Conway. a. Apply fault at the Conway 115kV 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.
56	FLT56-1PH	*Single phase fault and sequence like previous*
57	FLT57-3PH	3 phase fault on the Wheeler 230kV (523777) to 345kV (525835) transformer, near the 230kV bus. a. Apply fault at the Wheeler 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
58	FLT58-1PH	*Single phase fault and sequence like previous*
59	FLT59-3PH	3 phase fault on the Wheeler/Midpoint (525835) to Anadarko (521210) 345kV line, near Wheeler/Midpoint. a. Apply fault at the Wheeler/Midpoint 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.
60	FLT60-1PH	*Single phase fault and sequence like previous*
63	FLT63-3PH	3 phase fault on the Conway 115kV (524079) to 345kV (560000) transformer, near the 115kV bus. a. Apply fault at the Conway 115kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
64	FLT64-1PH	*Single phase fault and sequence like previous*
65	FLT65-3PH	3 phase fault on the Conway (560000) to Wheeler/Midpoint (525835) 345kV line, near Conway. a. Apply fault at the Conway 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.
66	FLT66-1PH	*Single phase fault and sequence like previous*
67	FLT67-3PH	3 phase fault on the Grapevine 230kV (523771) to 115kV (523770) transformer, near the 230kV bus. a. Apply fault at the Grapevine 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
68	FLT68-1PH	*Single phase fault and sequence like previous*
69	FLT69-3PH	3 phase fault on the Tuco (525832) to Wheeler/Midpoint (525835) 345kV line, near Tuco. a. Apply fault at the Tuco 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.
70	FLT70-1PH	*Single phase fault and sequence like previous*
71	FLT71-3PH	3 phase fault on the Wheeler/Midpoint (525835) to Woodward (515375) 345kV line, near Wheeler/Midpoint. a. Apply fault at the Wheeler/Midpoint 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.

Cont. No.	Contingency Name	Description
72	FLT72-1PH	*Single phase fault and sequence like previous*
73	FLT73-3PH	3 phase fault on the Tuco (525832) to GEN-2005-015 (560813) 345kV line, near Tuco. a. Apply fault at the Tuco 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.
74	FLT74-1PH	*Single phase fault and sequence like previous*
75	FLT75-3PH	3 phase fault on the Kirby (524088) to McClellan (523804) 115kV line, near Kirby. a. Apply fault at the Kirby 115kV 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.
76	FLT76-1PH	*Single phase fault and sequence like previous*
77	FLT77-3PH	3 phase fault on the Grapevine (523770) to Bowers (523748) 115kV line, near Grapevine. a. Apply fault at the Grapevine 115kV 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.
78	FLT78-1PH	*Single phase fault and sequence like previous*

4. Results and Observations

4.1 Stability Analysis Results

All faults provided by SPP were run for both summer and winter peak conditions. If a previously-queued generator tripped for any of these faults, the voltage and frequency tripping was disabled, and the fault was re-run to check for system stability.

Table 4-1 summarizes the overall results for all faults. Figure 4-1 through Figure 4-6 show representative summer peak season plots for faults at the POIs for each of the study projects. Complete sets of plots for both summer and winter peak seasons for each fault and each wind project are included in Appendices A and B.

As shown in Figure 4-1 and Figure 4-2, GEN-2007-008 and the POI voltages are unstable following Fault 27, a three-phase fault on the Grapevine to Wheeler 230 kV line. Fault 28, the single-phase fault version, is also unstable. The pre-fault voltages at Grapevine 230 kV and inside the GEN-2007-008 wind farm are already low to begin with, since GEN-2007-008 does not come with any reactive power support by default (see Figure 3-1). Following the fault, the voltages are too low to support stable operation of GEN-2007-008.

The Power Factor analysis in Section 4.3 shows that GEN-2007-008 will be required to install reactive power compensation devices to achieve 0.95 power factor lagging at the POI. To test a fix for the unstable faults 27 and 28, capacitors were added to the GEN-2007-008 substation buses to achieve the voltage schedule of 1.0 at the POI. Approximately 100 Mvar were needed (50 Mvar each bus), which is only a portion of the power factor requirement. With the capacitors on-line in the base case, faults 27 and 28 become stable.

Table 4-1. Summary of Results

Cont. No.	Contingency Name	Description	Summer Peak Results	Winter Peak Results
7	FLT07-3PH	3 phase fault on the Potter Co. (523961) to GEN-2005-017 (51700) 345kV line, near Potter Co.	OK	OK
8	FLT08-1PH	*Single phase fault and sequence like previous*	OK	OK
9	FLT09-3PH	3 phase fault on the GEN-2005-017 (51700) to Hitchland (523097) 345kV line, near GEN-2005-017.	OK	OK
10	FLT10-1PH	*Single phase fault and sequence like previous*	OK	OK
11	FLT11-3PH	3 phase fault on the Potter Co. 345kV (523961) to 230kV (523959) transformer, near the 345kV kV bus.	OK	OK
12	FLT12-1PH	*Single phase fault and sequence like previous*	OK	OK
17	FLT17-3PH	3 phase fault on the Anadarko (521210) to GEN-2007-043 (210431) 345kV line, near Anadarko.	OK	OK
18	FLT18-1PH	*Single phase fault and sequence like previous*	OK	OK

Cont. No.	Contingency Name	Description	Summer Peak Results	Winter Peak Results
19	FLT19-3PH	3 phase fault on the Lawton Eastside (511468) to Sunnyside (515136) 345kV line, near Lawton Eastside.	OK	OK
20	FLT20-1PH	*Single phase fault and sequence like previous*	OK	OK
21	FLT21-3PH	3 phase fault on the GEN-2007-048 (525228) to Amarillo South (524415) 230kV line, near GEN-2007-048.	OK	OK
22	FLT22-1PH	*Single phase fault and sequence like previous*	OK	OK
23	FLT23-3PH	3 phase fault on the GEN-2007-048 (525228) to Swisher (525213) 230kV line, near GEN-2007-048.	OK	OK
24	FLT24-1PH	*Single phase fault and sequence like previous*	OK	OK
25	FLT25-3PH	3 phase fault on the Nichols (524044) to Grapevine (523771) 230kV line, near Nichols.	OK	OK
26	FLT26-1PH	*Single phase fault and sequence like previous*	OK	OK
27	FLT27-3PH	3 phase fault on the Grapevine (523771) to Wheeler (523777) 230kV line, near Grapevine.	G07-08 and nearby voltages Unstable	OK
27fix1	FLT27-3PH-fix1	3 phase fault on the Grapevine (523771) to Wheeler (523777) 230kV line, near Grapevine. 100 Mvar of pre-fault caps in service	OK	NA
28	FLT28-1PH	*Single phase fault and sequence like previous*	OK	OK
39	FLT39-3PH	3 phase fault on the Tolk (525524) to Tuco (525830) 230kV line, near Tolk.	OK, but generators at buses 560817 and 560818 tripped at 1.1 sec.	
39nt	FLT39nt-3PH	3 phase fault on the Tolk (525524) to Tuco (525830) 230kV line, near Tolk. Tripping disabled.	OK	OK
40	FLT40-1PH	*Single phase fault and sequence like previous*	OK	OK
41	FLT41-3PH	3 phase fault on the Tuco 230kV (525830) to 345kV (525832) transformer, near the 230kV bus.	OK	OK
42	FLT42-1PH	*Single phase fault and sequence like previous*	OK	OK
43	FLT43-3PH	3 phase fault on the GEN-2005-015 (560813) to Oklaunion (511456) 345kV line, near GEN-2005-015.	OK	OK
44	FLT44-1PH	*Single phase fault and sequence like previous*	OK	OK
45	FLT45-3PH	3 phase fault on the Oklaunion (511456) to Lawton Eastside (511468) 345kV line, near Oklaunion.	OK	OK
46	FLT46-1PH	*Single phase fault and sequence like previous*	OK	OK
51	FLT51-3PH	3 phase fault on the Grapevine (523771) to Nichols (524044) 230kV line, near Grapevine.	OK	OK
52	FLT52-1PH	*Single phase fault and sequence like previous*	OK	OK
53	FLT53-3PH	3 phase fault on the Conway (524079) to Yarnell (524072) 115kV line, near Conway.	OK	OK
54	FLT54-1PH	*Single phase fault and sequence like previous*	OK	OK
55	FLT55-3PH	3 phase fault on the Conway (524079) to Kirby (524088) 115kV line, near Conway.	OK	OK
56	FLT56-1PH	*Single phase fault and sequence like previous*	OK	OK

Cont. No.	Contingency Name	Description	Summer Peak Results	Winter Peak Results
57	FLT57-3PH	3 phase fault on the Wheeler 230kV (523777) to 345kV (525835) transformer, near the 230kV bus.	OK	OK
58	FLT58-1PH	*Single phase fault and sequence like previous*	OK	OK
59	FLT59-3PH	3 phase fault on the Wheeler/Midpoint (525835) to Anadarko (521210) 345kV line, near Wheeler/Midpoint.	OK	OK
60	FLT60-1PH	*Single phase fault and sequence like previous*	OK	OK
63	FLT63-3PH	3 phase fault on the Conway 115kV (524079) to 345kV (560000) transformer, near the 115kV bus.	OK	OK
64	FLT64-1PH	*Single phase fault and sequence like previous*	OK	OK
65	FLT65-3PH	3 phase fault on the Conway (560000) to Wheeler/Midpoint (525835) 345kV line, near Conway.	OK	OK
66	FLT66-1PH	*Single phase fault and sequence like previous*	OK	OK
67	FLT67-3PH	3 phase fault on the Grapevine 230kV (523771) to 115kV (523770) transformer, near the 230kV bus.	OK	OK
68	FLT68-1PH	*Single phase fault and sequence like previous*	OK	OK
69	FLT69-3PH	3 phase fault on the Tuco (525832) to Wheeler/Midpoint (525835) 345kV line, near Tuco.	OK	OK
70	FLT70-1PH	*Single phase fault and sequence like previous*	OK	OK
71	FLT71-3PH	3 phase fault on the Wheeler/Midpoint (525835) to Woodward (515375) 345kV line, near Wheeler/Midpoint.	OK	OK
72	FLT72-1PH	*Single phase fault and sequence like previous*	OK	OK
73	FLT73-3PH	3 phase fault on the Tuco (525832) to GEN-2005-015 (560813) 345kV line, near Tuco.	OK	OK
74	FLT74-1PH	*Single phase fault and sequence like previous*	OK	OK
75	FLT75-3PH	3 phase fault on the Kirby (524088) to McClellan (523804) 115kV line, near Kirby.	OK	OK
76	FLT76-1PH	*Single phase fault and sequence like previous*	OK	OK
77	FLT77-3PH	3 phase fault on the Grapevine (523770) to Bowers (523748) 115kV line, near Grapevine.	OK	OK
78	FLT78-1PH	*Single phase fault and sequence like previous*	OK	OK

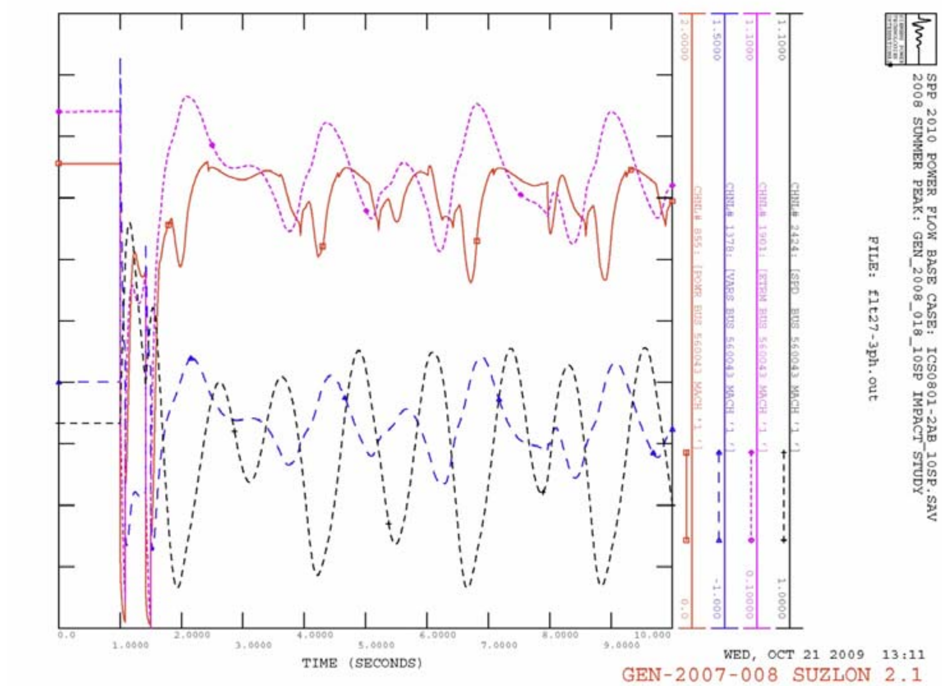

Figure 4-1. GEN-2007-008 Plot for Fault 27 – 3-Phase Fault on the Grapevine to Wheeler 230 kV line, near Grapevine

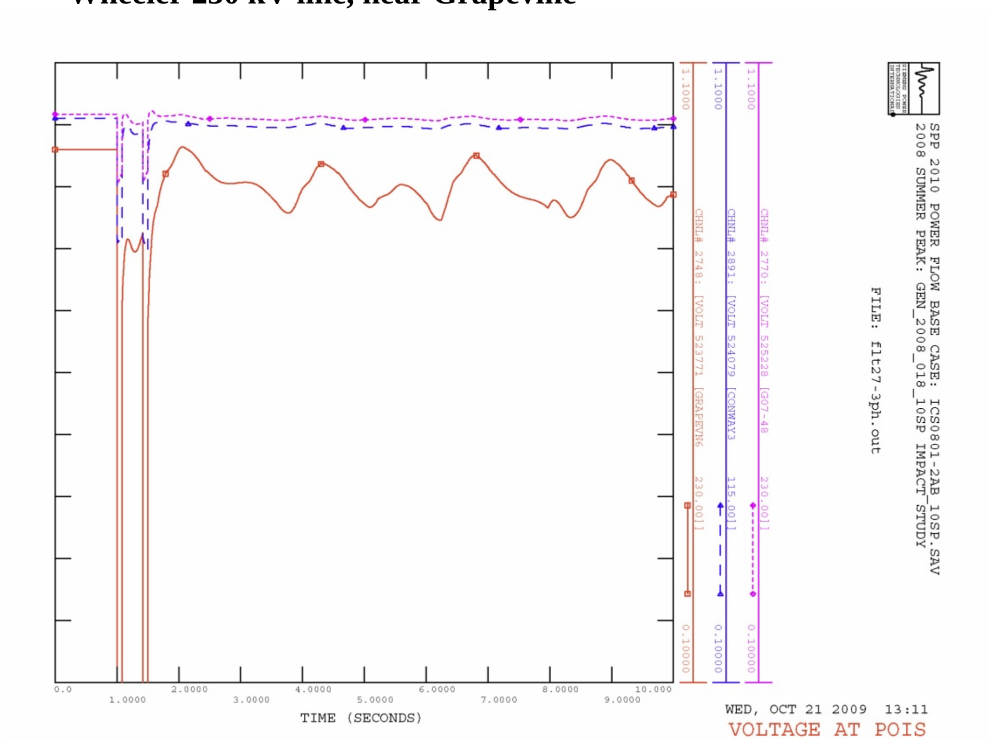

Figure 4-2. POI Voltages Plot for Fault 27 – 3-Phase Fault on the Grapevine to Wheeler 230 kV line, near Grapevine

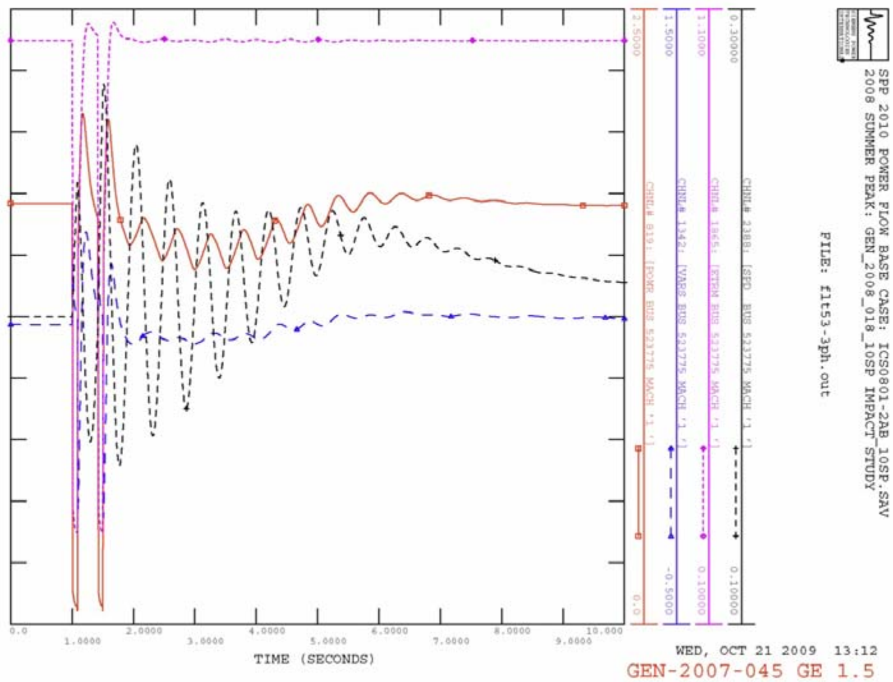

Figure 4-3. GEN-2007-045 Plot for Fault 53 – 3-Phase Fault on the Conway to Yarnell 115 kV line, near Conway

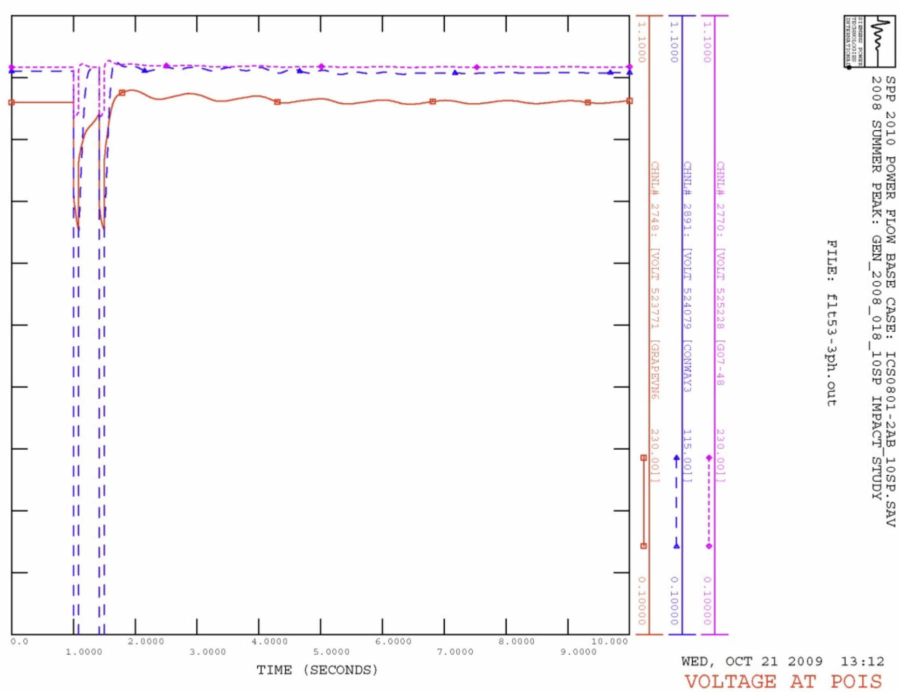

Figure 4-4. POI Voltages Plot for Fault 53 – 3-Phase Fault on the Conway to Yarnell 115 kV line, near Conway

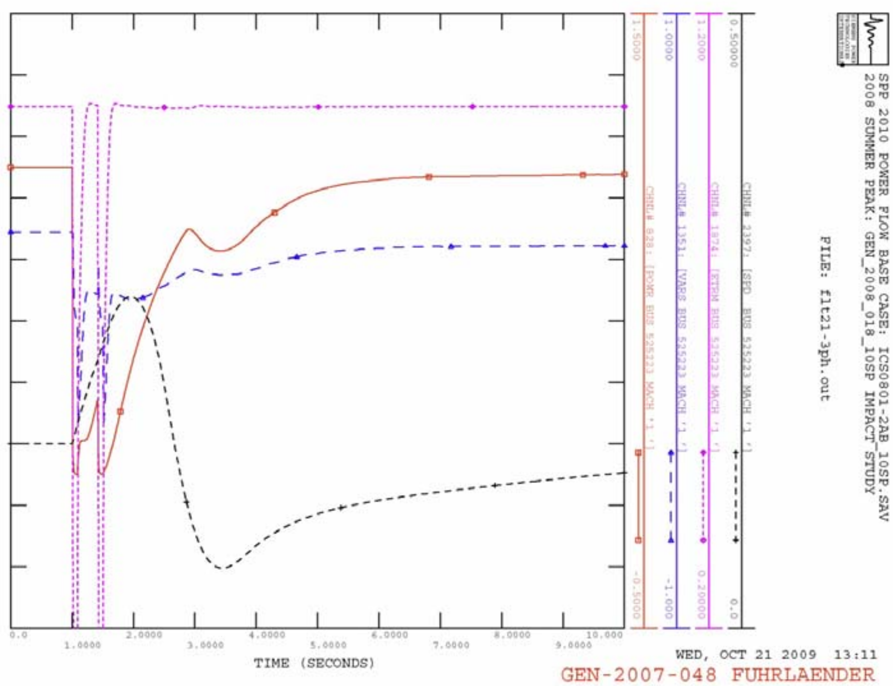

Figure 4-5. GEN-2007-048 Plot for Fault 21 – 3-Phase Fault on the GEN-2007-048 to Amarillo South 230 kV line, near GEN-2007-048

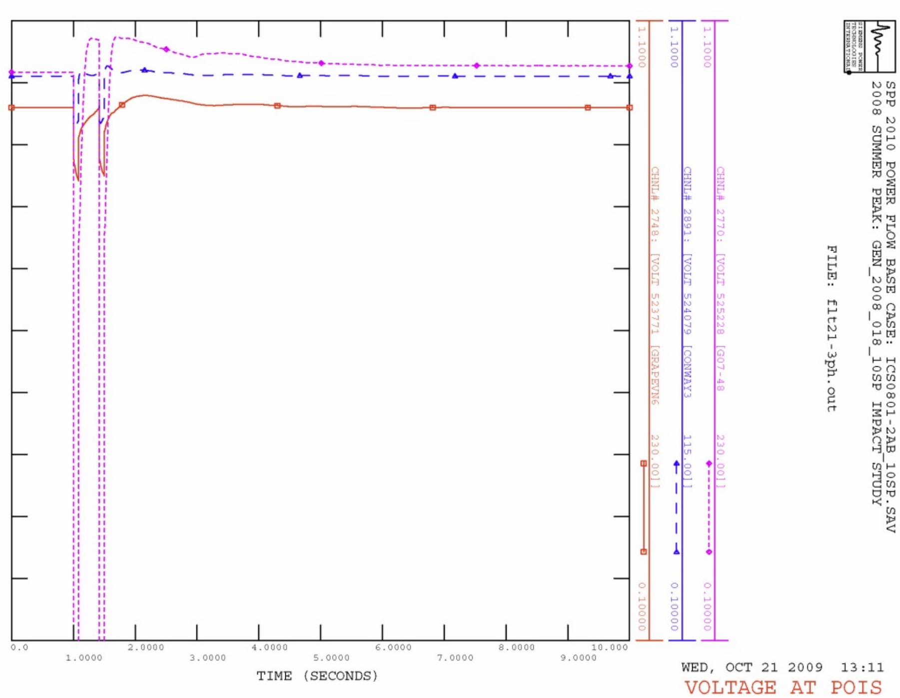

Figure 4-6. POI Voltages Plot for Fault 21 – 3-Phase Fault on the GEN-2007-048 to Amarillo South 230 kV line, near GEN-2007-048

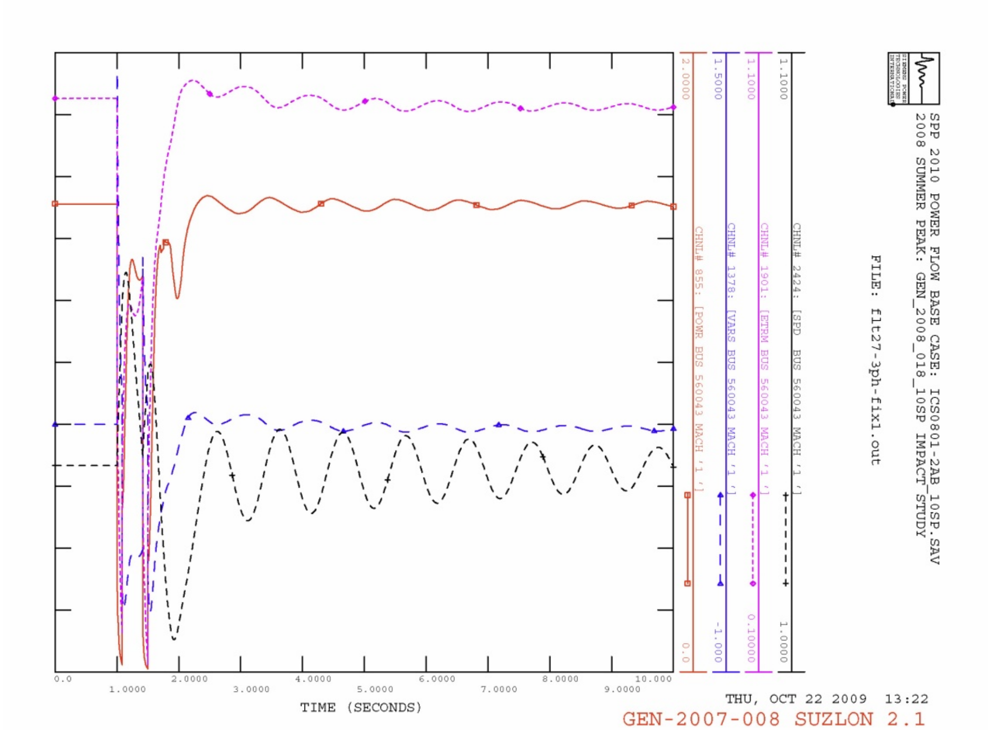

Figure 4-7. **GEN-2007-008 Plot for Fault 27 – with 100 Mvar of capacitors added to GEN-2007-008**

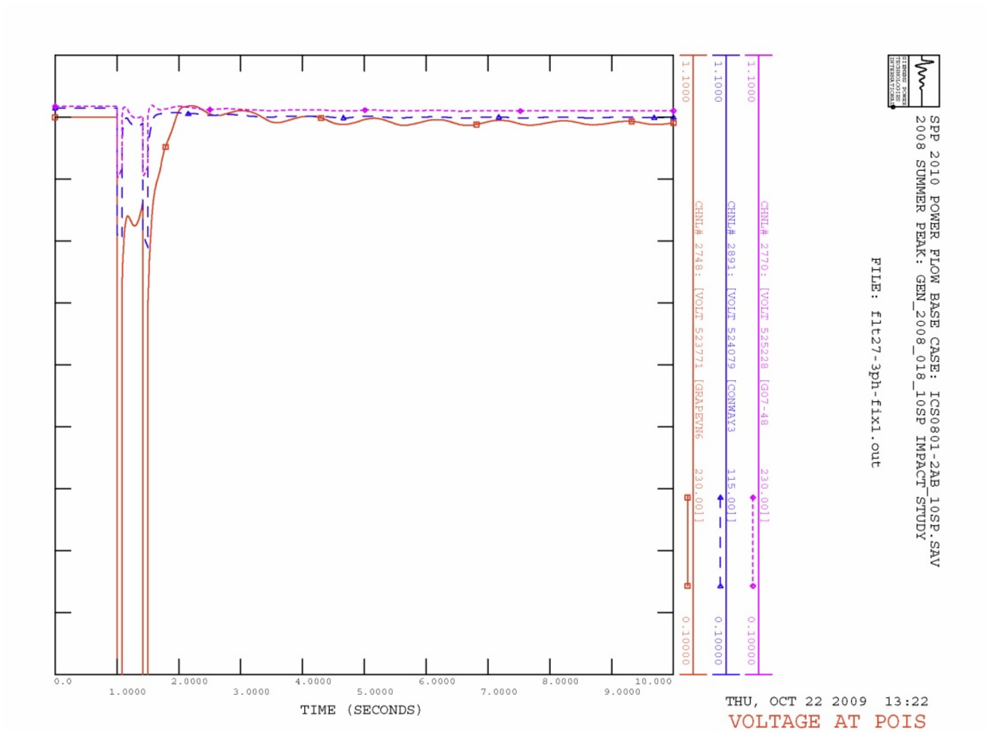

Figure 4-8. **POI Voltages Plot for Fault 27 – with 100 Mvar of capacitors added to GEN-2007-008**

4.2 Generator Performance

All Suzlon wind turbines have rather oscillatory generator speeds, with low but positive damping. The oscillations die out within 30 seconds as shown in Figure 4-9. These speed oscillations have minimal impact on the electric system. The Suzlon dynamic model should be reviewed by the turbine manufacturer for accuracy.

The Fuhrlaender models are slow to recover to steady state (for example Figure 4-5 above). The Fuhrlaender model documentation indicates that this is normal behavior for these wind turbines.

The two GEN-2005-010 Gamesa generators tripped due to undervoltage in both summer and winter peak conditions for Fault 39 (3-phase fault on the Tolk-Tuco 230 kV line). See Figure 4-10 below. The generators are set to trip if the voltage drops below 15% for more than 0.04 second; during this fault, the voltage dropped below 15% for 0.0875 second. As specified by SPP standards, this fault was retested with tripping turned off to check for instability. With tripping disabled (Figure 4-11), no stability problems were found in either summer or winter peak conditions.

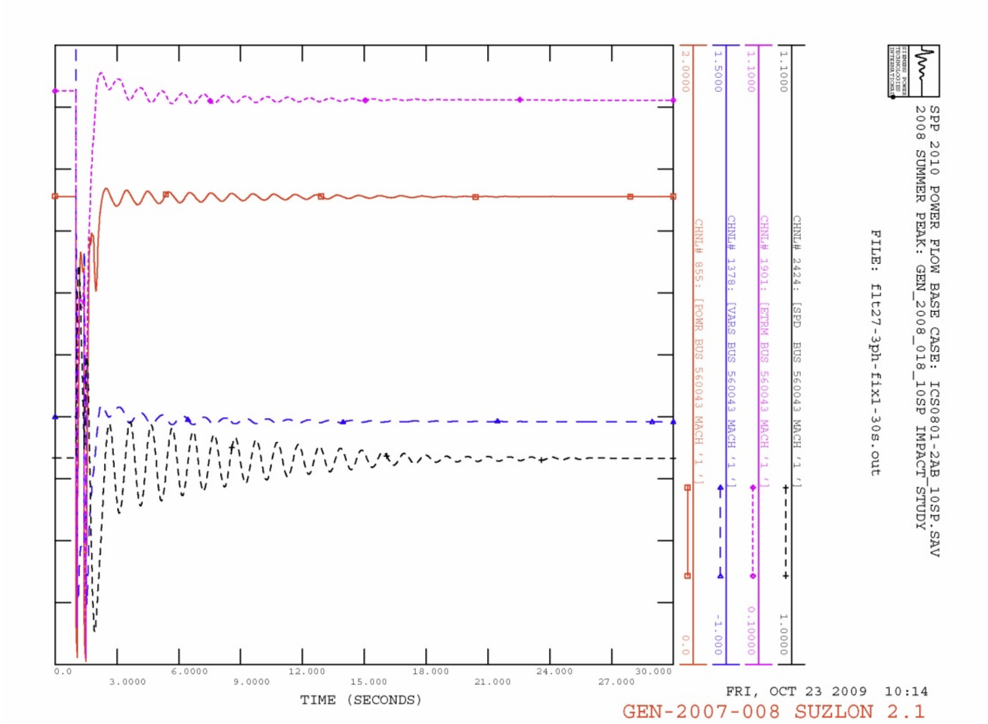

Figure 4-9. GEN-2007-008 Plot for Fault 27 – with 100 Mvar of capacitors added to GEN-2007-008 - extended to 30 seconds

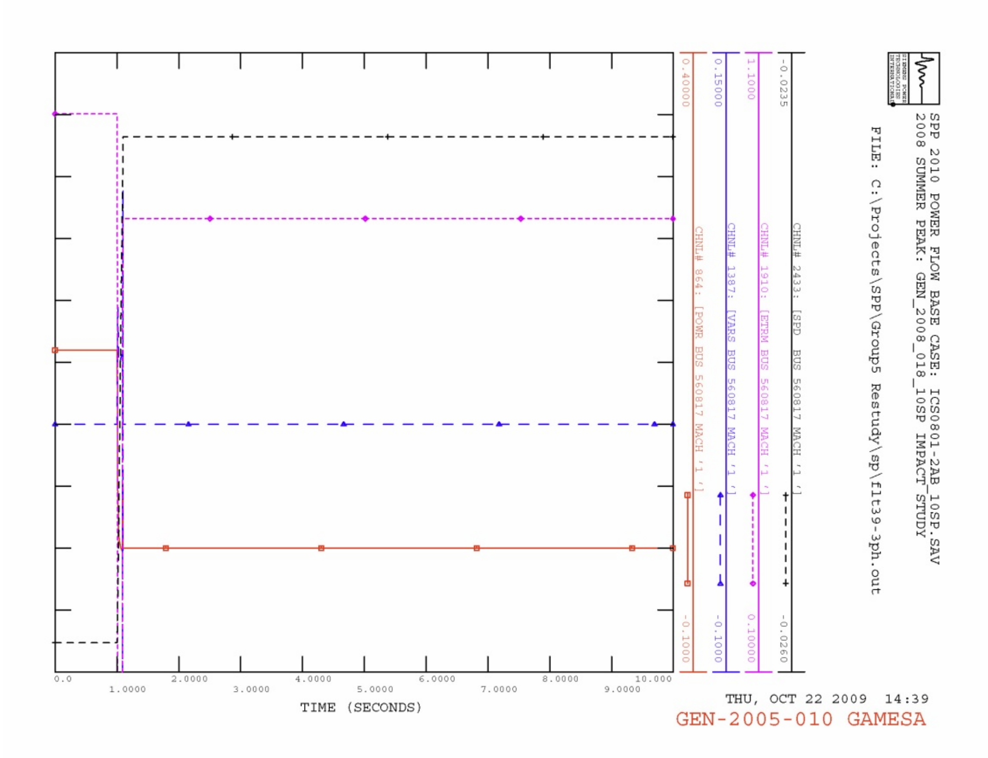

Figure 4-10. Fault 39 – 3-Phase Fault on the Tolk to Tuco 230kV line, near Tolk – GEN-2005-010 Trips

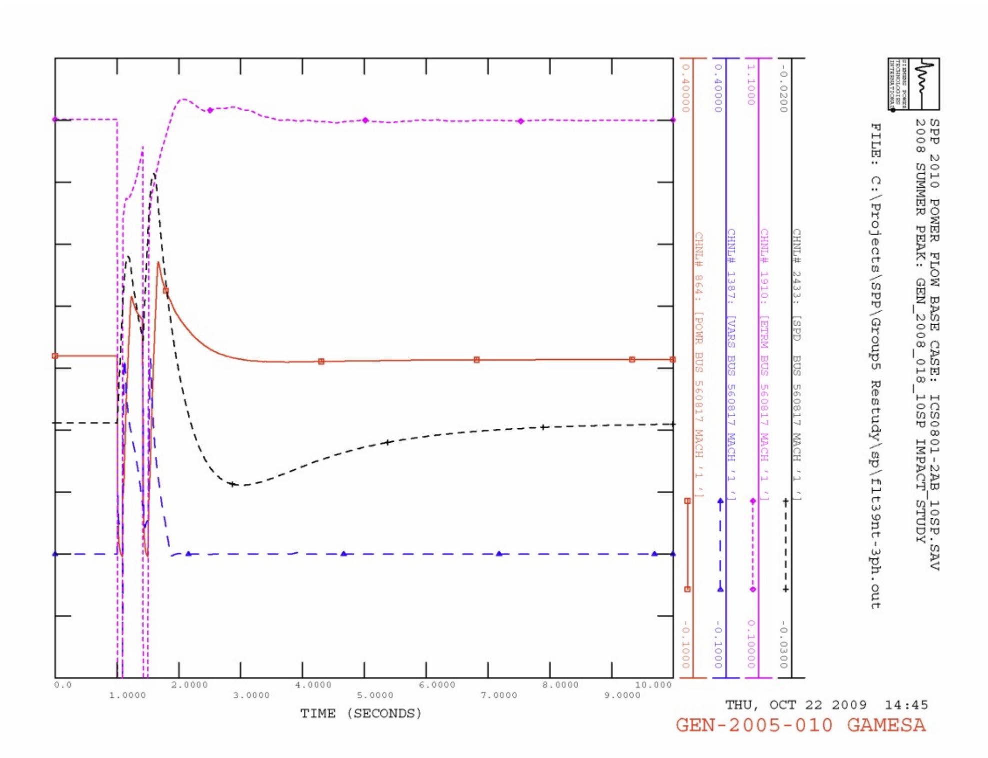

Figure 4-11. Fault 39 – 3-Phase Fault on the Tolk to Tuco 230kV line, near Tolk – GEN-2005-010 Tripping Blocked

4.3 Power Factor Requirements

All stability faults were tested as power flow contingencies to determine the power factor requirements for the wind farm study projects to maintain scheduled voltage at their respective points of interconnection (POI). The voltage schedules are set equal to the voltages at the POIs before the projects are added, with a minimum of 1.0 per unit. Fictitious reactive power sources were added to the study projects to maintain scheduled voltage during all studied contingencies. The MW and Mvar injections from the study projects at the POIs were recorded and the resulting power factors were calculated for all contingencies for summer peak and winter peak cases. The most leading and most lagging power factors determine the minimum power factor range capability that the study projects must install before commercial operation.

If more than one study project shared a single POI (none in this case), the projects were grouped together and a common power factor requirement was determined for those study projects. This ensures that none of the study projects is required to provide more or less than its fair share of the reactive power requirements at a single POI. *Prior-queued* projects at the same POI, if any, were not grouped with the study projects because their interconnection requirements were determined in previous studies.

Per FERC and SPP Tariff requirements, if the power factor needed to maintain scheduled voltage were less than 0.95 lagging, then the requirement would be set to 0.95 lagging. This limit was reached for GEN-2007-008 and GEN-2007-045. Much greater reactive power supply would be needed to meet the voltage schedules under some contingencies, but only 0.95 lagging will be required. The limit for leading power factor requirement is also 0.95, but this level was not reached for any project.

The final power factor requirements are shown in Table 4-2 below. These are only the minimum power factor ranges. A project developer may install more capability than this if desired.

The full details for each contingency in summer and winter peak cases are given in Appendix C.

Table 4-2. Power Factor Requirements [1]

Project	MW	Turbine	POI	Final PF Requirement	
				Lagging [2]	Leading [3]
GEN-2007-008	300	Suzlon 2.1MW	Grapevine 230kV	0.95	1.0
GEN-2007-045	171	G.E. 1.5MW	Conway 115kV	0.95	1.0
GEN-2007-048	400	Fuhrlaender	Amarillo S. – Swisher 230kV line	1.0	0.997

Notes:

1. For each plant, the table shows the minimum required power factor capability at the point of interconnection that must be designed and installed with the wind farm. The power factor capability at the POI includes the net effect of the wind turbine generators, transformer and collector line impedances, and any reactive compensation devices installed on the plant side of the meter. Installing more capability than the minimum requirement is acceptable.
2. Lagging is when the generating plant is supplying reactive power to the transmission grid. In this situation, the alternating current sinusoid “lags” behind the alternating voltage sinusoid, meaning that the current peaks shortly after the voltage.
3. Leading is when the generating plant is taking reactive power from the transmission grid. In this situation, the alternating current sinusoid “leads” the alternating voltage sinusoid, meaning that the current peaks shortly before the voltage.

5. Conclusions

The Cluster #1 Group #5 Impact Study Restudy evaluated the impacts of interconnecting each of the projects shown below.

Table 5-1. Interconnection Requests to be Evaluated

Request	Size	Wind Turbine Model	Point of Interconnection
GEN-2007-008	300	Suzlon 2.1 MW	Grapevine 230kV (523771)
GEN-2007-045	171	G.E. 1.5MW	Conway 115kV (524079)
GEN-2007-048	400	Fuhrlaender	Amarillo South – Swisher 230kV line (525228)

One stability problem was found in the summer peak model after the addition of these generators. GEN-2007-008 is unstable following a fault on the Grapevine-Wheeler 230 kV line. The solution is for GEN-2007-008 to add reactive power resources to meet the power factor requirements listed in Table 4-2 and to use those resources to maintain a voltage schedule of at least 1.0 per unit at the Grapevine 230 kV bus. Dynamically controlled reactive power devices are not required as long as the voltage schedule can be maintained.

Power factor requirements were determined, and all study plants must install sufficient reactive power resources to meet these requirements listed in Table 4-2. The reactive power resources need not be dynamically controlled. However, any change in wind turbine model or controls could change the stability results, possibly resulting in a need for a dynamically controlled reactive power supply.

Some generator tripping occurred during Fault 39 (3-phase fault on the Tolk-Tuco 230 kV line). In this instance, the two GEN-2005-010 Gamesa generators tripped due to undervoltage in both summer and winter peak conditions. As specified by SPP standards, this fault was retested with tripping turned off to check for instability. With tripping disabled, no stability problems were found in either summer or winter peak conditions.

All Suzlon wind turbines have rather oscillatory machine speeds, with low but positive damping. The oscillations die out within 30 seconds. These speed oscillations have minimal impact on the electric system. The turbine manufacturer should review the PSS/E dynamic model for accuracy.

The Fuhrlaender models are slow to recover to steady state. The Fuhrlaender model documentation indicates that this is normal for these wind turbines.

Appendix A – Summer Peak Plots

See attachment.

Appendix B – Winter Peak Plots

See attachment.

Appendix C – Power Factor Details

See attachment.

Appendix D – Dynamic Model Data

See attachment.

O: Stability Study for Group 6

R179-09

Generator Interconnection Impact Restudy for Cluster #1: ICS-2008-001-Group 6

Prepared for

Southwest Power Pool, Inc.

Submitted by:
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Final Report: December 23, 2009
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Siemens PTI Project Number: P/21-113379-B-4

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Contents

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Section

1

Introduction

1.1 Background

Pursuant to the tariff and at the request of the Southwest Power Pool (SPP), Siemens PTI performed the Impact Study R101-09 *"Generator Interconnection Impact Study for Cluster # 1: ICS-2008-001 - Group 6"* to satisfy the Impact Study Agreement executed by the customers. The requests for interconnection were placed with SPP in accordance to SPP's Open Access Transmission Tariff, which covers new generation interconnections on SPP's transmission system.

Along the interconnection process some proposed wind projects no longer intend to interconnect to SPP's system, such that they dropped their positions in the queue list. The following wind generation projects are not part of group 6 anymore:

- GEN-2007-027
- GEN-2007-055
- GEN-2008-007
- GEN-2008-015

Without these wind projects the network as planned by SPP has suffered a significant change, therefore a reevaluation is required to determine the system behavior under the new generation scenario.

The purpose of this report is to present the results of the stability and power factor analysis performed to reevaluate the impact of the proposed cluster of interconnections of the ICS-2008-001 with regard to Group 6 remaining wind projects on the Southwest Power Pool system. Eventual indicative solutions to the identified issues are proposed based on the impact of each generation interconnection on the Southwest Power Pool system.

Five remaining projects in this cluster are connected to four different Points of Interconnection (to be known hereafter as POI) at different voltage levels, ranging from 69 kV to 345 kV. Section 2 describes all proposed wind farms projects in detail.

Transient stability analysis was performed using the package provide by SPP. It contains the latest stability database in PSS®E version 30.3.2. The stability package also includes the dynamic data for the previously queued projects.

1.2 Purpose

The steady state and stability study was carried out to:

1. Determine the ability of the proposed generation facilities to remain in synchronism and within applicable planning standards following two types of system faults tested a) unsuccessful reclosing b) Normally Cleared faults.
2. Determine the amount of transient support required from the costumer to meet the power factor requirement at the POI.
3. Determine the ability of the wind farm to meet FERC Order 661A (low voltage ride through and wind farm recovery to pre-fault voltage).

Section
2

Model Development

The study has considered the 2010 Summer Peak and Winter Peak load flow models with the required interconnection generations modeled. The base cases also contain all the significant previous queued generation interconnection projects in the interconnection queue.

2.1 Power Flow Data

The Group 6 of ICS-2008-001 contains five proposed wind generation projects. Table 2-1 presents the size of the wind generation projects, the Wind Turbine Generator (WTGs) manufacturers, the reactive capability of the wind farm as well as the point of interconnection and the PSS®E bus numbers in the load flow models.

Table 2-1 – Details of the Interconnection Requests

Request	Size (MW)	Model	Reactive Capability of Wind Farm		Point of Interconnection	Bus Number
			Max (MVAR)	Min (MVAR)		
GEN-2007-034	150	GE 1.5 MW	49.3	-49.3	TOLK-EDDY COUNTY 345kV	210340
GEN-2008-008	60	GE 1.5 MW	19.7	-19.7	GRAHAM 69kV	526693
GEN-2008-009	60	GE1.5 MW	19.7	-19.7	SAN JUAN MESA 230kV	524885
GEN-2008-014	150	Vestas V90	0	0	TUCO-OKLAUNION 345kV	560813
GEN-2008-016	248	Vestas V90	0	0	GRASSLAND 230kV	526677

The analysis was carried out using the database package provided by SPP which also includes the modeling data for the previously queued projects, as shown in Table 2-2:

Table 2-2 – Details of the Prior Queued Interconnection Requests

Request	Size (MW)	Model	Point of Interconnection	Bus Number
GEN-2001-033	180	Mitsubishi 1000	SAN JUAN MESA 230kV	524885
GEN-2001-036	80	CIMTR	CURRY-TUCUMCARI 115kV	524502
GEN-2005-010	160	Gamesa	TOLK-ROOSEVELT 230kV	525531
GEN-2005-015	150	Gamesa	TUCO-OKLAUNION 345kV	560813

Figures 2-1 to 2-4 present the surrounding area of the Group 6 points of interconnection, showing the line flows and voltage profile for the load flow models considered in the study for summer and winter peak scenarios, respectively.

Figure 2-1 - Group 6 Points of Interconnection Surrounding Area – *Diagram1* Summer Peak

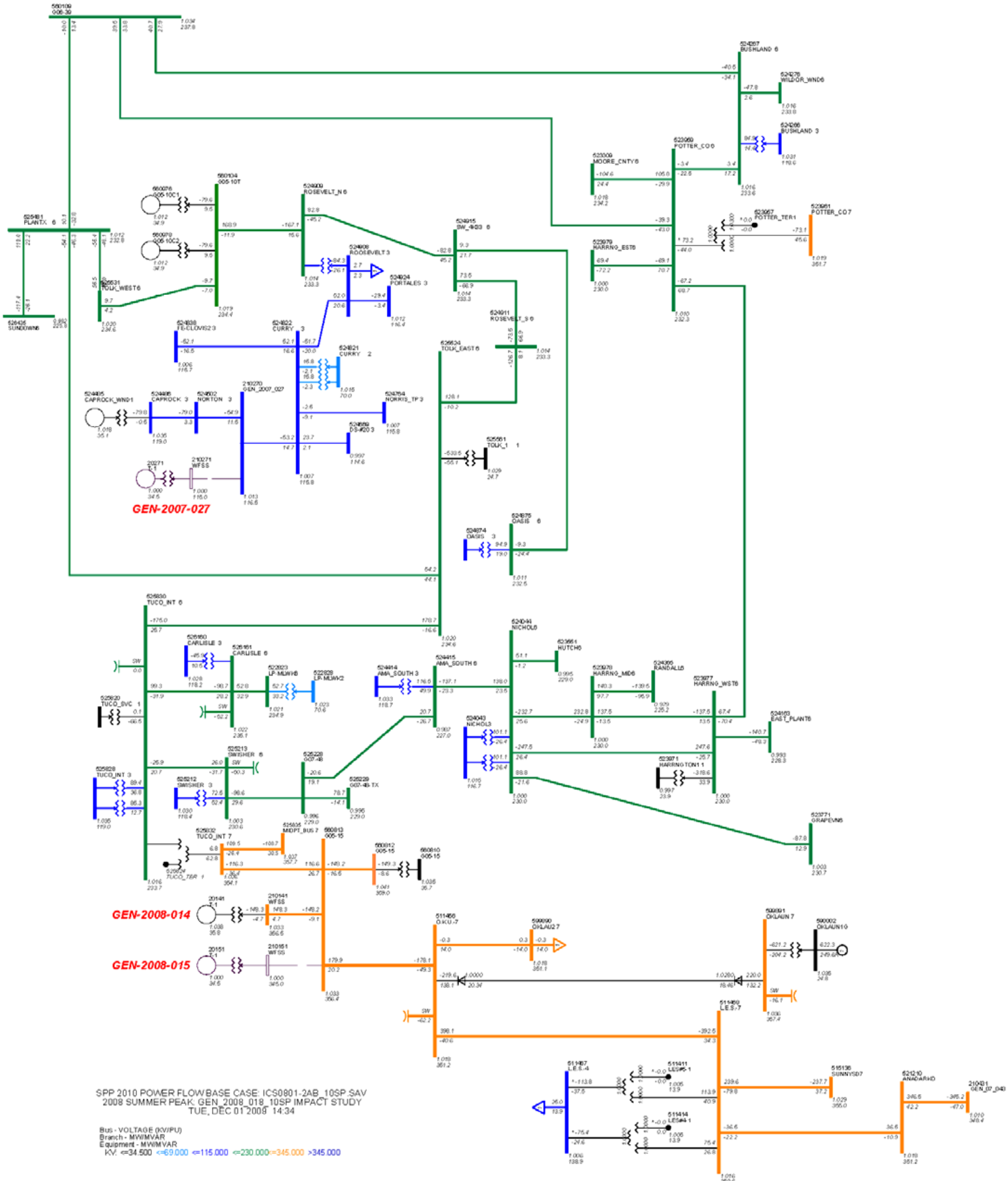


Figure 2-2 - Group 6 Points of Interconnection Surrounding Area – Diagram2 Summer Peak

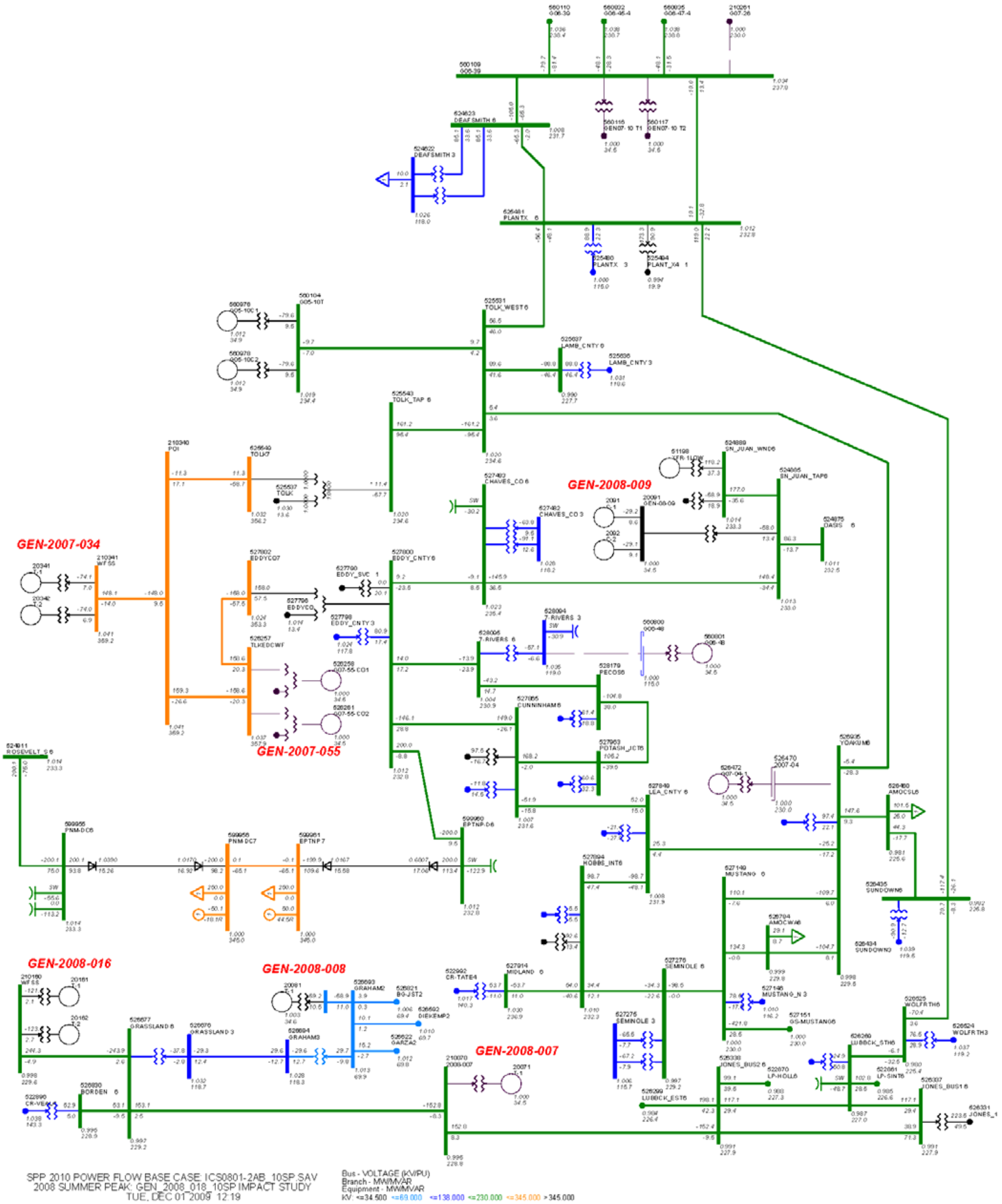


Figure 2-3 - Group 6 Points of Interconnection Surrounding Area – *Diagram1* Winter Peak

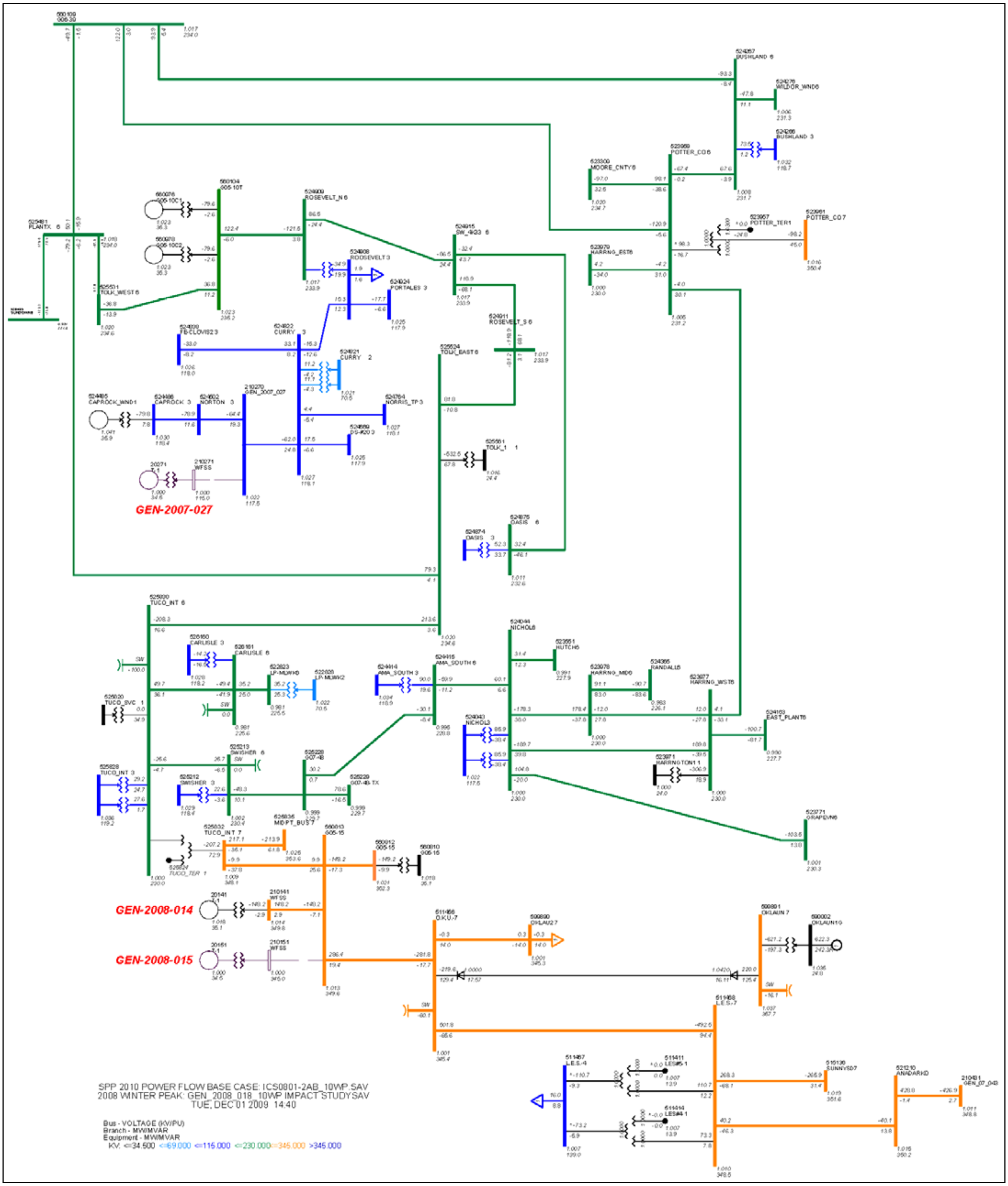
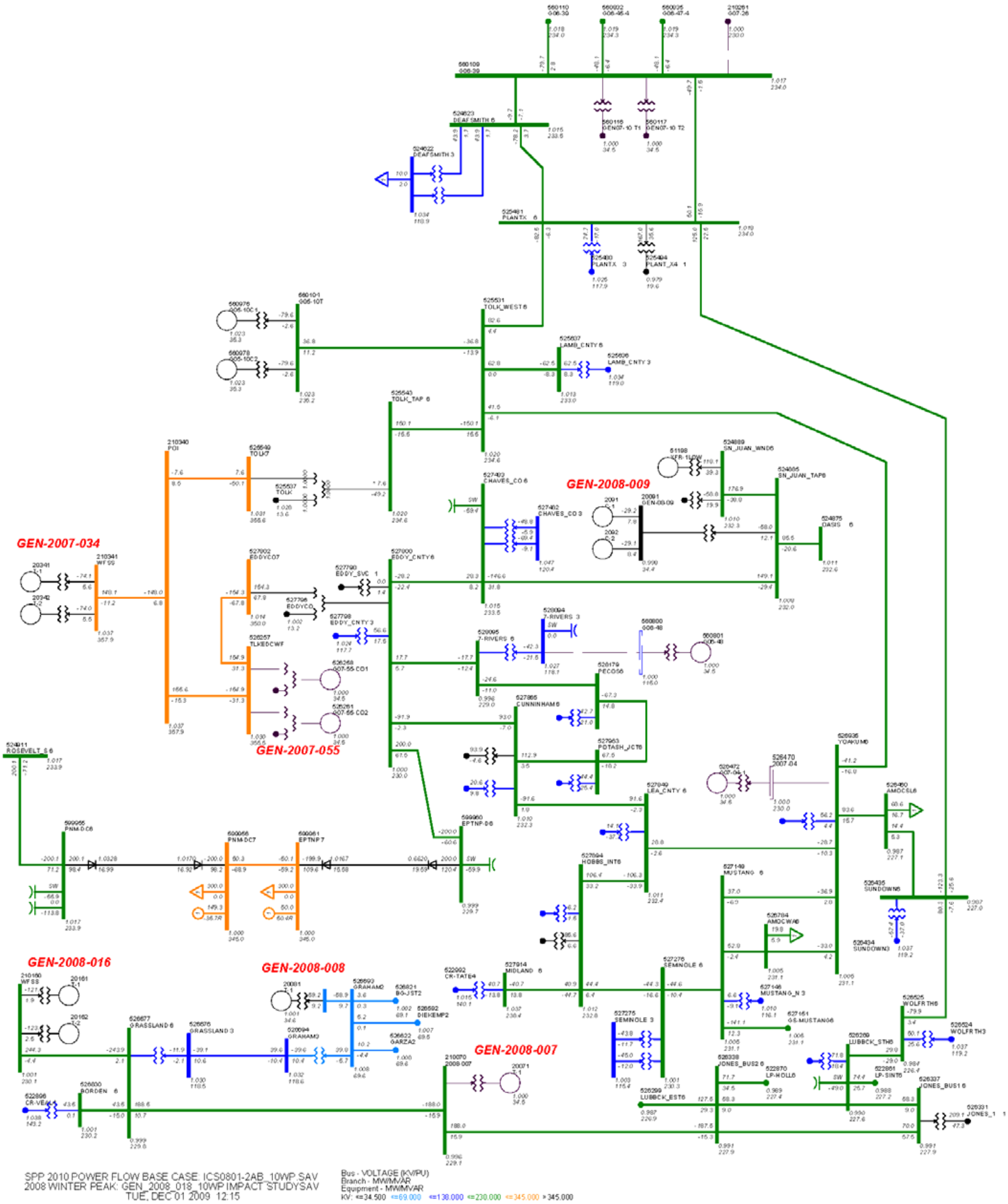


Figure 2-4 - Group 6 Points of Interconnection Surrounding Area – *Diagram2* Winter Peak



Figures A-1 to A-5 in Appendix A present the single line diagrams, showing the modeling details of each Group 6 interconnection requests considered in this restudy.

2.2 Stability Database

The transient stability analysis was performed using the data provided by SPP. Stability models for the Group 6 interconnection requests were added to the dynamic database, based on the technical documentation given. All turbine parameters used in the simulation models are the default parameters in the wind turbine package. It is assumed that each wind turbine generators (WTGs) would be controlling the voltage of its own bus.

The default voltage protection model set points recommended by the manufacturer were used, that is, the wind units were modeled with their built-in voltage ride through capability. Also, the default frequency protection model set points recommended by the manufacturer were used.

In the analysis, the wind generation projects are modeled using equivalents representing groups of turbines and the respective collector systems.

The PSS®E dynamic models output list is shown in Appendix B, documenting the model parameters of each one of the Group 6 wind turbines modeled in the stability restudy.

Section

3

Methodology and Assumptions

The study considered the 2010 power flow cases with the required interconnection generation requests modeled as described in Section 2. The base case also contains all the significant previous queued projects in the interconnection queue.

The monitored areas in this study are shown in Table 3-1.

Table 3-1 – Areas of Interest

Area Number	Area Name
520	AEPW
524	OKGE
525	WFEC
526	SPS
531	MIDW
534	SUNC
536	WERE

3.1 Methodology

3.1.1 Stability Simulations

The dynamic simulations were performed using the PSS®E version 30.3.2 with the latest stability database provided by SPP. Three-phase faults and single-phase faults in the neighborhood of ICS-2008-001 – Group 6 points of interconnection were simulated. Any adverse impact on the system stability was documented and further investigated with appropriate solutions to determine whether a static or dynamic VAR device is required or not.

3.1.2 Steady State Simulations

3.1.2.1 N-1 Contingency Analysis

An N-1 contingency analysis was performed to evaluate voltage violations, if any, caused by disturbances (tripping of the faulted line). The voltages at each POI were monitored for deviations from the base case voltage and the percentage deviations were documented.

The summer peak and winter peak load flow cases were adjusted to ensure there are no relevant pre contingency voltage criteria violations. During contingency analysis it was reported voltages of any monitored bus found to be outside the range of the post-contingency criteria and / or having more than 1% of project impact.

3.1.2.2 Power Factor Analysis

A QV analysis was performed to determine the reactive support requirement at each project's POI. QV tables, tabulated for base case and contingency conditions, are used to determine the reactive power support required at each POI, in order to maintain the scheduled pre contingency bus voltages.

These tables are obtained through a series of AC load flow calculations. Starting with no reactive support at a bus, the voltage is computed for a series of power flows as the reactive support is increased in steps, until the power flow experiences convergence difficulties as the system approaches the voltage collapse point.

3.2 Disturbances for Stability Analysis

The stability simulations considered three-phase (3PH) faults and single line-to-ground (SLG) faults. For transmission line outages the complete fault clearing process includes the following sequence of events:

1) Line fault, cleared after 5 cycles by tripping the both line terminals

2) After 20 cycles the line is reclosed under fault conditions (unsuccessful reclosing)

3) The fault is cleared by tripping both ends of the faulted line. Once again, 5 cycles later.

Furthermore, the clearing process for transformer faults is:

1) Transformer fault, cleared after 5 cycles by tripping the equipment

The disturbances evaluated along with corresponding clearing methods are listed in the following Table 3-2:

Note: Some of the contingencies tested in the previous analysis are no longer relevant for this restudy as some projects have dropped the queue; however the contingency number remain unchanged from the initial study.

Table 3-2: Disturbances for Stability Analysis

Cont. #	Fault Location	Fault Type	Fault Clearing
17	At Roosevelt S end of 230 kV line to PNM DC	3PH	trip Roosevelt S – PNM DC 230 kV
18	At Roosevelt S end of 230 kV line to PNM DC	SLG	trip Roosevelt S – PNM DC 230 kV
19	At San Juan end of 230 kV line to Oasis	3PH	trip San Juan – Oasis 230 kV
20	At San Juan end of 230 kV line to Oasis	SLG	trip San Juan – Oasis 230 kV

Cont. #	Fault Location	Fault Type	Fault Clearing
21	At San Juan end of 230 kV line to Chaves Co	3PH	trip San Juan – Chaves Co 230 kV
22	At San Juan end of 230 kV line to Chaves Co	SLG	trip San Juan – Chaves Co 230 kV
23	At Eddy Co end of 230 kV line to EPTNP	3PH	trip Eddy Co – EPTNP 230 kV
24	At Eddy Co end of 230 kV line to EPTNP	SLG	trip Eddy Co – EPTNP 230 kV
25	At Eddy Co end of 230/345 kV transformer	3PH	trip Eddy Co 230/345 kV transformer
26	At Eddy Co end of 230/345 kV transformer	SLG	trip Eddy Co 230/345 kV transformer
31	At GEN-2007-034 end of 345 kV line to GEN-2007-055	3PH	trip GEN-2007-034 – GEN-07-055 345 kV
32	At GEN-2007-034 end of 345 kV line to GEN-2007-055	SLG	trip GEN-2007-034 – GEN-07-055 345 kV
33	At GEN-2007-034 end of 345 kV line to Tolk	3PH	trip GEN-2007-034 – Tolk 345 kV
34	At GEN-2007-034 end of 345 kV line to Tolk	SLG	trip GEN-2007-034 – Tolk 345 kV
35	At Tolk end of 230/345 kV transformer	3PH	trip Tolk 230/345 kV transformer
36	At Tolk end of 230/345 kV transformer	SLG	trip Tolk 230/345 kV transformer
37	At Tolk E end of 230 kV line to Tuco	3PH	trip Tolk E – Tocu 345 kV
38	At Tolk E end of 230 kV line to Tuco	SLG	trip Tolk E – Tocu 345 kV
39	At Plant X end of 230 kV line to Sundown	3PH	trip Plant X – Sundown 230 kV
40	At Plant X end of 230 kV line to Sundown	SLG	trip Plant X – Sundown 230 kV
41	At Graham end of 230 kV line to Garza	3PH	trip Graham – Garza 230 kV
42	At Graham end of 230 kV line to Garza	SLG	trip Graham – Garza 230 kV
43	At Graham end of 69/115 kV transformer	3PH	trip Graham 69/115 kV transformer
44	At Graham end of 69/115 kV transformer	SLG	trip Graham 69/115 kV transformer

Cont. #	Fault Location	Fault Type	Fault Clearing
45	At Grassland end of 115 kV line to Lynn Co	3PH	trip Grassland – Lynn Co 115 kV
46	At Grassland end of 115 kV line to Lynn Co	SLG	trip Grassland – Lynn Co 115 kV
47	At Grassland end of 115/230 kV transformer	3PH	trip Grassland 115/230 kV transformer
48	At Grassland end of 115/230 kV transformer	SLG	trip Grassland 115/230 kV transformer
49	At Grassland end of 230/115 kV transformer	3PH	trip Grassland 230/115 kV transformer
50	At Grassland end of 230/115 kV transformer	SLG	trip Grassland 230/115 kV transformer
51	At Grassland end of 230 kV line to Borden	3PH	trip Grassland – Borden 230 kV
52	At Grassland end of 230 kV line to Borden	SLG	trip Grassland – Borden 230 kV
53	At Grassland end of 230 kV line to GEN-2008-007	3PH	trip Grassland – GEN-2008-007 230 kV
54	At Grassland end of 230 kV line to GEN-2008-007	SLG	trip Grassland – GEN-2008-007 230 kV
59	At Jones Bus2 end of 230 kV line to Lubbock E	3PH	trip Jones Bus2 – Lubbock E 230 kV
60	At Jones Bus2 end of 230 kV line to Lubbock E	SLG	trip Jones Bus2 – Lubbock E 230 kV
61	At Jones Bus1 end of 230 kV line to Tuco	3PH	trip Jones Bus1 – Tuco 230 kV
62	At Jones Bus1 end of 230 kV line to Tuco	SLG	trip Jones Bus1 – Tuco 230 kV
63	At Tuco end of 230 kV line to Swisher	3PH	trip Tuco – Swisher 230 kV
64	At Tuco end of 230 kV line to Swisher	SLG	trip Tuco – Swisher 230 kV
65	At Tuco end of 230/345 kV transformer	3PH	trip Tuco 230/345 kV transformer
66	At Tuco end of 230/345 kV transformer	SLG	trip Tuco 230/345 kV transformer
67	At GEN-2005-015 end of 345 kV line to Tuco	3PH	trip GEN-2005-015 – Tuco 345 kV

Cont. #	Fault Location	Fault Type	Fault Clearing
68	At GEN-2005-015 end of 345 kV line to Tuco	SLG	trip GEN-2005-015 – Tuco 345 kV
69	At GEN-2005-015 end of 345 kV line to Oklaunion	3PH	trip GEN-2005-015 – Oklaunion 345 kV
70	At GEN-2005-015 end of 345 kV line to Oklaunion	SLG	trip GEN-2005-015 – Oklaunion 345 kV
71	At Oklaunion end of 345 kV line to Lawton Eastside	3PH	trip Oklaunion – Lawton Eastside 345 kV
72	At Oklaunion end of 345 kV line to Lawton Eastside	SLG	trip Oklaunion – Lawton Eastside 345 kV
73	At Potter Co end of 230/345 kV transformer	3PH	trip Potter Co 230/345 kV transformer
74	At Potter Co end of 230/345 kV transformer	SLG	trip Potter Co 230/345 kV transformer
75	At Nichols end of 230 kV line to Grapevine	3PH	trip Nichols – Grapevine 230 kV
76	At Nichols end of 230 kV line to Grapevine	SLG	trip Nichols – Grapevine 230 kV
77	At Tuco end of 345 kV line to Wheeler/Midpoint	3PH	trip Tuco – Wheeler/Midpoint 345 kV
78	At Tuco end of 345 kV line to Wheeler/Midpoint	SLG	trip Tuco – Wheeler/Midpoint 345 kV

In order to simulate single line to ground faults, equivalent reactances were determined to be applied at the buses. Table 3-3 presents the equivalent reactances obtained:

Table 3-3: Equivalent Reactances – Line to Ground Faults

BUS	Equivalent Reactance (Mvar)	
	WP	SP
524911	1700	
524885	1000	
527800	1600	
210340	1600	
525543	4400	

BUS	Equivalent Reactance (Mvar)	
	WP	SP
525524	5200	
525481	4400	
526693	150	
526676	600	
526677	1650	1800
526388	2700	2900
526337	2700	2900
525830	2700	2800
560813	2000	
511456	1500	
523959	4500	
524044	5300	
525832	2700	

The following Figures 3-1 and 3-2 present the fault locations within the study area.

Figure 3-1 – Fault Locations in the Study Area – *Diagram1*

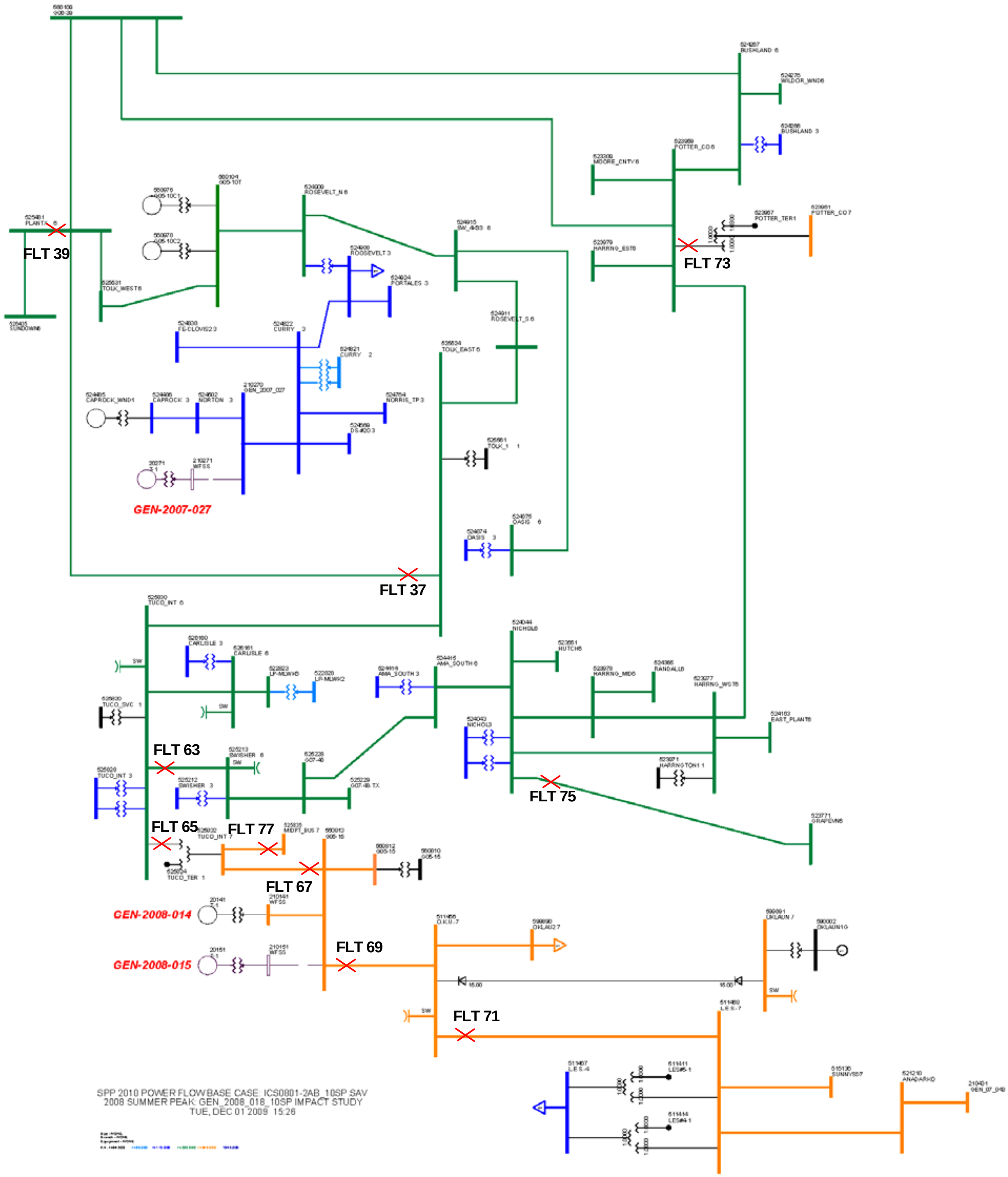
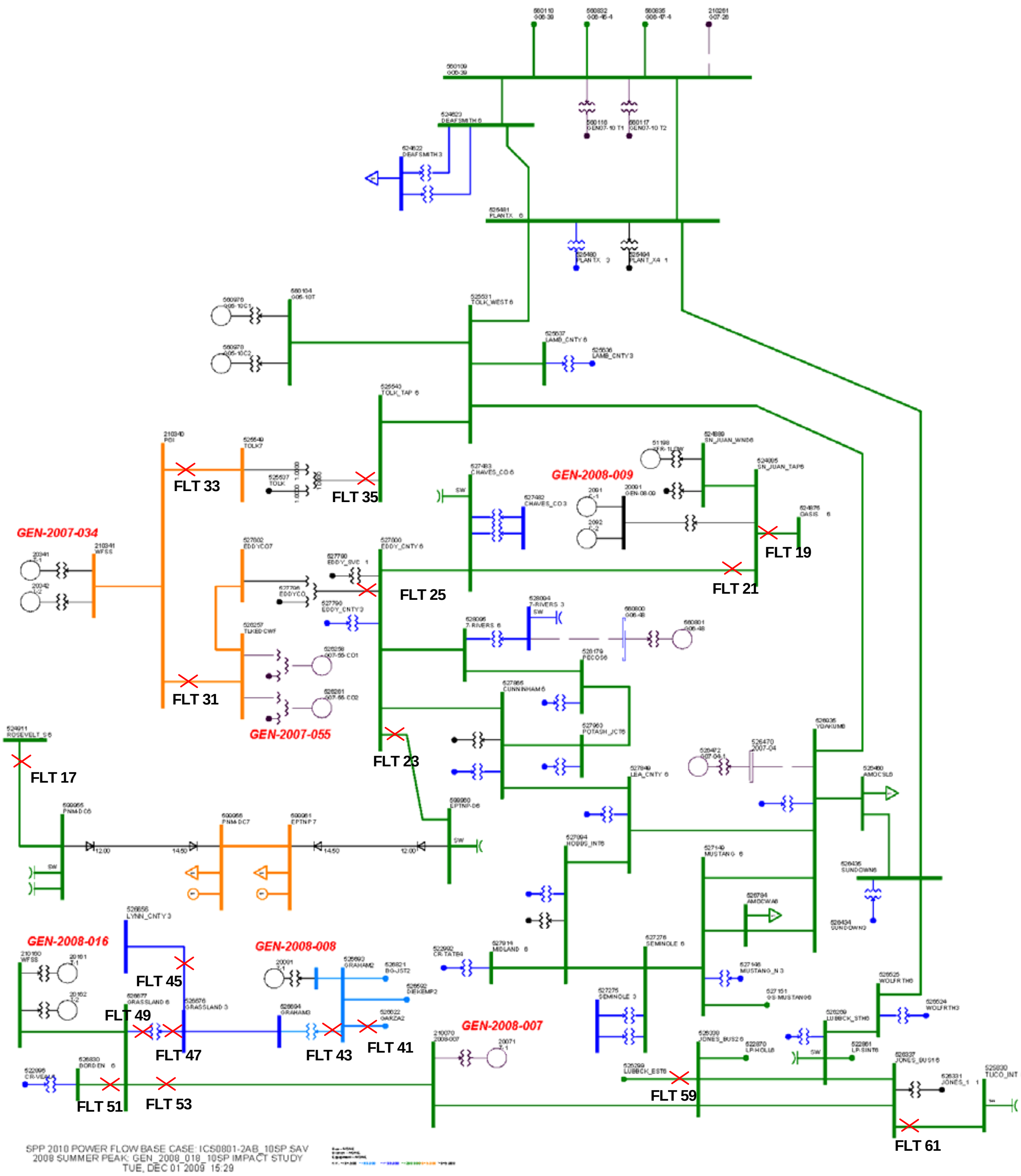


Figure 3-2 – Fault Locations in the Study Area – *Diagram2*



Section
4

Analysis Performed

4.1 Steady State Performance

Table 4-1 and Table 4-2 summarize the results obtained from the steady state analysis for summer peak and winter peak base cases, respectively. The tables list the voltage deviations at the points of interconnection of the proposed study projects of Group 6, as well as the prior queued projects. Note that only the contingencies that cause a voltage criterion violation and / or have an impact of at least 1% in the POI's voltages are listed.

The complete set of results for both summer peak and winter peak scenarios are presented in Appendix C.

Table 4-1: Results Obtained – Steady State Analysis – Summer Peak

Bus #	Bus Name	Base kV	Contingency Voltage	Base Voltage	% Deviation
Base Case					
210270	GEN_2007_027	115.0	-	1.0130	-
210340	POI	345.0	-	1.0410	-
524885	SN_JUAN_TAP6	230.0	-	1.0129	-
525524	TOLK_EAST 6	230.0	-	1.0200	-
526677	GRASSLAND 6	230.0	-	0.9966	-
526693	GRAHAM2	69.0	-	1.0130	-
560813	G05-15	345.0	-	1.0330	-
FLT 19					
524885	SN_JUAN_TAP6	230.0	0.9755	1.0129	-3.69
FLT 21					
524502	NORTON	115	1.0059	1.0258	-1.94
524885	SN_JUAN_TAP6	230.0	0.9674	1.0129	-4.49
FLT 25					
210340	POI	345.0	1.0684	1.0410	2.63
FLT 35					
210340	POI	345.0	1.0735	1.0410	3.12
FLT 53					
526677	GRASSLAND 6	230.0	0.9300	0.9966	-6.68
526693	GRAHAM2	69.0	0.9902	1.0130	-2.25

Bus #	Bus Name	Base kV	Contingency Voltage	Base Voltage	% Deviation
FLT 65					
560813	G05-15	345.0	1.0551	1.0330	2.14
FLT 71					
560813	G05-15	345.0	0.9877	1.0330	-4.39

Table 4-2: Results Obtained – Steady State Analysis – Winter Peak Base Case

Bus#	Bus Name	kV	Contingency Voltage	Base Voltage	% Deviation
Base Case					
210270	GEN_2007_027	115.0	-	1.0216	-
210340	POI	345.0	-	1.0373	-
524885	SN_JUAN_TAP6	230.0	-	1.0085	-
525524	TOLK_EAST 6	230.0	-	1.0200	-
526677	GRASSLAND 6	230.0	-	0.9990	-
526693	GRAHAM2	69.0	-	1.0084	-
560813	G05-15	345.0	-	1.0134	-
FLT 19					
524885	SN_JUAN_TAP6	230.0	0.9536	1.0085	-5.44
FLT 21					
524502	NORTON	115	1.007	1.0276	-2.00
524885	SN_JUAN_TAP6	230.0	0.9671	1.0085	-4.11
FLT 25					
210340	POI	345.0	1.0684	1.0373	3.00
FLT 27					
210340	POI	345.0	1.0522	1.0373	1.44
FLT 35					
210340	POI	345.0	1.0634	1.0373	2.52
FLT 41					
526693	GRAHAM2	69.0	0.9970	1.0084	-1.13
FLT 53					
526677	GRASSLAND 6	230.0	0.9594	0.9990	-3.96
526693	GRAHAM2	69.0	0.9934	1.0084	-1.49
FLT 65					
560813	G05-15	345.0	1.0579	1.0134	4.39
FLT 67					
560813	G05-15	345.0	1.0522	1.0134	3.83
FLT 71					
560813	G05-15	345.0	0.9670	1.0134	-4.58
FLT 77					
560813	G05-15	345.0	0.9980	1.0134	-1.52

In both scenarios, summer and winter peak, some contingencies cause voltage rise or drop equal to or greater than 0.01 p.u. the main findings of the steady state analysis is given below:

- For both summer peak and winter peak cases, the loss of the three winding 345/230/13 kV transformer at Eddy County Substation (FLT 25) causes POI 345 kV substation (GEN-2007-034) and several other adjacent substations (highlighted in tables 4-1 and 4-2) to show high voltage violations. This is mainly because under this outage, the lines from EddyCo7 to TLKED CWF 345 kV and from TLKED CWF to POI 345 kV substations become radial with no loading whatsoever. The voltage issue can be mitigated by local resources or by tripping the unloaded 345 kV lines.

- A similar situation is found for Contingency FLT 35 that also causes voltage violations at POI 345 kV substation (GEN-2007-034) and several other adjacent substations for both summer peak and winter peak cases (also highlighted in tables 4-1 and 4-2). The voltage issue can be mitigated by local resources or by tripping the unloaded radial line between POI and Tolk7 345 kV substations.

- Contingency FLT 51 causes a low voltage violation at Borden 6 230 kV substation due to the outage of the Borden to Grassland 6 230 kV line for both summer and winter peak cases. However this contingency does not cause any violations at any of the Project POI's. As such this violation is not considered significant to this study.

- For both summer and winter peak cases, contingency FLT 65 causes GO5-15 345 kV substation (GEN-2008-014) and several other adjacent substations (highlighted in tables 4-1 and 4-2) to show high voltage violations due to the outage of the three winding 345/230/13 kV transformer in Tuco substation. By switching out the shunt capacitors at GEN-2008-014 and Gen-2008-015 projects, the high voltage issues can be mitigated.

- Contingency FLT 67 causes similar voltage violations to FLT 65 in the winter peak case only and can be resolved using the same method described in the paragraph above.

- In both generation scenarios, contingencies FLT 53 and FLT 71 cause low voltage violations to occur at Grassland 6 230 kV (GEN-2008-16) and O.K.U.-7 345 kV substations respectively. The low voltage issues can be resolved using the new project's reactive capabilities.

4.2 Power Factor Analysis

A QV analysis was performed to determine the amount of reactive support required to maintain the scheduled voltages at the points of interconnection of each one of the proposed wind facilities. The contingencies described in Table 3-2 were evaluated in steady state conditions for summer and winter peak base cases, with variable Mvar injection at the POI's.

Table 4-3 presents for each one of the proposed wind facilities in Group 6, the Mvar requirements and the associated power factor that the projects must be able to provide under contingencies.

Table 4-3: Mvar Requirements and Power Factor at the POI for the Proposed Projects Interconnection

Project	Point of Interconnection	V Scheduled (p.u)	Mvar Requirements at POI (Mvar)	Contingency	Power Factor POI (lagging)
GEN-2007-034	Tolk-Eddy County 345 kV (210340)	1.041	23	FLT 29	0.988
GEN-2008-008	Graham 69 kV (526693)	1.013	8	FLT 53	0.991
GEN-2008-009	San Juan Mesa 230 kV (524885)	1.000	25	FLT 21	0.923
GEN-2008-014	Tuco - Oklaunion 345 kV (560813)	1.000	54	FLT 71	0.941
GEN-2008-016	Grassland 230 kV (526677)	0.996	52	FLT 53	0.979

In order to control the POI voltages at 1.013 p.u the maximum amount of Mvar required for GEN-2008-009 is 33 Mvar, while 106 Mvar is required for Gen-2008-014. However, these requirements could be reduced to 54 and 25 Mvar if each respective POI could be operated at a voltage of 1.0 p.u. during contingency as oppose to scheduled voltage of 1.013 p.u.. The results shown in the Table 4-3 are based on this assumption.

QV Tables showing the injected Mvar for each voltage level in base case and contingencies are presented in Appendix D for both summer peak and winter peak scenarios. The values chosen are the highest between the two scenarios.

4.3 Stability Results

The stability analysis was carried out using both summer peak and winter peak load flow models.

In order to determine the impact of the project on the overall system dynamics as well as to determine the requirements to meet the FERC Order 661-A Guidelines, 54 contingencies listed by Table 3-2 were simulated.

As some WTGs do not have capacity to provide transient reactive support, shunt capacitors were added to some projects, at the 34.5 kV collector buses close to the POIs. These were added not to control the post contingency voltages, but to provide minimum reactive support to prevent LVRT issues.

Table 4-4 presents the shunt compensation added for each proposed wind project.

Table 4-4: Shunt Compensation Added to the Projects

Project	Point of Interconnection	Requirements
GEN-2007-034	Tolk – Eddy County 345 kV	-
GEN-2008-008	Graham 69 kV	-
GEN-2008-009	San Juan Mesa 230 kV	10 Mvar at 34.5 kV
GEN-2008-014	Tuco – Oklaunion 345 kV	20 Mvar at 34.5 kV
GEN-2008-016	Grassland 230 kV	40 Mvar at 34.5 kV

It is important to note that the reactive compensation added are merely indicative and is enclosed within the maximum amount presented by Table 4-3. For complete reactive support requirement, Table 4-3 is the reference that must be achieved using the wind turbine generator (WTG) capabilities and/or adding shunt compensation to the system.

The stability simulation results are summarized as follows:

Initial testing of contingencies FLT 49, FLT 51, FLT 53, FLT 54, FLT 59 and FLT 61 for both summer peak and winter peak cases, caused numerical errors (not caused by the projects) when changing from one dynamic state to another. This caused PSS®E to cease solving each of the contingencies in question. The issue was resolved by changing the solution parameters from 60 iterations to 150 and the acceleration factor from 0.5 to 0.4. It is important to note that with the modified solution parameters there is no adverse impact to the accuracy of the results.

Tables 4-5 and 4-6 summarize the results obtained from the stability simulations for summer and winter peak base cases. Note that only the critical contingencies that lead to trips due to LVRT or loss of synchronism are listed.

Table 4-5: Results Obtained – Summer Peak Base Case

Name	Wind Projects Dynamic Performance
FLT43-3PH	GEN-2008-008 (1081) tripped for over frequency
FLT44-1PH	GEN-2008-008 (1081) tripped for over frequency

Table 4-6: Results Obtained – Winter Peak Base Case

Name	Wind Projects Dynamic Performance
FLT35-3PH	GEN-2005-010 (560977) tripped for low voltage at 0.6083 s
	GEN-2005-010 (560979) tripped for low voltage at 0.6083 s
FLT37-3PH	GEN-2005-010 (560977) tripped for low voltage at 0.6083 s
	GEN-2005-010 (560979) tripped for low voltage at 0.6083 s
FLT43-3PH	GEN-2008-008 (1081) tripped for over frequency at 0.7417s
FLT44-1PH	GEN-2008-008 (1081) tripped for over frequency at 0.7542 s

Gen-2005-010 project trips due to low voltage protection for FLT 35 and 37 in the winter peak scenario. It is important to note that the trips occur during the fault clearing. Since it is a prior queued project, no solutions will be attempted to mitigate the issue.

For both summer and winter peak scenarios, outage of the 115/69 kV transformer at Graham substation (FLT 43 and FLT 44) isolates Gen-2008-008 wind project from the bulk system such that they trip due to over frequency protection for both 3PH and SLG type faults.

Besides the issues described above, the results obtained show:

- The new proposed projects, did not trip during any of the contingencies tested, that is, no trips occurred due to LVRT or frequency protection.
- Furthermore, trips were not identified in the prior queued wind projects.
- All synchronous generators in the monitored areas were stable and remained in synchronism during all contingencies and the system conditions considered.
- Acceptable damping and voltage recovery was observed, within applicable standards.

Additional plots of selected system variables documenting the stability simulations are included in Appendix E.

Section

5

Conclusions

The five projects of ICS-2008-001 Group 6 have been evaluated to determine the system requirements to meet the FERC Order 661-A Guidelines for Low Voltage Ride Through (LVRT) and therefore, for them to deliver their full power to the SPP transmission system.

Steady state and stability analysis were carried out to evaluate the system performance under contingencies. In general, the Group 6 interconnection requests have more than 1% impact on the voltage profile of the monitored system, under contingencies. No major voltage criteria violations were identified through the simulations performed, although significant voltage deviations were identified:

- FLT 19: 5.5 % in San Juan Tap 230 kV (winter peak)
- FLT 21: 4.5% in San Juan Tap 230 kV (summer peak)
- FLT 35: 3.0% in POI (210340) 345 kV (summer peak)
- FLT 53: 6.7% in Grassland 230 kV (summer peak)
- FLT 65: 4.4% in G05-15 345 kV (winter peak)

The power factor analysis determined the amount of reactive support required to maintain the scheduled voltages at each one of the points of interconnection. The amount of reactive support indicated by Table 4-3 must be provided by each interconnection request using the wind turbine generator (WTG) reactive capabilities and/or adding capacitor banks to the system.

The stability results indicate that none of the Group 6 projects trip during the contingencies tested, that is, no trips occurred due to LVRT or frequency protection. Moreover, the new interconnection requests have no adverse impact on the stability of the SPP system, for system conditions tested.

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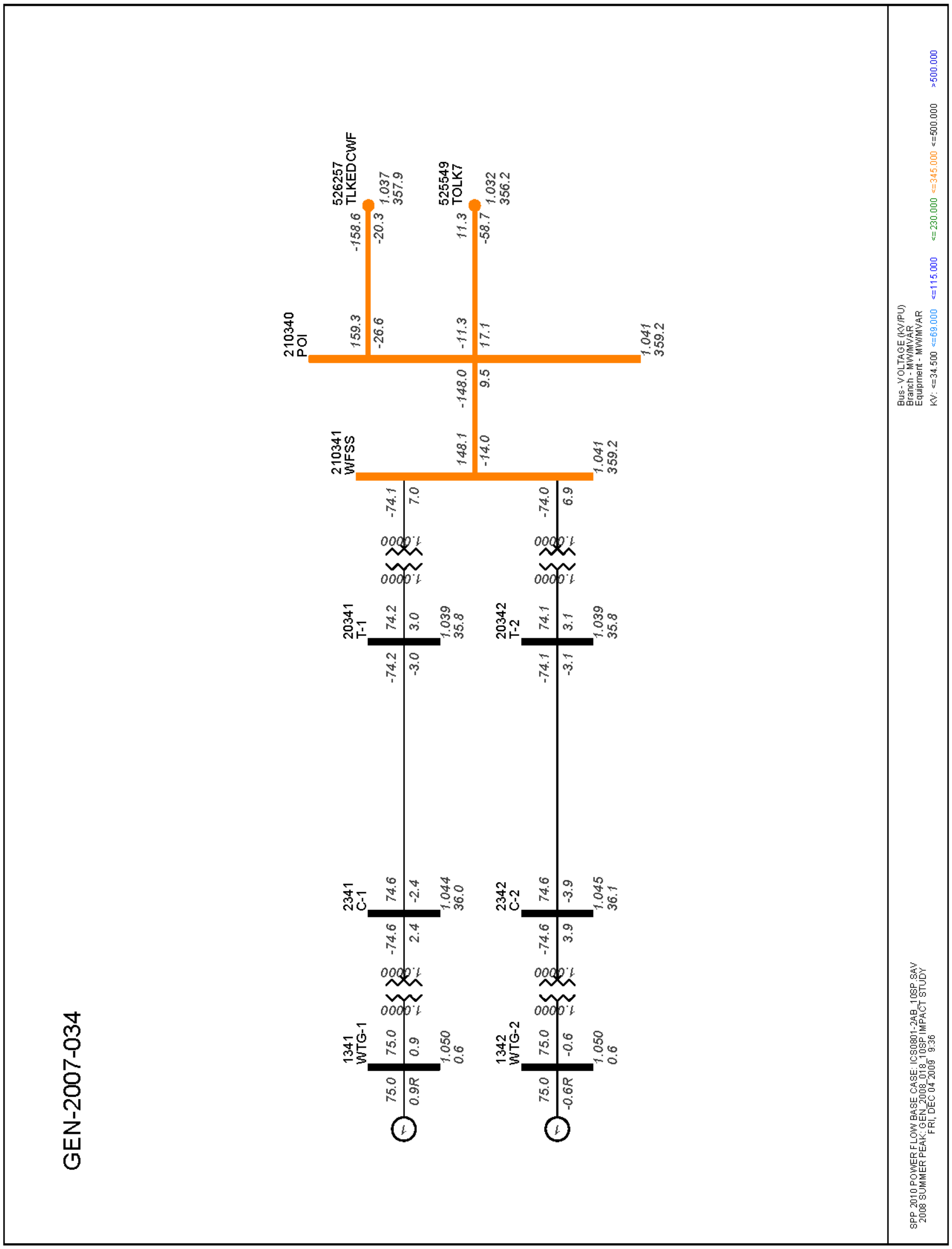
Appendix

A

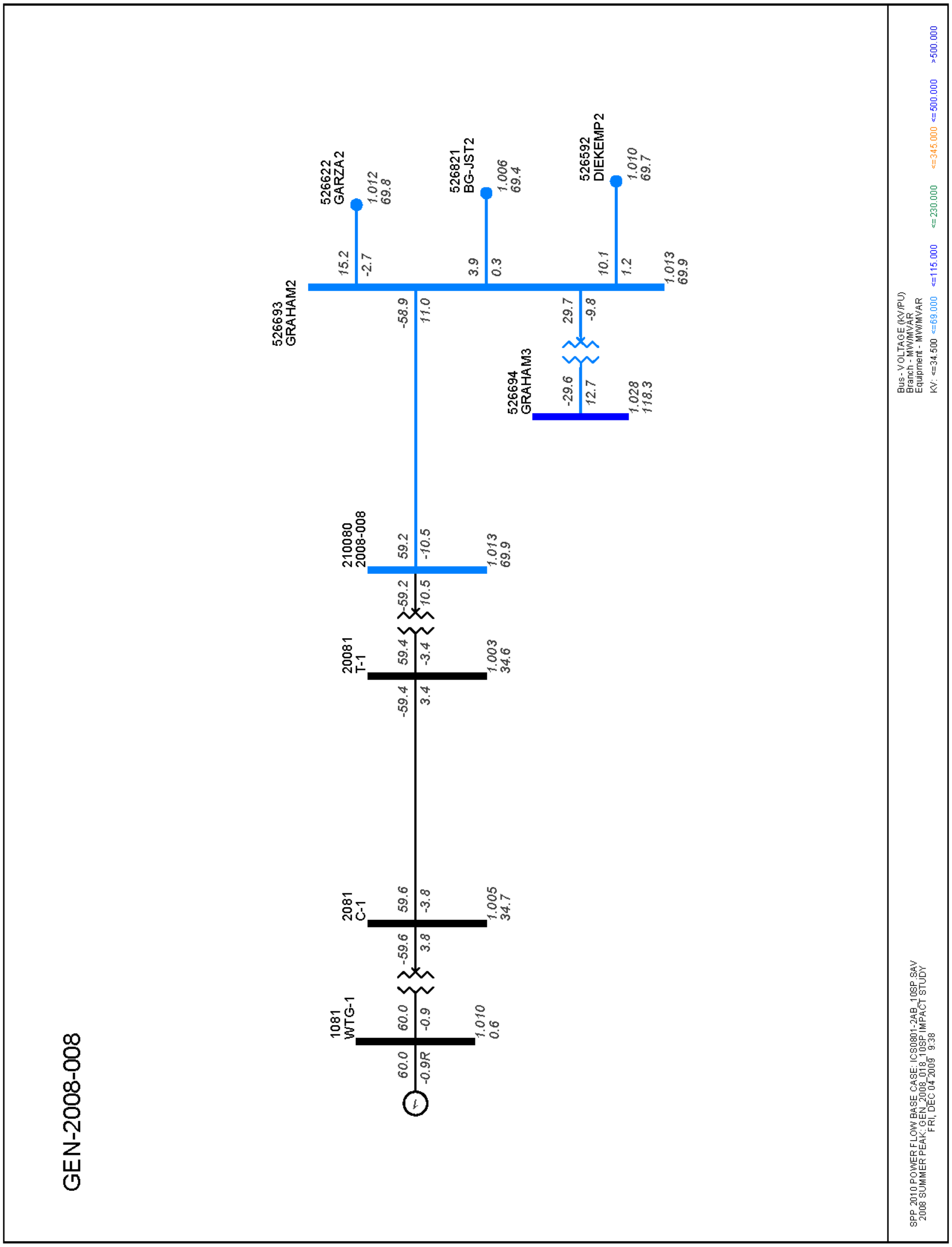
WTG Single Line Diagrams

This appendix contains the single line diagrams, showing the modeling details of each remaining Group 6 wind generation projects.

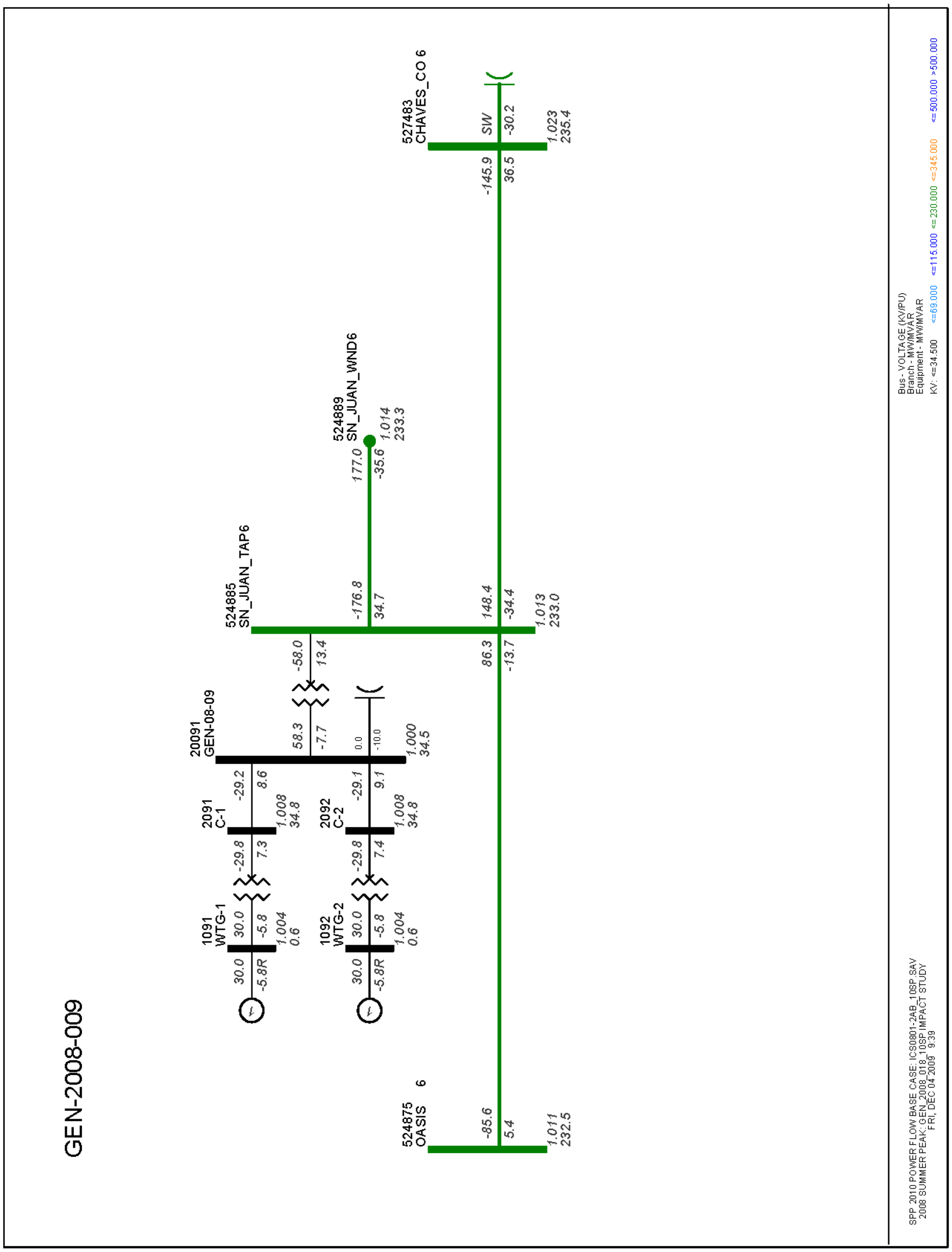
A.1 Gen-2007-034



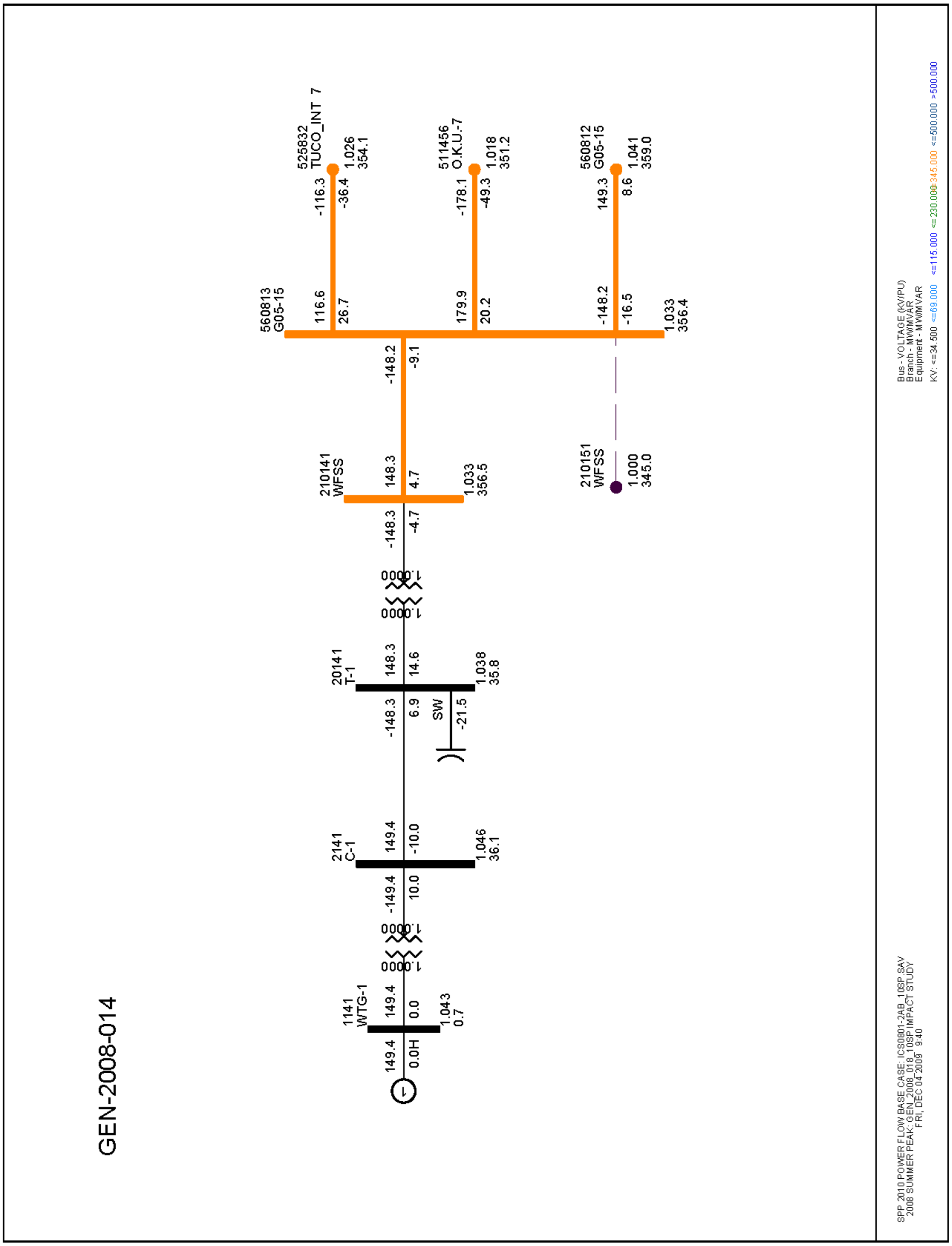
A.2 Gen-2008-008



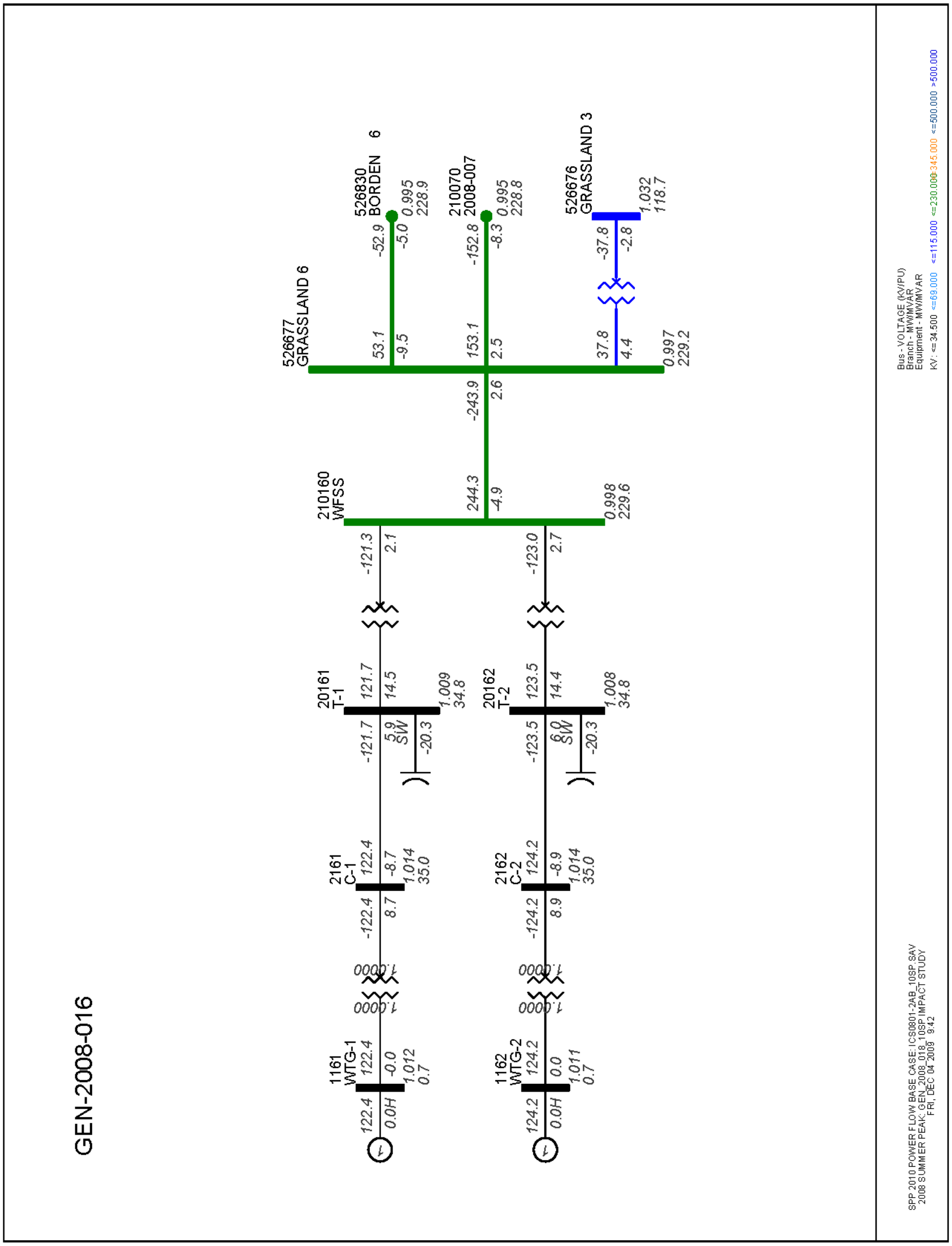
A.3 Gen-2008-009



A.4 Gen-2008-014



A.5 Gen-2008-016



Appendix

B

WTG Dynamic Models Documentation

This appendix shows the model data used to represent the turbines in the simulations for the Summer Peak case.

Appendix

C

Steady State Results

This Appendix shows the voltage analysis results. The voltages at each he POI were monitored for any deviations from the base case voltage and the percentage voltage deviations were documented.

Appendix

D

QV Tables – Power Factor Analysis

This appendix shows tables presenting the injected Mvar for each voltage level in base case and contingencies for both summer peak and winter peak scenarios.

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Appendix

E

Stability Results

The plots of the evaluated contingencies are shown in this appendix. There are 4 plots for each interconnection request, which may include some of the following channels:

- Bus Voltages.
- Speed Deviation.
- Synchronous Machine Rotor Angles.
- Electric Power of the Proposed WTGs (in Per Unit on 100 MVA Base)

E.1 Summer Peak Stability Results

E.2 Winter Peak Stability Results

P: Stability Study for Group 7

SPP Cluster #1 Group #7 Impact Study

Restudy

Report for

Southwest Power Pool

Prepared by:

Excel Engineering, Inc.

November 3, 2009

Principal Contributor:

William Quaintance, P.E.

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0. Certification

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the Laws of the State of **Arkansas**.

William Quaintance
Arkansas Registration Number 13865

1. Background and Scope

The Cluster #1 Group #7 Impact Study Restudy is a generation interconnection study performed by Excel Engineering, Inc. for its non-affiliated client, Southwest Power Pool (SPP). Its purpose is to study the impacts of interconnecting each of the three projects shown in Table 1-1. The in-service date assumed for the generation addition was 2010.

After the first Cluster #1 Impact Studies were completed, a number of projects dropped out of the SPP interconnection queue. This change resulted in a scaling back of the needed transmission upgrades for Cluster #1. Because of the canceled projects and transmission changes, all Cluster #1 Impact Studies were repeated, including Group 7 described in this report.

Table 1-1. Interconnection Requests to be Evaluated

Request	Size	Wind Turbine Model	Point of Interconnection
GEN-2007-032	150	Acciona 1.5MW	Clinton Jct. – Clinton 138kV (560939)
GEN-2007-043	300	G.E. 1.5MW	Cimarron – Anadarko 345kV (210431)
GEN-2007-052	150	Gas Turbine	Anadarko 138kV (520814)

The previously-queued requests shown in Table 1-2 were included in this study.

Table 1-2. Nearby Interconnection Requests Already in the Queue

Request	Size	Wind Turbine Model	Point of Interconnection
Blue Canyon I	74	CIMTR	Washita 138kV (521089)
Blue Canyon II (GEN-2003-004)	151	Vestas V80	Washita 138kV (521089)
Weatherford	147	G.E. 1.5MW	Weatherford 138kV (511506)
GEN-2003-005	100	G.E. 1.5MW	Anadarko – Paradise 138kV (560916)
GEN-2006-002	150	Gamesa	Beckham County 230kV (560014)
GEN-2006-035	224	Gamesa	Beckham County 230kV (560014)
GEN-2006-043	99	G.E. 1.5MW	Beckham County 230kV (560014)

The study included a stability analysis for each proposed 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 disabled. Since two of the interconnection requests in this group were wind projects, a power factor analysis was performed.

ATC (Available Transfer Capability) studies were not performed as part of this study. These studies will be required at the time transmission service is actually requested. Additional transmission upgrades may be required based on that analysis.

Study assumptions in general have been based on Excel's knowledge of the electric power system and on the specific information and data provided by SPP. The accuracy of the conclusions contained within this study is sensitive to the assumptions made with respect to other generation additions and transmission improvements being contemplated by other entities. Changes in the assumptions of the timing of other generation additions or transmission improvements will affect this study's conclusions.

2. Executive Summary

The Cluster #1 Group 7 Impact Study Restudy evaluated the impacts of interconnecting projects GEN-2007-032, GEN-2007-043, and GEN-2007-052. No stability problems were found during summer or winter peak conditions after the addition of these plants.

Power factor requirements were determined for the wind plants GEN-2007-032 and GEN-2007-043, and both of these plants must install sufficient reactive power resources to meet the requirements listed in Table 4-2. Because no stability problems were found, the reactive power resources need not be high speed or continuously controlled. However, any change in wind turbine model or controls could change the stability results, possibly resulting in a need for a high-speed reactive power supply. GEN-2007-052 will be a combustion turbine with synchronous generators, and the standard power factor requirement is 0.95 leading to 0.95 lagging at the POI.

The prior-queued GEN-2003-004 plant showed a couple of known issues with its Vestas V80 wind turbines that are not caused by the proposed study plants. GEN-2003-004 has poor damping in its generator speed following most faults, but this oscillation does not affect the transmission grid (P, Q, or V). For one of the faults close to GEN-2003-004, the machines go into high frequency oscillations caused by poor operation of its voltage/var control. It is not known if these are problems only with the PSS/E model or problems with the actual Vestas V80 wind turbines. Either way, they are previously known and not caused by the new projects. If the Blue Canyon I wind turbines are tripped for these faults, as they are expected to, the high frequency oscillations go away.

With the assumptions described in this report, the Cluster #1 Group 7 projects should be able to connect without causing any stability problems on the SPP transmission grid.

3. Study Development and Assumptions

3.1 Simulation Tools

The Siemens Power Technologies, Inc. PSS/E digital computer power flow simulation program Version 30.3.3 was used in this study.

3.2 Models Used

SPP provided its latest stability database cases for both summer and winter peak seasons. The power flow cases from the previous Group 7 study were updated by removing cancelled projects and adjusting transmission plans accordingly. Each plant's PSS/E model had been developed prior to this study and was included in the power flow case and the dynamics database. As a result, no additional generator modeling was required. Power flow one-line diagrams of the study projects are shown in Figure 3-1, Figure 3-2, and Figure 3-3. As the figures show, each wind farm model includes explicit representation of the radial transmission line, if any; the substation transformer(s) from transmission voltage to 34.5 kV; and the substation reactive power device(s), if any. The remainder of each wind farm is represented by one or more lumped equivalents including a generator, a step-up transformer, and a collector system impedance. Project GEN-2007-052 is a gas turbine plant with explicit representation of each of the three generators and transformers.

No special modeling is required of line relays in these cases, except for the special modeling related to the wind-turbine tripping.

Figure 3-4 and Figure 3-5 show the locations these projects on the transmission system. The green ellipses indicate the study projects points of interconnection (POI), and the yellow ellipses indicate the prior-queued project POIs. The red X's indicate the fault locations examined in this study. Orange transmission lines are nominally 345 kV, blue lines are 230 kV, and black lines are 138 kV.

3.3 Monitored Facilities

All generators in Areas 520, 524, 525, 526, 531, 534, and 536 were monitored.

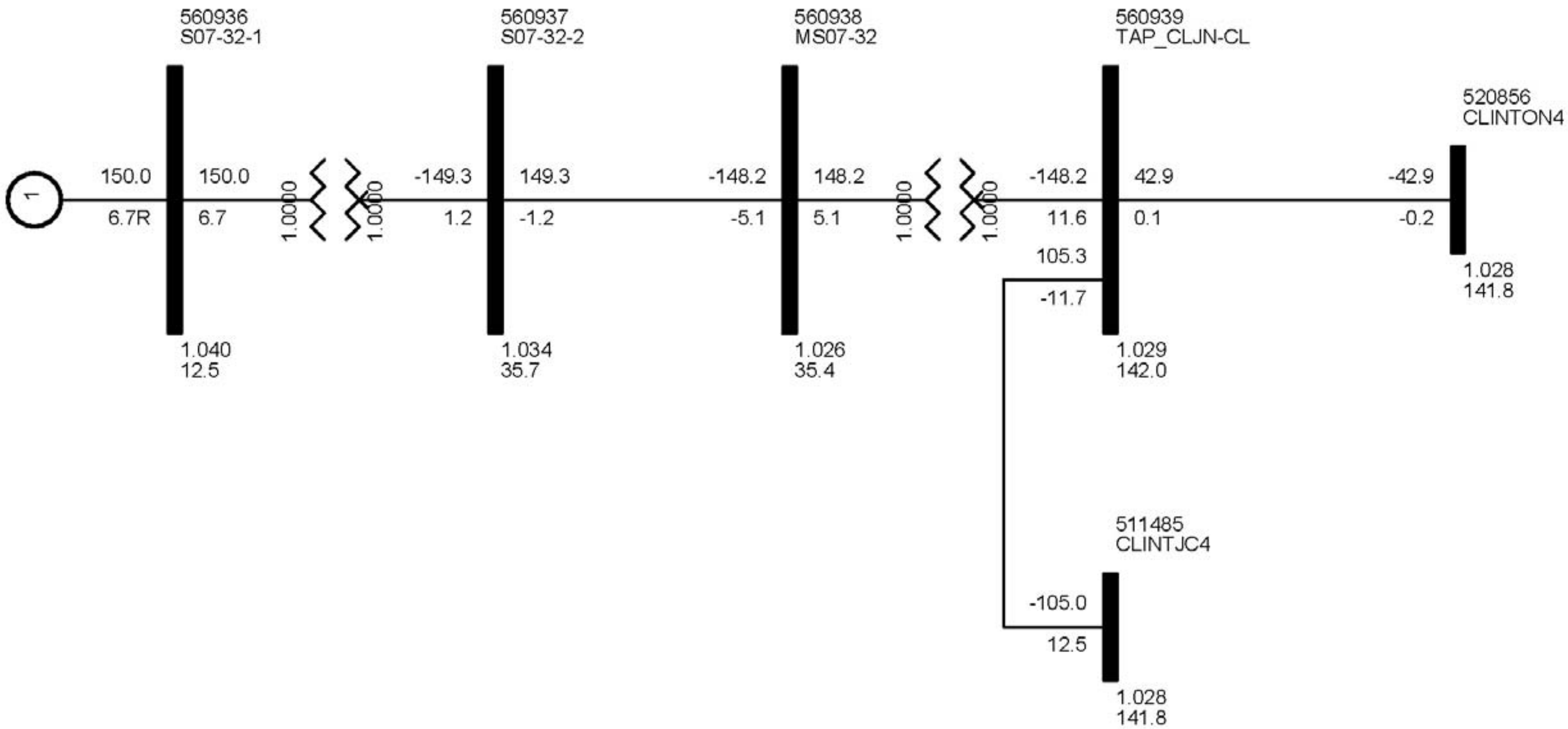

Figure 3-1. Power Flow One-line for GEN-2007-032

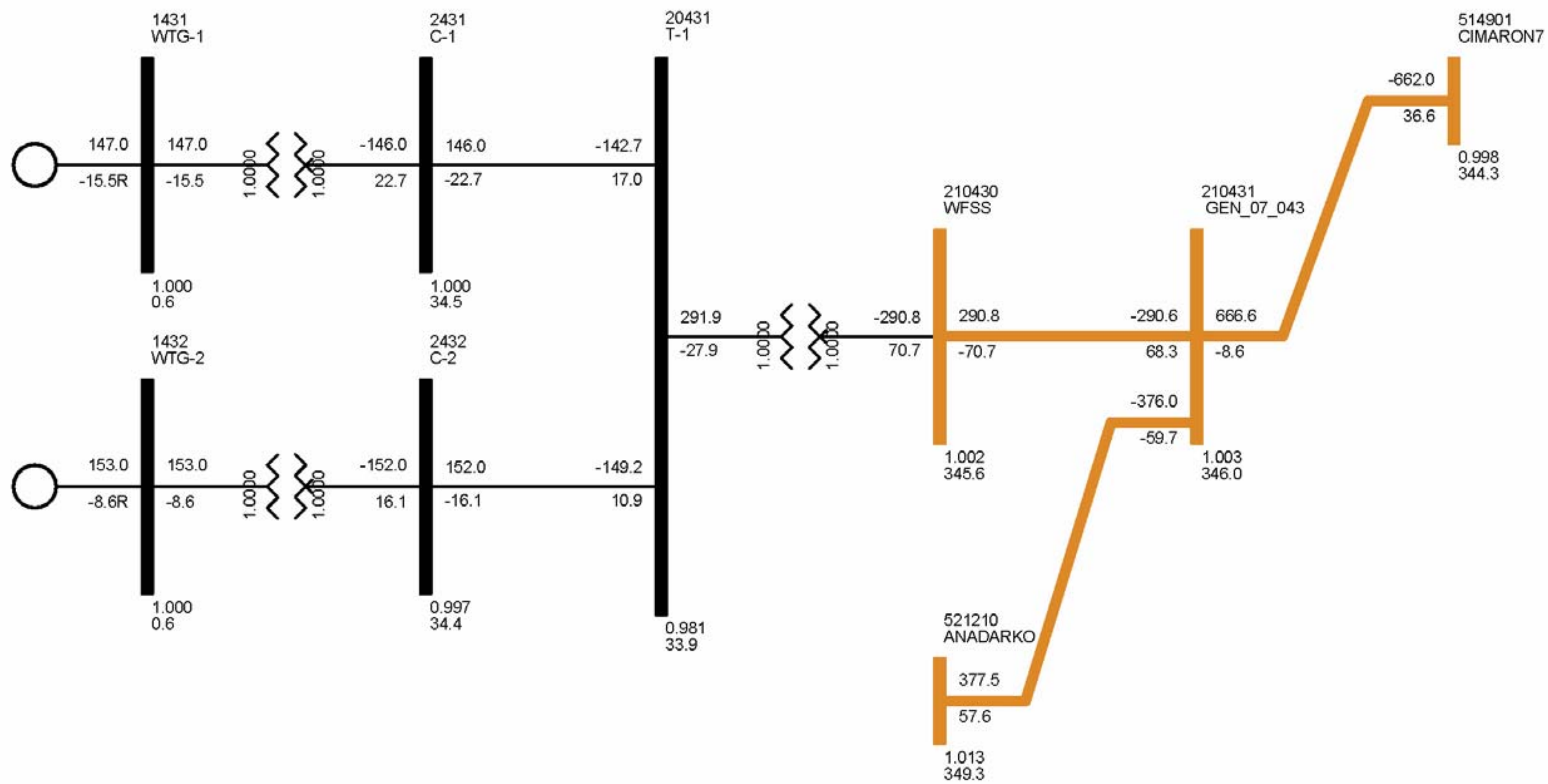

Figure 3-2. Power Flow One-line for GEN-2007-043

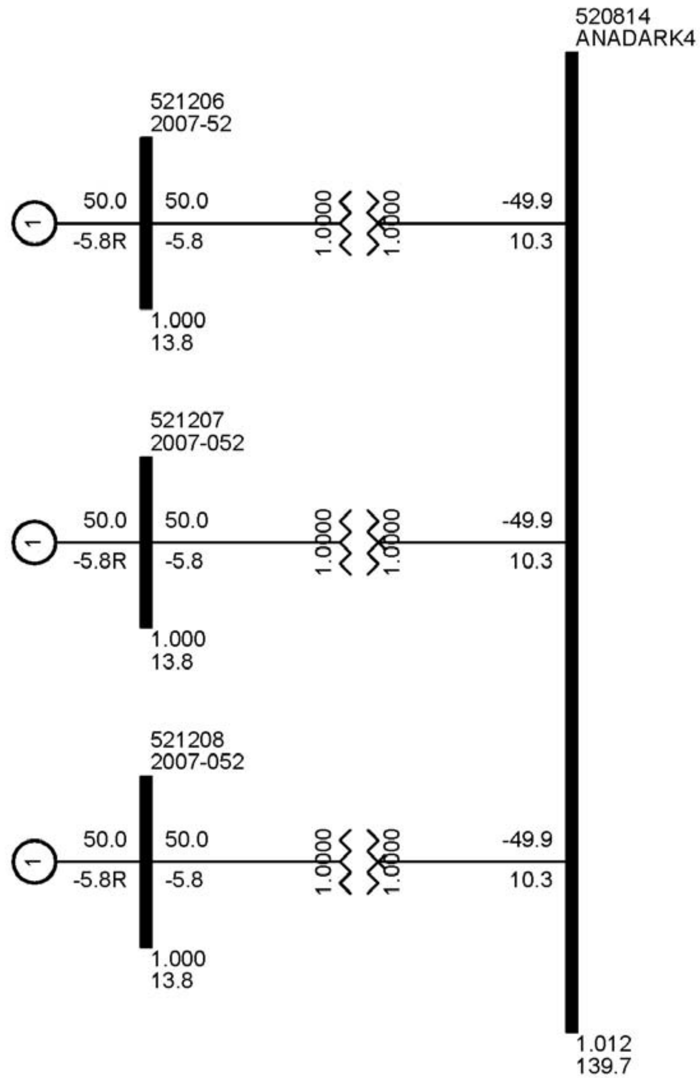

Figure 3-3. Power Flow One-line for GEN-2007-052

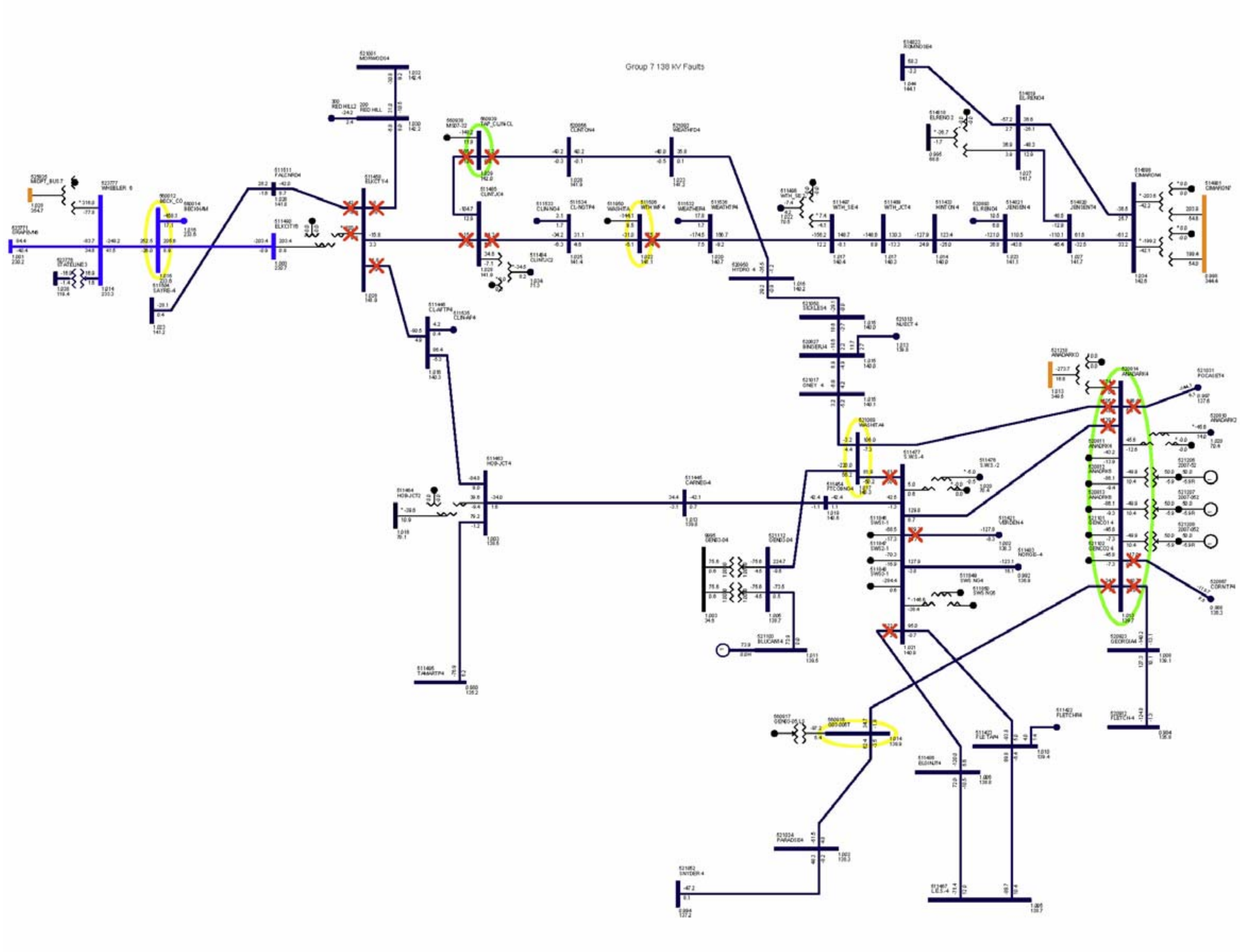

Figure 3-4. SPP 138 kV Transmission System with Group 7 Projects

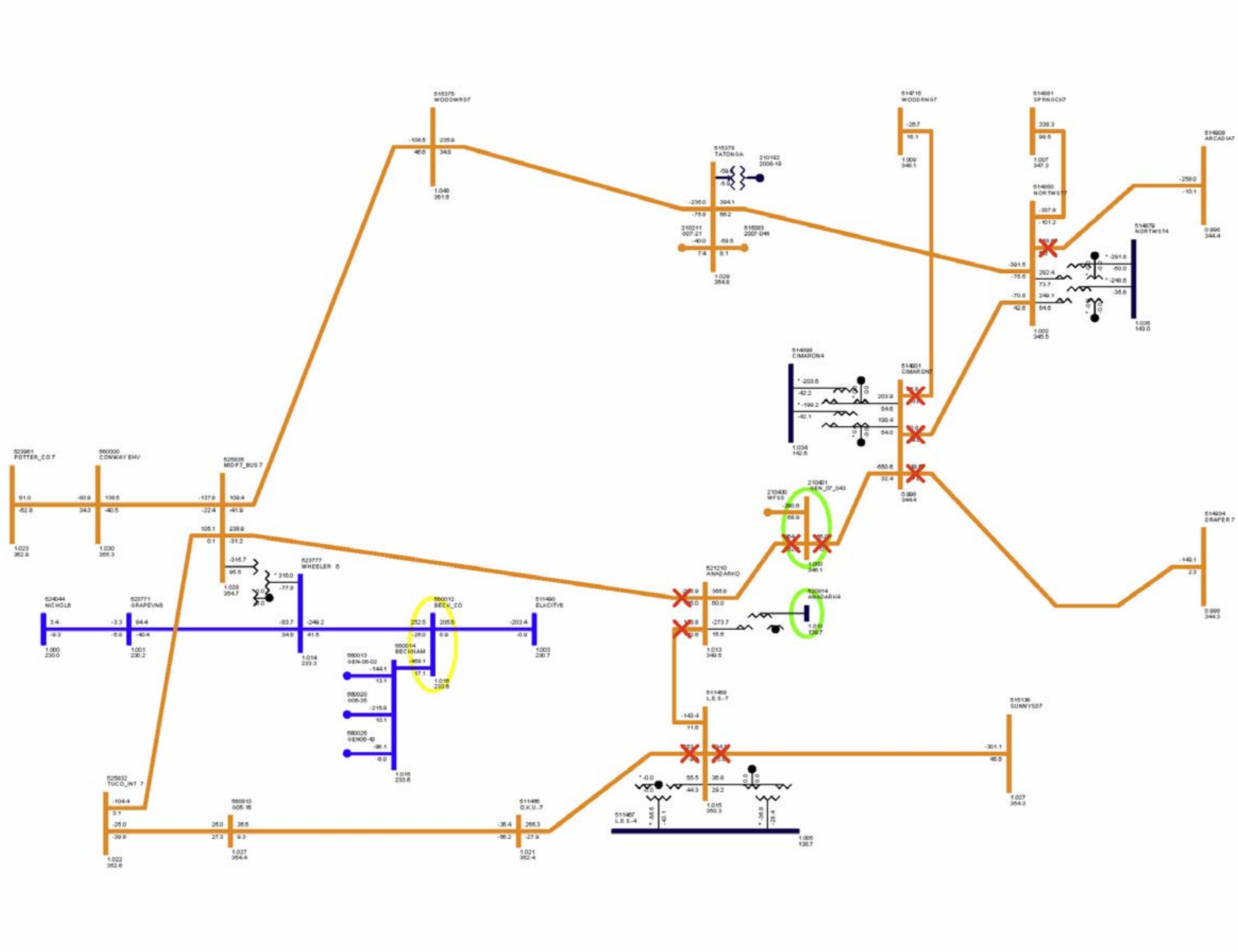

Figure 3-5. SPP 230 and 345 kV Transmission System with Group 7 Projects

3.4 Performance Criteria

The wind generators must comply with the FERC Order 661A on low voltage ride through for wind farms. Therefore, the wind generators should not trip off line for faults for under voltage relay actuation. If a wind generator trips off line, an appropriately sized SVC or STATCOM device may need to be specified to keep the wind generator on-line for the fault. SPP was consulted to determine if the addition of an SVC or STATCOM is warranted for the specific condition.

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 disabled to check for stability issues.

3.5 Performance Evaluation Methods

Since two of the interconnection requests are wind projects, a power factor analysis was performed. The power factor analysis consisted of modeling a var generator in the wind farm holding a voltage schedule at the POI. The voltage schedule was set equal to the higher of the voltage with the wind farm off-line or 1.0 per unit (p.u.) voltage.

If the required power factor at the POI is beyond the capability of the studied wind turbines, then capacitor banks would be considered. Factors used in sizing capacitor banks would include two requirements of FERC Order 661A: the ability of the wind farm to ride through low voltage with and without capacitor banks and the ability of the wind farm to recover to pre-fault voltage. If a wind generator trips on high voltage, a leading power factor may be required.

ATC studies were not performed as part of this study. These studies will be required at the time transmission service is actually requested. Additional transmission facilities may be required based on subsequent ATC analysis.

Stability analysis was performed for each proposed interconnection request. Faults were simulated on transmission lines at the POIs and on other nearby transmission equipment. The faults in Table 3-1 were run for each case (three phase and single phase as noted). The fault numbers from the previous Group 7 study were maintained for consistency. Faults no longer applicable were removed, and new faults were added at the end as necessary.

Table 3-1. Fault Definitions for Group 7

Cont. No.	Contingency Name	Description
1	FLT01-3PH	3 phase fault on the GEN-2007-043 (210431) to Cimarron (514901) 345kV line, near GEN-2007-043. a. Apply fault at the GEN-2007-043 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.
2	FLT02-1PH	*Single phase fault and sequence like previous*
3	FLT03-3PH	3 phase fault on the GEN-2007-043 (210431) to Anadarko (521210) 345kV line, near GEN-2007-043. a. Apply fault at the GEN-2007-043 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.
4	FLT04-1PH	*Single phase fault and sequence like previous*
5	FLT05-3PH	3 phase fault on the Cimarron (514901) to Draper (514934) 345kV line, near Cimarron. a. Apply fault at the Cimarron 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.
6	FLT06-1PH	*Single phase fault and sequence like previous*
7	FLT07-3PH	3 phase fault on the Cimarron (514901) to Northwest (514880) 345kV line, near Cimarron. a. Apply fault at the Cimarron 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.
8	FLT08-1PH	*Single phase fault and sequence like previous*
9	FLT09-3PH	3 phase fault on the Cimarron (514901) to Woodring (514715) 345kV line, near Cimarron. a. Apply fault at the Cimarron 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.
10	FLT10-1PH	*Single phase fault and sequence like previous*
11	FLT11-3PH	3 phase fault on the Northwest (514880) to Arcadia (514908) 345kV line, near Northwest. a. Apply fault at the Northwest 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.
12	FLT12-1PH	*Single phase fault and sequence like previous*
13	FLT13-3PH	3 phase fault on the Anadarko (521210) to Lawton Eastside (511468) 345kV line, near Anadarko. a. Apply fault at the Anadarko 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	FLT14-1PH	*Single phase fault and sequence like previous*

Cont. No.	Contingency Name	Description
15	FLT15-3PH	3 phase fault on the Anadarko (521210) to Wheeler/Midpoint (525835) 345kV line, near Anadarko. a. Apply fault at the Anadarko 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.
16	FLT16-1PH	*Single phase fault and sequence like previous*
17	FLT17-3PH	3 phase fault on the Lawton Eastside (511468) to Sunnyside (515136) 345kV line, near Lawton Eastside. a. Apply fault at the Lawton Eastside 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.
18	FLT18-1PH	*Single phase fault and sequence like previous*
19	FLT19-3PH	3 phase fault on the Lawton Eastside (511468) to Oklaunion (511456) 345kV line, near Lawton Eastside. a. Apply fault at the Lawton Eastside 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.
20	FLT20-1PH	*Single phase fault and sequence like previous*
21	FLT21-3PH	3 phase fault on the Anadarko (520814) to Pocasset (521031) 138kV line, near Anadarko. a. Apply fault at the Anadarko 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
22	FLT22-1PH	*Single phase fault and sequence like previous*
23	FLT23-3PH	3 phase fault on the Anadarko (520814) to Washita (521089) 138kV line, near Anadarko. a. Apply fault at the Anadarko 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
24	FLT24-1PH	*Single phase fault and sequence like previous*
25	FLT25-3PH	3 phase fault on the Anadarko (520814) to Southwest (511477) 138kV line, near Anadarko. a. Apply fault at the Anadarko 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
26	FLT26-1PH	*Single phase fault and sequence like previous*
27	FLT27-3PH	3 phase fault on the Anadarko (520814) to Cornville Tap (520867) 138kV line, near Anadarko. a. Apply fault at the Anadarko 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
28	FLT28-1PH	*Single phase fault and sequence like previous*

Cont. No.	Contingency Name	Description
29	FLT29-3PH	3 phase fault on the Anadarko (520814) to Georgia St. (520923) 138kV line, near Anadarko. a. Apply fault at the Anadarko 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
30	FLT30-1PH	*Single phase fault and sequence like previous*
31	FLT31-3PH	3 phase fault on the Anadarko (520814) to GEN-2003-005 (560916) 138kV line, near Anadarko. a. Apply fault at the Anadarko 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
32	FLT32-1PH	*Single phase fault and sequence like previous*
33	FLT33-3PH	3 phase fault on the Southwest (511477) to Washita (521089) 138kV line, near Southwest. a. Apply fault at the Southwest 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
34	FLT34-1PH	*Single phase fault and sequence like previous*
35	FLT35-3PH	3 phase fault on the Southwest (511477) to Verden (511421) 138kV line, near Southwest. a. Apply fault at the Southwest 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
36	FLT36-1PH	*Single phase fault and sequence like previous*
37	FLT37-3PH	3 phase fault on the Southwest (511477) to Elgin Jct. (511486) 138kV line, near Southwest. a. Apply fault at the Southwest 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
38	FLT38-1PH	*Single phase fault and sequence like previous*
39	FLT39-3PH	3 phase fault on the GEN-2007-032 (560939) to Clinton (520856) 138kV line, near GEN-2007-032. a. Apply fault at the GEN-2007-032 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
40	FLT40-1PH	*Single phase fault and sequence like previous*
41	FLT41-3PH	3 phase fault on the GEN-2007-032 (560939) to Clinton Jct. (511485) 138kV line, near GEN-2007-032. a. Apply fault at the GEN-2007-032 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
42	FLT42-1PH	*Single phase fault and sequence like previous*

Cont. No.	Contingency Name	Description
43	FLT43-3PH	3 phase fault on the Clinton Jct. (511485) to Clinton NG (511534) 138kV line, near Clinton Jct. a. Apply fault at the Clinton Jct. 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
44	FLT44-1PH	*Single phase fault and sequence like previous*
45	FLT45-3PH	3 phase fault on the Clinton Jct. (511485) to Elk City (511458) 138kV line, near Clinton Jct. a. Apply fault at the Clinton Jct. 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
46	FLT46-1PH	*Single phase fault and sequence like previous*
47	FLT47-3PH	3 phase fault on the Weatherford Wind (511506) to Weatherford Tap (511536) 138kV line, near Weatherford Wind. a. Apply fault at the Weatherford Wind 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
48	FLT48-1PH	*Single phase fault and sequence like previous*
49	FLT49-3PH	3 phase fault on the Elk City (511458) to Red Hill (200) 138kV line, near Elk City. a. Apply fault at the Elk City 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
50	FLT50-1PH	*Single phase fault and sequence like previous*
55	FLT55-3PH	3 phase fault on the Elk City (511458) to Clinton AF (511446) 138kV line, near Elk City. a. Apply fault at the Elk City 138kV bus. b. Clear fault after 5 cycles by tripping the faulted line. c. Wait 20 cycles, and then re-close the line in (b) back into the fault. d. Leave fault on for 5 cycles, then trip the line in (b) and remove fault.
56	FLT56-1PH	*Single phase fault and sequence like previous*
57	FLT57-3PH	3 phase fault on the Elk City 138kV (511458) to 230kV (511490) transformer, near the 138kV bus. a. Apply fault at the Elk City 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
58	FLT58-1PH	*Single phase fault and sequence like previous*
69	FLT69-3PH	3 phase fault on the Anadarko 138kV (520814) to 345kV (521210) transformer, near the 138kV bus. a. Apply fault at the Anadarko 138kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
70	FLT70-1PH	*Single phase fault and sequence like previous*

4. Results and Observations

4.1 Stability Analysis Results

All faults provided by SPP were run for both summer and winter peak conditions. If a previously-queued generator tripped for any of these faults, the voltage and frequency tripping was disabled, and the fault was re-run to check for system stability.

Table 4-1 summarizes the overall results for all faults run. Figure 4-1 through Figure 4-6 show representative summer peak season plots for faults at the POIs of each of the three study projects. Complete sets of plots for both summer and winter peak seasons for each fault and each wind project are included in Appendices A and B.

The system remains stable for all simulated faults. All study projects stay on-line for all simulated faults. No tripping occurred for any fault.

Table 4-1. Summary of Results

Cont. No.	Contingency Name	Contingency Description	Summer Peak Results	Winter Peak Results
1	FLT01-3PH	3 phase fault on the GEN-2007-043 (210431) to Cimarron (514901) 345kV line, near GEN-2007-043.	OK	OK
2	FLT02-1PH	*Single phase fault and sequence like previous*	OK	OK
3	FLT03-3PH	3 phase fault on the GEN-2007-043 (210431) to Anadarko (521210) 345kV line, near GEN-2007-043.	OK	OK
4	FLT04-1PH	*Single phase fault and sequence like previous*	OK	OK
5	FLT05-3PH	3 phase fault on the Cimarron (514901) to Draper (514934) 345kV line, near Cimarron.	OK	OK
6	FLT06-1PH	*Single phase fault and sequence like previous*	OK	OK
7	FLT07-3PH	3 phase fault on the Cimarron (514901) to Northwest (514880) 345kV line, near Cimarron.	OK	OK
8	FLT08-1PH	*Single phase fault and sequence like previous*	OK	OK
9	FLT09-3PH	3 phase fault on the Cimarron (514901) to Woodring (514715) 345kV line, near Cimarron.	OK	OK
10	FLT10-1PH	*Single phase fault and sequence like previous*	OK	OK
11	FLT11-3PH	3 phase fault on the Northwest (514880) to Arcadia (514908) 345kV line, near Northwest.	OK	OK
12	FLT12-1PH	*Single phase fault and sequence like previous*	OK	OK
13	FLT13-3PH	3 phase fault on the Anadarko (521210) to Lawton Eastside (511468) 345kV line, near Anadarko.	OK	OK
14	FLT14-1PH	*Single phase fault and sequence like previous*	OK	OK
15	FLT15-3PH	3 phase fault on the Anadarko (521210) to Wheeler/Midpoint (525835) 345kV line, near Anadarko.	OK	OK
16	FLT16-1PH	*Single phase fault and sequence like previous*	OK	OK

Cont. No.	Contingency Name	Contingency Description	Summer Peak Results	Winter Peak Results
17	FLT17-3PH	3 phase fault on the Lawton Eastside (511468) to Sunnyside (515136) 345kV line, near Lawton Eastside.	OK	OK
18	FLT18-1PH	*Single phase fault and sequence like previous*	OK	OK
19	FLT19-3PH	3 phase fault on the Lawton Eastside (511468) to Oklaunion (511456) 345kV line, near Lawton Eastside.	OK	OK
20	FLT20-1PH	*Single phase fault and sequence like previous*	OK	OK
21	FLT21-3PH	3 phase fault on the Anadarko (520814) to Pocasset (521031) 138kV line, near Anadarko.	OK	OK
22	FLT22-1PH	*Single phase fault and sequence like previous*	OK	OK
23	FLT23-3PH	3 phase fault on the Anadarko (520814) to Washita (521089) 138kV line, near Anadarko.	OK	OK
24	FLT24-1PH	*Single phase fault and sequence like previous*	OK	OK
25	FLT25-3PH	3 phase fault on the Anadarko (520814) to Southwest (511477) 138kV line, near Anadarko.	OK	OK
26	FLT26-1PH	*Single phase fault and sequence like previous*	OK	OK
27	FLT27-3PH	3 phase fault on the Anadarko (520814) to Cornville Tap (520867) 138kV line, near Anadarko.	OK	OK
28	FLT28-1PH	*Single phase fault and sequence like previous*	OK	OK
29	FLT29-3PH	3 phase fault on the Anadarko (520814) to Georgia St. (520923) 138kV line, near Anadarko.	OK	OK
30	FLT30-1PH	*Single phase fault and sequence like previous*	OK	OK
31	FLT31-3PH	3 phase fault on the Anadarko (520814) to GEN-2003-005 (560916) 138kV line, near Anadarko.	OK	OK
32	FLT32-1PH	*Single phase fault and sequence like previous*	OK	OK
33	FLT33-3PH	3 phase fault on the Southwest (511477) to Washita (521089) 138kV line, near Southwest.	OK	OK
34	FLT34-1PH	*Single phase fault and sequence like previous*	OK	OK
35	FLT35-3PH	3 phase fault on the Southwest (511477) to Verden (511421) 138kV line, near Southwest.	OK	OK
36	FLT36-1PH	*Single phase fault and sequence like previous*	OK	OK
37	FLT37-3PH	3 phase fault on the Southwest (511477) to Elgin Jct. (511486) 138kV line, near Southwest.	OK	OK
38	FLT38-1PH	*Single phase fault and sequence like previous*	OK	OK
39	FLT39-3PH	3 phase fault on the GEN-2007-032 (560939) to Clinton (520856) 138kV line, near GEN-2007-032.	OK	OK
40	FLT40-1PH	*Single phase fault and sequence like previous*	OK	OK
41	FLT41-3PH	3 phase fault on the GEN-2007-032 (560939) to Clinton Jct. (511485) 138kV line, near GEN-2007-032.	OK	OK
42	FLT42-1PH	*Single phase fault and sequence like previous*	OK	OK
43	FLT43-3PH	3 phase fault on the Clinton Jct. (511485) to Clinton NG (511534) 138kV line, near Clinton Jct.	OK	OK
44	FLT44-1PH	*Single phase fault and sequence like previous*	OK	OK
45	FLT45-3PH	3 phase fault on the Clinton Jct. (511485) to Elk City (511458) 138kV line, near Clinton Jct.	OK	OK

Cont. No.	Contingency Name	Contingency Description	Summer Peak Results	Winter Peak Results
46	FLT46-1PH	*Single phase fault and sequence like previous*	OK	OK
47	FLT47-3PH	3 phase fault on the Weatherford Wind (511506) to Weatherford Tap (511536) 138kV line, near Weatherford Wind.	OK	OK
48	FLT48-1PH	*Single phase fault and sequence like previous*	OK	OK
49	FLT49-3PH	3 phase fault on the Elk City (511458) to Red Hill (200) 138kV line, near Elk City.	OK	OK
50	FLT50-1PH	*Single phase fault and sequence like previous*	OK	OK
55	FLT55-3PH	3 phase fault on the Elk City (511458) to Clinton AF (511446) 138kV line, near Elk City.	OK	OK
56	FLT56-1PH	*Single phase fault and sequence like previous*	OK	OK
57	FLT57-3PH	3 phase fault on the Elk City 138kV (511458) to 230kV (511490) transformer, near the 138kV bus.	OK	OK
58	FLT58-1PH	*Single phase fault and sequence like previous*	OK	OK
69	FLT69-3PH	3 phase fault on the Anadarko 138kV (520814) to 345kV (521210) transformer, near the 138kV bus.	OK	OK
70	FLT70-1PH	*Single phase fault and sequence like previous*	OK	OK

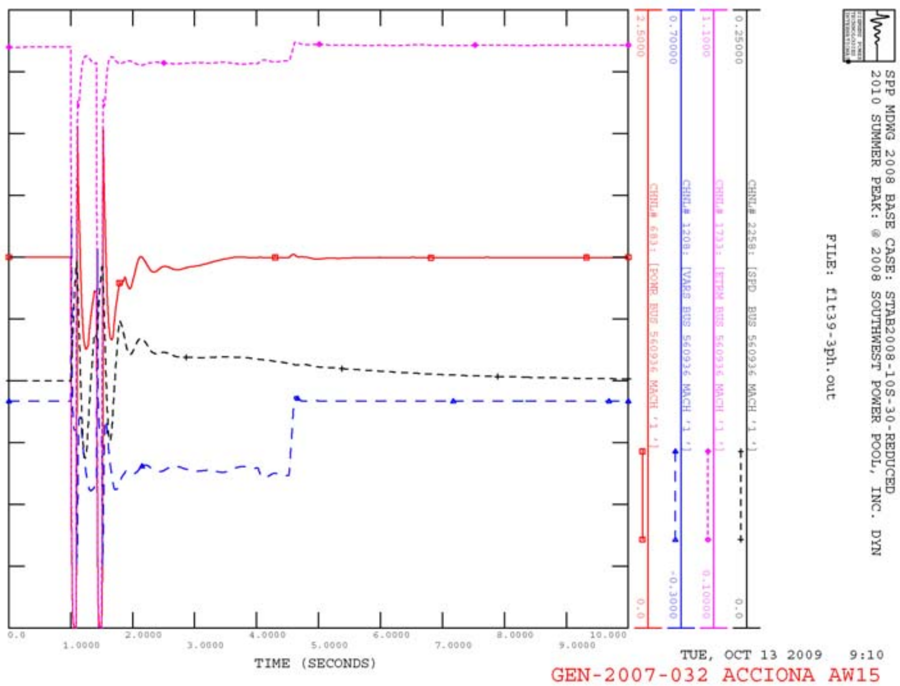

Figure 4-1. GEN-2007-032 Plot for Fault 39 – 3 phase fault on the GEN-2007-032 to Clinton 138kV line, near GEN-2007-032

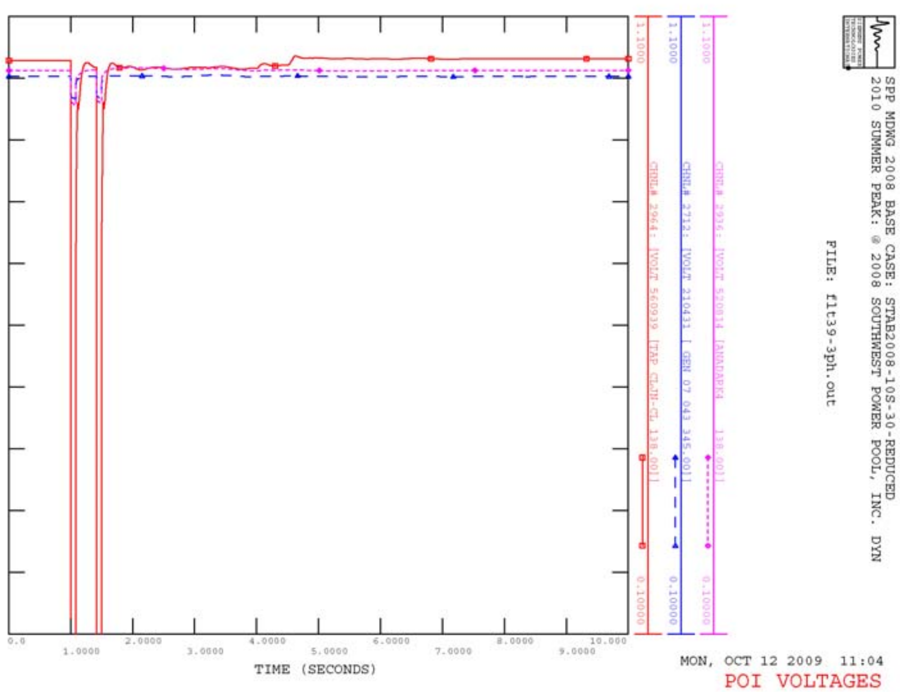

Figure 4-2. POI Voltages for Fault 39 – 3 phase fault on the GEN-2007-032 to Clinton 138kV line, near GEN-2007-032

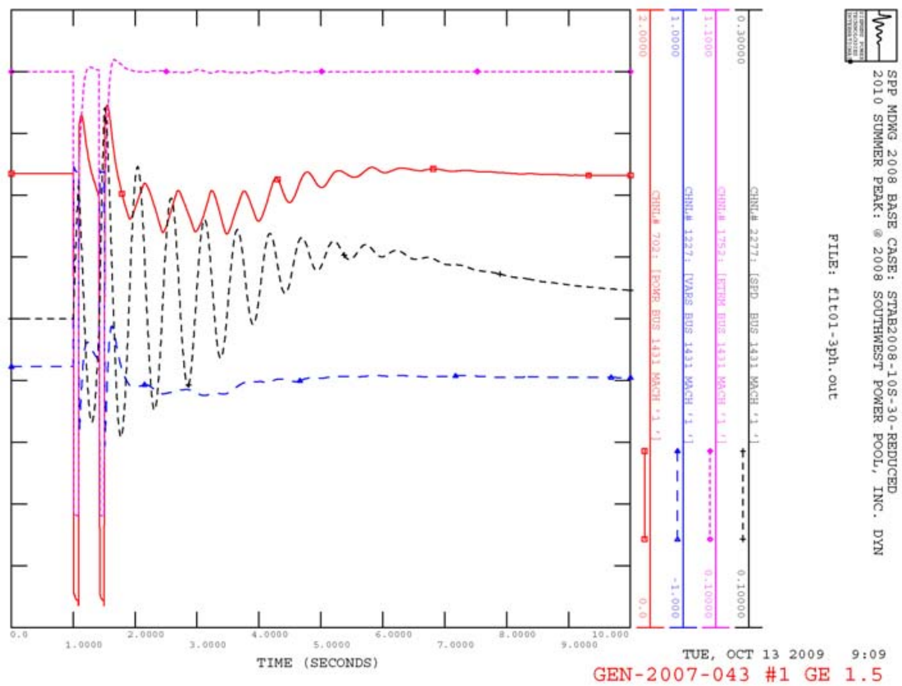

Figure 4-3. GEN-2007-043 Plot for Fault 1 – 3 phase fault on the GEN-2007-043 to Cimarron 345kV line, near GEN-2007-043

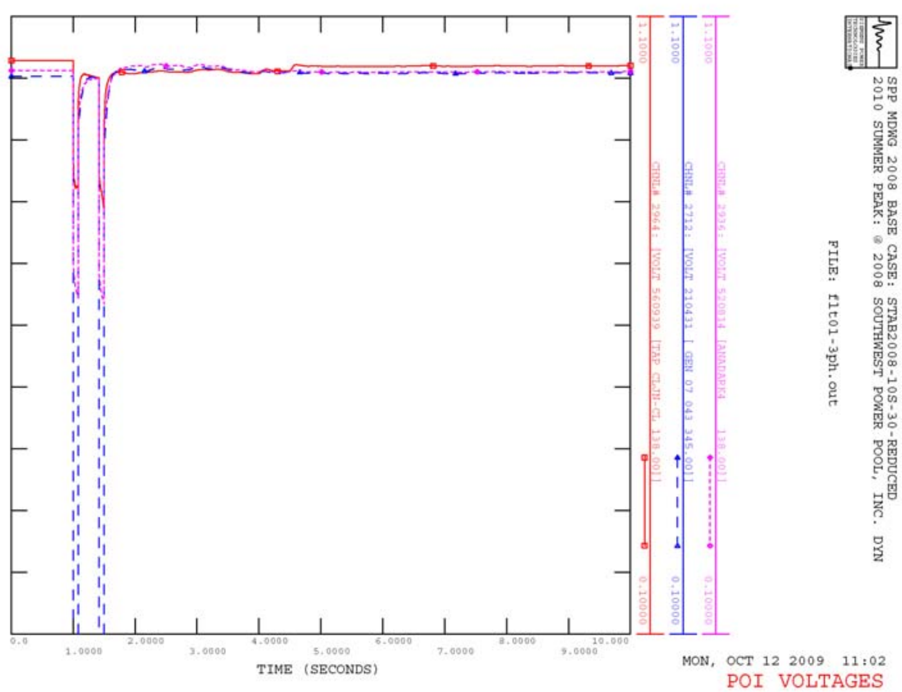

Figure 4-4. POI Voltages for Fault 1 – 3 phase fault on the GEN-2007-043 to Cimarron 345kV line, near GEN-2007-043

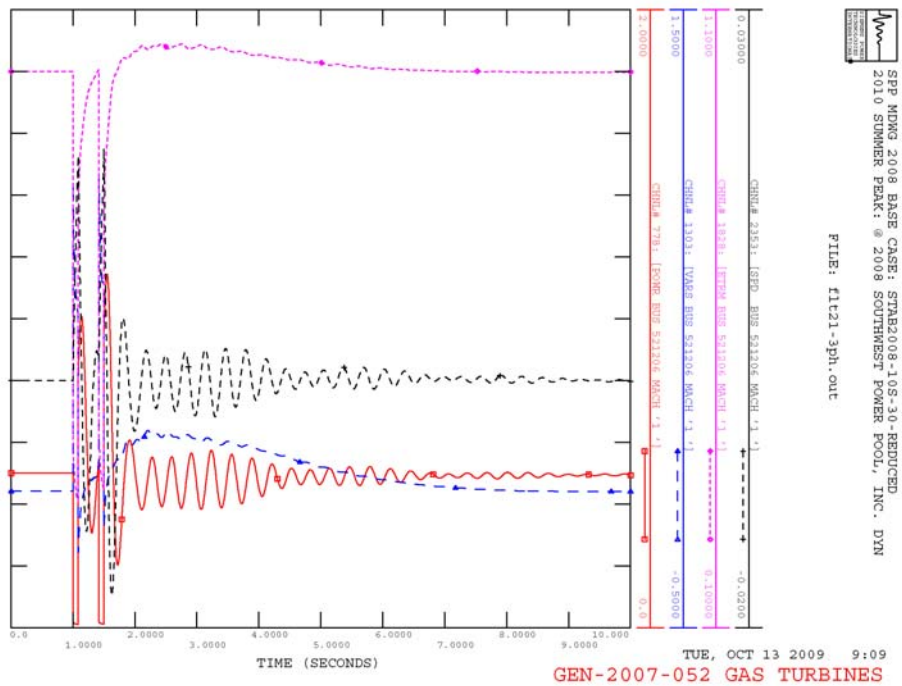

Figure 4-5. GEN-2007-052 Plot for Fault 21 – 3 phase fault on the Anadarko to Pocasset 138 kV line, near Anadarko

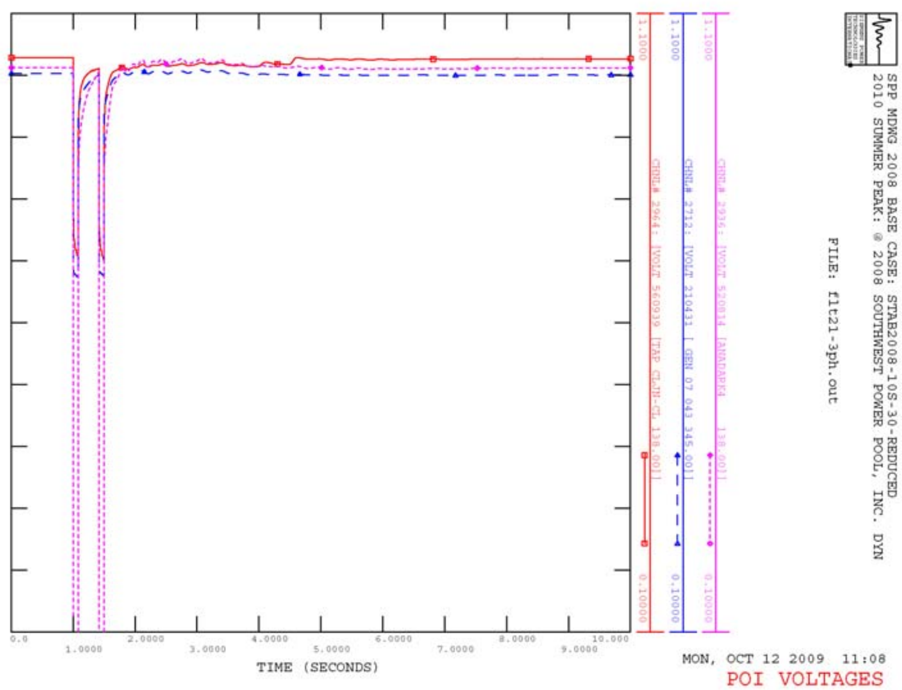

Figure 4-6. POI Voltages for Fault 21 – 3 phase fault on the Anadarko to Pocasset 138 kV line, near Anadarko

4.2 Generator Performance

Study project GEN-2007-032 uses Acciona AW1500 wind turbines, which perform acceptably during all faults. However, for all three-phase faults and many single-phase faults, the voltage and reactive power of these generators show delayed recovery after fault clearing. The voltage and reactive power stay slightly low for about 3 seconds after final fault clearing, after which they step back up to pre-fault values. This can be seen in Figure 4-1 above. No stability criteria are violated. The prior-queued Gamesa turbines at projects GEN-2006-002 and GEN-2006-035 exhibit a similar behavior.

Study project GEN-2007-043 uses GE 1.5 MW wind turbines, which perform well for all simulations.

Study project GEN-2007-052 is a gas turbine plant with synchronous generators. As demonstrated in Figure 4-5, the reactive power and terminal voltage overshoot for about 3 seconds following most faults. The excitation system of a modern synchronous generator should normally control voltage much faster and more accurately than this. The developer of GEN-2007-052 should provide a properly tuned excitation system model before the plant goes in service. However, no stability criteria are violated.

GEN-2007-052 also has some oscillations in active power and speed for many faults with an oscillation frequency of around 3 Hz. The oscillations seem to mostly go away within the 10 second simulation, but consideration of this mode should be given during excitation system tuning and updated model preparation.

For most of the fault simulations, the generator speed of the prior-queued GEN-2003-004 Vestas V80 generator has poor damping, as shown in Figure 4-7 below. However, the oscillations have no significant effect on the generator active or reactive power or the terminal voltage, and thus it has no effect on the transmission system.

For faults 33 and 34, which result in loss of the Southwest to Washita 138 kV line, the GEN-2003-004 Vestas V80 generator initially showed high-frequency oscillations. See Figure 4-8 below. This is a known problem with the V80 generators. When the voltage drops below around 92%, the controls reduce the reactive power absorption of the machine. This causes the voltage to rise, which causes the reactive power to go back to normal and thus the voltage drops again. This unstable oscillation is frequently seen in the Vestas V80 model, and it is not caused by the study projects.

The neighboring Blue Canyon I wind farm is known to trip for faults 33 and 34, but there is not a low voltage tripping model in the case. These faults were rerun with Blue Canyon I manually tripped (Figure 4-9) after final fault clearing, and GEN-2003-004 no longer has high frequency oscillations (Figure 4-10).

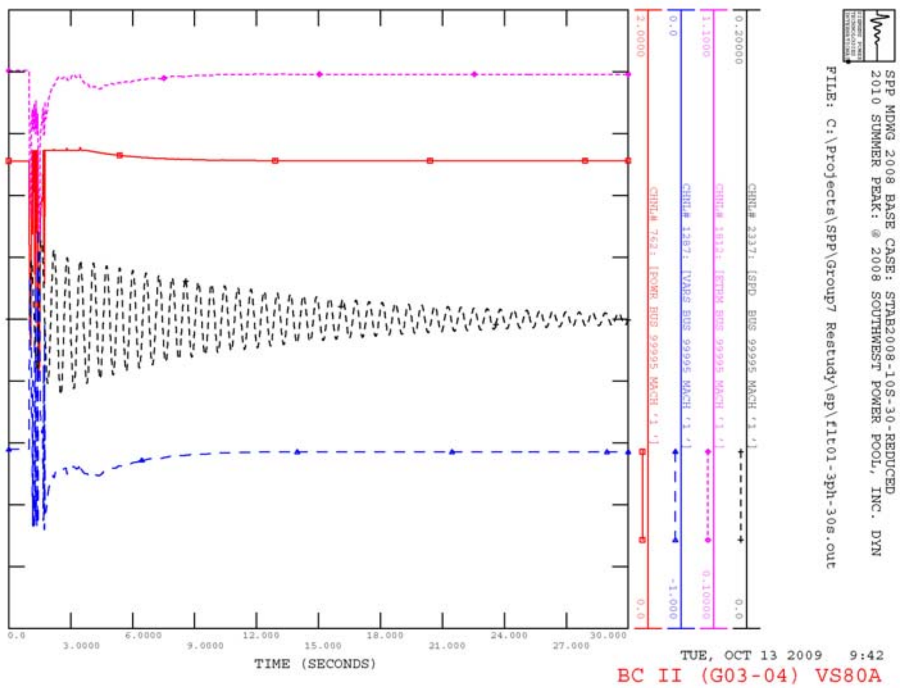

Figure 4-7. GEN-2003-004 Plot for Fault 1 – 3 phase fault on the GEN-2007-043 to Cimarron 345kV line, near GEN-2007-043

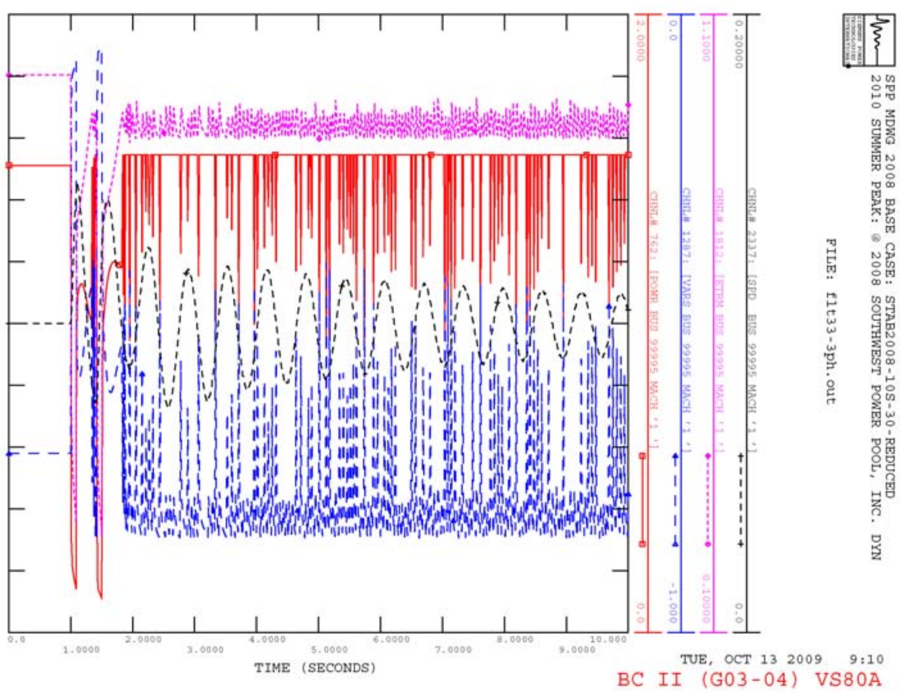

Figure 4-8. GEN-2003-004 Plot for Fault 33 – 3 phase fault on the Southwest to Washita 138kV line, near Southwest

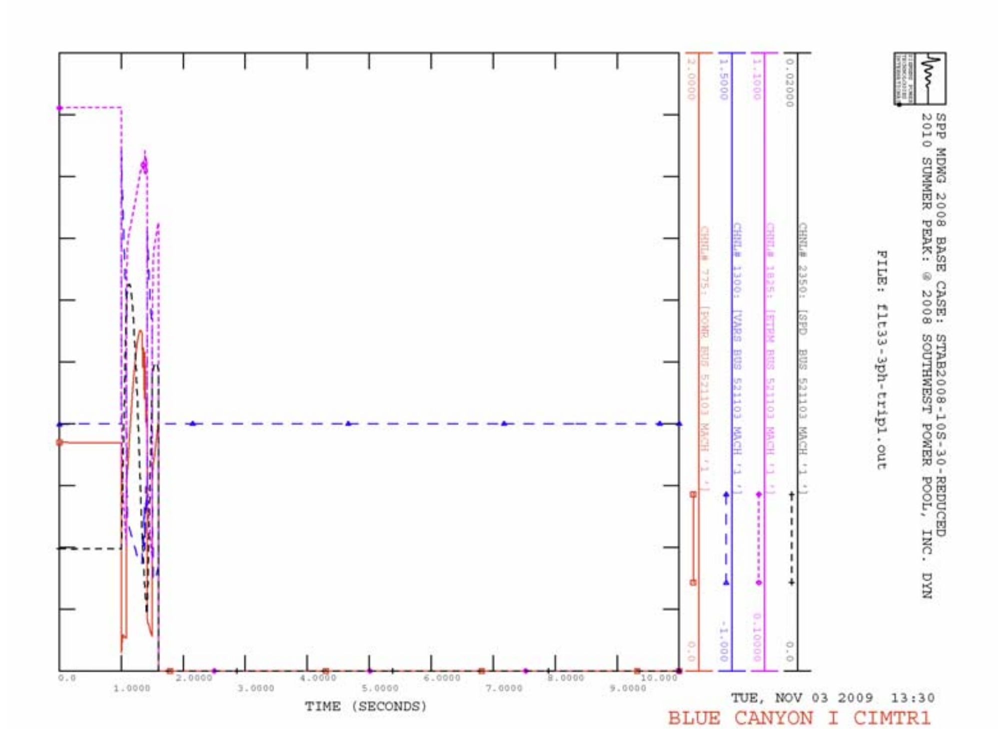

Figure 4-9. **Blue Canyon I Plot for Fault 33 – 3 phase fault on the Southwest to Washita 138kV line, near Southwest, with Blue Canyon I tripped manually**

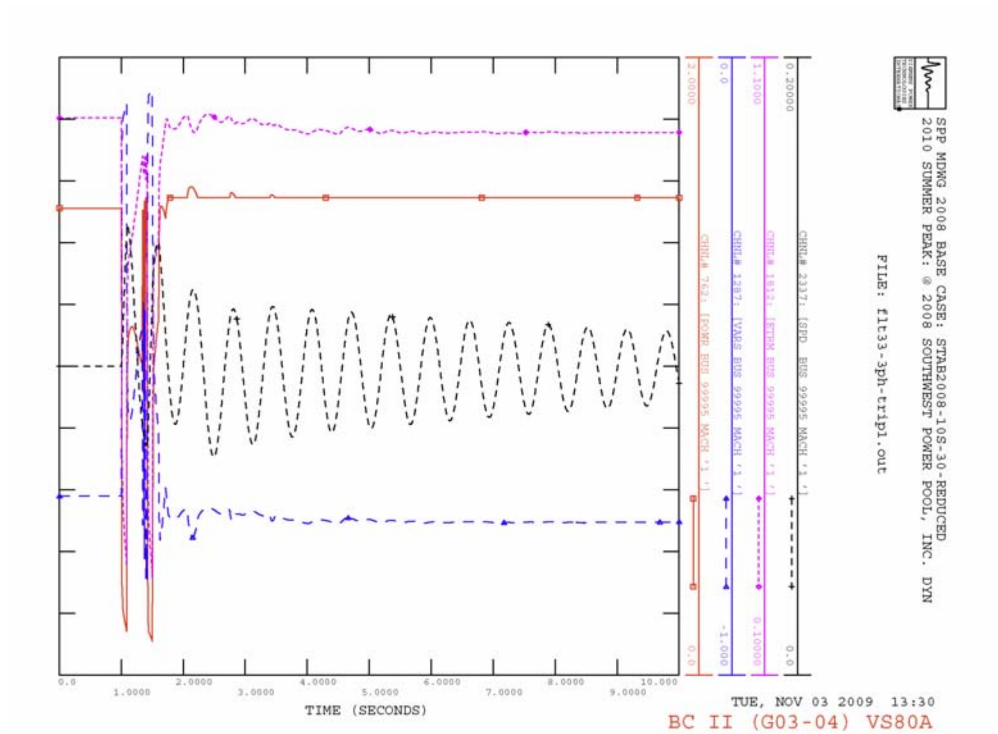

Figure 4-10. **GEN-2003-004 Plot for Fault 33 – 3 phase fault on the Southwest to Washita 138kV line, near Southwest, with Blue Canyon I tripped manually**

4.3 Power Factor Requirements

All stability faults were tested as power flow contingencies to determine the power factor requirements for the study projects to maintain scheduled voltage at their respective points of interconnection (POI). Only wind farm projects require a power factor test (GEN-2007-032 and GEN-2007-043). The voltage schedules are set equal to the voltages at the POIs before the projects are added, with a minimum of 1.0 per unit. Fictitious reactive power sources were added to the study projects to maintain scheduled voltage during all studied contingencies. The MW and Mvar injections from the study projects at the POIs were recorded and the resulting power factors were calculated for all contingencies for summer peak and winter peak cases. The most leading and most lagging power factors determine the minimum power factor range capability that the study projects must install before commercial operation.

If more than one study project shared a single POI (none in this case), the projects were grouped together and a common power factor requirement was determined for those study projects. This ensures that none of the study projects is required to provide more or less than its fair share of the reactive power requirements at a single POI. *Prior-queued* projects at the same POI, if any, were not grouped with the study projects because their interconnection requirements were determined in previous studies.

Per FERC and SPP Tariff requirements, if the power factor needed to maintain scheduled voltage were less than 0.95 lagging, then the requirement would be set to 0.95 lagging. This limit was not reached for either project. Similarly for the leading power factor requirement, the limit is 0.95 but this was not reached for either project.

The standard requirement for synchronous generators such as those in GEN-2007-052 is 0.95 lagging to 0.95 leading.

The final power factor requirements are shown in Table 4-2 below. These are only the minimum power factor ranges. A project developer may install more capability than this if desired.

The full details for each contingency in summer and winter peak cases are given in Appendix C.

Table 4-2. Power Factor Requirements [1]

Project	MW	Turbine	POI	Final PF Requirement	
				Lagging [2]	Leading [3]
GEN-2007-032	150	Acciona 1.5MW	Clinton Jct. – Clinton 138kV	0.9999	0.9818
GEN-2007-043	300	G.E. 1.5MW	Cimarron – Anadarko 345kV	0.9851	0.9550
GEN-2007-052	150	Gas Turbine	Anadarko 138kV	0.95	0.95

Notes:
1. For each plant, the table shows the minimum required power factor capability at the point of interconnection that must be designed and installed with the plant. The power factor capability at the POI includes the net effect of the generators, transformers, and collector line impedances, and any reactive compensation devices installed on the plant side of the meter. Installing more capability than the minimum requirement is acceptable.
2. Lagging is when the generating plant is supplying reactive power to the transmission grid. In this situation, the alternating current sinusoid “lags” behind the alternating voltage sinusoid, meaning that the current peaks shortly after the voltage.
3. Leading is when the generating plant is taking reactive power from the transmission grid. In this situation, the alternating current sinusoid “leads” the alternating voltage sinusoid, meaning that the current peaks shortly before the voltage.

5. Conclusions

The Cluster #1 Group #7 Impact Study evaluated the impacts of interconnecting each of the three projects shown below.

Table 5-1. Interconnection Requests to be Evaluated

Request	Size	Wind Turbine Model	Point of Interconnection
GEN-2007-032	150	Acciona 1.5MW	Clinton Jct. – Clinton 138kV (560939)
GEN-2007-043	300	G.E. 1.5MW	Cimarron – Anadarko 345kV (210431)
GEN-2007-052	150	Gas Turbine	Anadarko 138kV (520814)

No stability problems were found during summer or winter peak conditions due to the addition of these generators.

Power factor requirements were determined for the wind plants GEN-2007-032 and GEN-2007-043, and both of these plants must install sufficient reactive power resources to meet the requirements listed in Table 4-2. Because no stability problems were found, the reactive power resources need not be high speed or continuously controlled. However, any change in wind turbine model or controls could change the stability results, possibly resulting in a need for a high-speed reactive power supply. GEN-2007-052 will be a combustion turbine with synchronous generators, and the standard power factor requirement is 0.95 leading to 0.95 lagging at the POI.

The prior-queued GEN-2003-004 plant showed a couple of known issues with its Vestas V80 wind turbines that are not caused by the proposed study plants. GEN-2003-004 has poor damping in its generator speed following most faults, but this oscillation does not affect the transmission grid (P, Q, or V). For one of the faults close to GEN-2003-004, the machines go into high frequency oscillations caused by poor operation of its voltage/var control. It is not known if these are problems only with the PSS/E model or problems with the actual Vestas V80 wind turbines. Either way, they are previously known and not caused by the new projects. If the Blue Canyon I wind turbines are tripped for these faults, as they are expected to, the high frequency oscillations go away.

With the assumptions described in this report, the Cluster #1 Group 7 projects should be able to connect without causing any stability problems on the SPP transmission grid.

Appendix A – Summer Peak Plots

See attachment.

Appendix B – Winter Peak Plots

See attachment.

Appendix C – Power Factor Details

See attachment.

Appendix D – Dynamic Model Data

See attachment.

Q: Stability Study for Group 8

Pterra Consulting

Technical Report R110-09

Impact Study for Generation Interconnection Request GEN-2007-025 (Re-Study)

Submitted to

Southwest Power Pool

November 2009

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Contents

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Executive Summary

This report presents the impact study comprising of power factor and stability simulation of proposed interconnection GEN-2007-025 (the "Project"). The Project has a nominal maximum rating of 300 using Clipper 2.5 MW wind turbine generators ("WTGs"). The Point of Interconnection ("POI") is a new 345 kV substation on the existing Gen-2008-013 to Wichita 345 kV line.

The analysis was conducted through the Southwest Power Pool ("SPP") Tariff. Power factor analysis and transient stability simulations were conducted with the Project in service at full output of 300 MW.

Two base cases for 2010 summer and winter conditions, each comprising of a power flow and corresponding dynamics database, were provided by SPP. In order to integrate the proposed 300 MW wind farm into the SPP system, the existing generation in the SPP footprint was re-dispatched as specified by SPP.

The results of the Power Factor analysis showed that with the MVAR capability of the Clipper WTG and without reactive compensation, the wind farm will not be able to keep the voltage schedule at the POI consistent with the voltage schedule in the provided power flow cases for summer and winter. Additional VAR compensating devices need to be installed for the customer to maintain a power factor at the point of interconnection in the ±-0.95 range.

Sixty-six (66) disturbances were considered for the transient stability simulations which included 3-phase faults, as well as, 1-phase to ground faults, at the locations defined by SPP. The Clipper WTGs were modeled with voltage and frequency ride through protection set to manufacturer default settings. The results of the simulations showed no angular or voltage instability problems for the 66 disturbances. The study finds that the interconnection of the proposed 300 MW Project does not impact stability performance of the SPP system for the contingencies tested on the supplied base cases.

1.1. Project Overview

This report presents the impact study comprising of power factor and stability simulation of proposed interconnection GEN-2007-025 (the "Project"). The Project has a nominal maximum rating of 300 MW using Clipper 2.5 MW wind turbine generators ("WTGs"). The Project's Point of Interconnection ("POI") is at a new 345 kV Substation on the existing Gen-2008-013 to Wichita 345 kV line. Figure 1-1 shows a conceptual interconnection diagram of the Project to the 345 kV transmission network.

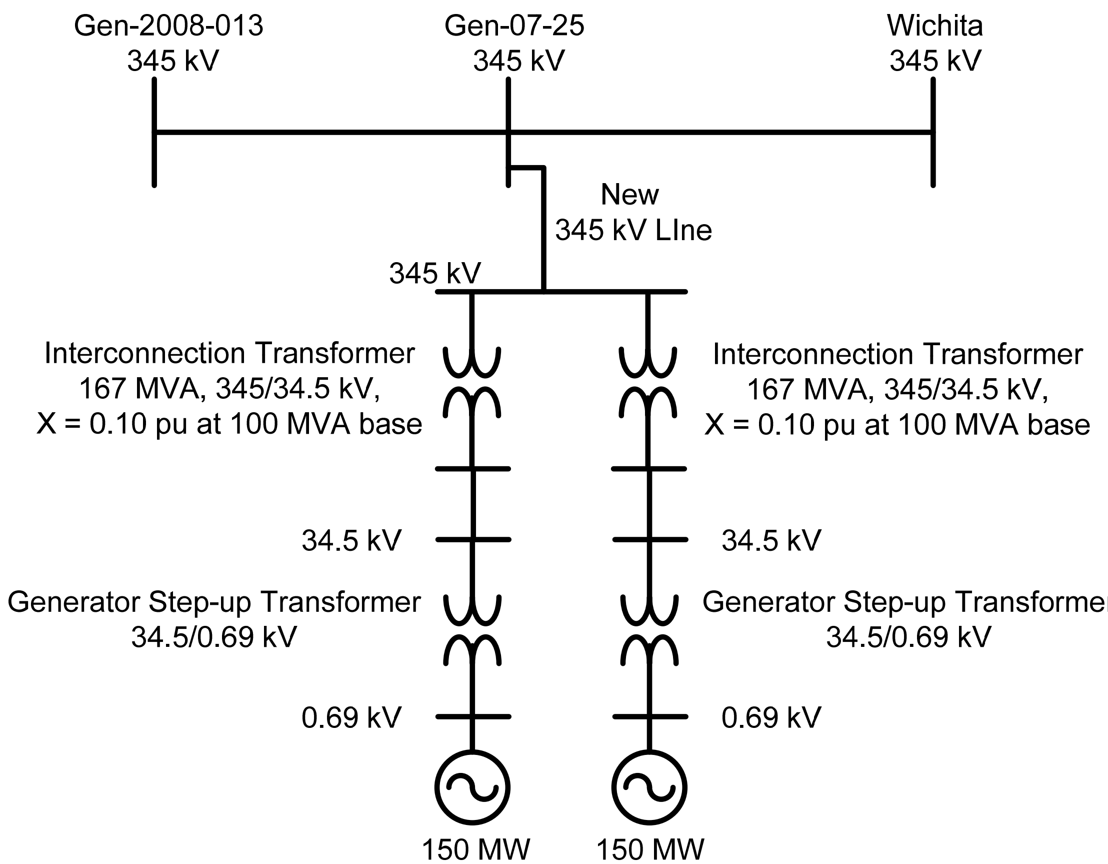

Figure 1-1 Interconnection Plan for the Project to SPP's 345 kV System

In order to integrate the proposed 300 MW wind farm in SPP system as an Energy Resource, existing generation in the SPP footprint was redispatched to maintain area interchange totals.

To simplify the model of the wind farm while capturing the effect of the different impedances of cables (due to change of the conductor size and length), the wind turbines connected to the same 34.5 kV feeder end points were aggregated into one equivalent unit. An equivalent impedance of that feeder was represented by taking the equivalent series impedances of the different feeders connecting the wind turbines. SPP modeled the proposed 300 MW wind farm in the provided power flow cases with 2 equivalent units, each generating 150 MW, as shown in Figure 1-1. Table 1-1 shows a list of the prior queued projects that are included in the base case.

Table 1-1 List of Prior Queued Projects

Request	Size	Wind Turbine Model	Point of Interconnection
GEN-2006-021	100 MW	Clipper 2.5MW	Medicine Lodge – Harper 138kV
GEN-2006-022	80 MW	Clipper 2.5MW	Medicine Lodge – Pratt 115kV

1.2. Objectives

The objectives of the study are to conduct power factor analysis and to determine the impact on system stability of interconnecting a proposed 300 MW wind farm to SPP's 345 kV transmission system.

Section 2. Power Factor Analysis

2.1. Methodology

Power factor analysis was conducted for the Project using a methodology which is summarized as follow:

1. Model a VAR generator at the Project's 345 kV bus. The VAR generator is set to hold a voltage schedule at the POI consistent with the voltage schedule in the provided power flow cases for summer and winter or 1.0 pu voltage (whichever is higher).

2. Steady state contingency analysis is conducted to determine the power factor necessary at the POI for each contingency.

3. According to the contingency analysis results, determine whether capacitors are required for the Project or not.

4. If the required power factor at the POI is beyond the capability of the studied wind turbines to meet (at the POI) capacitor banks are considered. The preference is to locate the capacitance banks is on the 34.5 kV Customer side. Factors to sizing capacitor banks include:

   4.1. The ability of the wind farm to meet FERC Order 661A (low voltage ride through) with and without capacitor banks.

   4.2. The ability of the wind farm to meet FERC Order 661A (wind farm recovery to pre-fault voltage).

   4.3. If wind farms trips on high voltage, power factor lower than unity may be required.

2.2. Analysis

A VAR generator was modeled in the provided power flow cases for summer and winter at the POI. The VAR generator was set to hold a voltage schedule at the POI consistent with the voltage schedule in the provided power flow cases for summer and winter. These values are 1.0 pu and 1.003 pu, for summer and winter power flow cases respectively.

Contingency analysis was run for all the contingencies listed in the fault definition table (Table 3-4). A summary of the contingency analysis results, according to Table 2-1, for both summer and winter power flow cases is as follows:

1. The loss of the 345 kV line from Wichita to the POI showed that the VAR generator is absorbing 49.3 MVAR and 43.2 MVAR in summer and winter power flow cases, respectively.

2. The loss of any other 345 kV line in the contingency list showed that the VAR generator is either absorbing or delivering MVAR to the system to hold a voltage

schedule at the POI consistent with the voltage schedule in the provided power flow cases for summer and winter. The maximum delivered MVAR output is associated with the loss of the 345 kV line from the POI to Gen-2008-013. The VAR generator is delivering 70.3 MVAR and 48.3 MVAR in both summer and winter power flow cases, respectively.

3. With the MVAR capability of the Clipper WTG and without reactive compensation, the wind farm will not be able to keep the voltage schedule at the POI consistent with the voltage schedule in the provided power flow cases for summer and winter.

Table 2-1 VAR Generator Output in Summer and winter Peak Power Flow Cases

Season	Contingency Description	PF @ POI	PF	MW @ POI	MVAR @ POI
10SP	BASE CASE	0.9968	Lead	294.6	23.8
	560006 GEN-07-25 345 210130 GEN_2008_013 345 1	0.9727	Lag	294.6	-70.3
	560006 GEN-07-25 345 532796 WICHITA7 345 1	0.9863	Lead	294.6	49.3
	532796 WICHITA7 345 532791 BENTON 7 345 1	0.9863	Lead	294.6	49.3
	531469 SPERVIL7 345 531487 COMANCHE 345 1	0.9985	Lag	294.6	-16.0
	531469 SPERVIL7 345 530700 KNOLL 345 1	0.9985	Lag	294.6	-15.9
	531487 COMANCHE 345 515375 WOODWRD7 345 1	0.9987	Lead	294.6	15.3
	539695 SPEARVL6 230 539679 MULGREN6 230 1	0.9995	Lag	294.6	-8.9
	539679 MULGREN6 230 532871 CIRCLE 6 230 1	0.9996	Lag	294.6	-8.1
	532781 MEDLODG 345 531487 COMANCHE 345 1	0.9998	Lag	294.6	-6.4
	531449 HOLCOMB7 345 210400 GEN_2007_40 345 1	0.9999	Lead	294.6	5.1
	530558 KNOLL 6 230 530592 SMOKYHLLS6 230 1	0.9998	Lag	294.6	-5.5
	515375 WOODWRD7 345 515378 TATONGA 345 1	0.9998	Lag	294.6	-5.3
	531451 MINGO 7 345 531465 SETAB 7 345 1	0.9999	Lag	294.6	-4.5
	210400 GEN_2007_40 345 531469 SPERVIL7 345 1	0.9999	Lead	294.6	3.5
	539671 JUD-LRG3 115 103 S AR_4 115 .00 1	1.0000	Lag	294.6	-1.2
	531469 SPERVIL7 345 539695 SPEARVL6 230 1	1.0000	Lag	294.6	-1.3
	531449 HOLCOMB7 345 531448 HOLCOMB3 115 1	1.0000	Lead	294.6	1.4
	531449 HOLCOMB7 345 531465 SETAB 7 345 1	1.0000	Lag	294.6	-2.9
	523961 POTTER_CO 7 345 523959 POTTER_CO 6 230 1	1.0000	Lead	294.6	0.1
	51700 G05-017 345 523961 POTTER_CO 7 345 1	1.0000	Lead	294.6	0.1
	539671 JUD-LRG3 115 539659 CUDAHY 3 115 1	1.0000	Lead	294.6	0.1
	539695 SPEARVL6 230 539694 SPEARVL3 115 2	1.0000	Lead	294.6	0.1
	523853 FINNEY7 345 531449 HOLCOMB7 345 1	1.0000	Lag	294.6	0.0
	560029 G03-13 345 523097 HITCHLAND 7 345 1	1.0000	Lag	294.6	-0.1
	523097 HITCHLAND 7 345 51700 G05-017 345 1	1.0000	Lag	294.6	0.0
	560029 G03-13 345 560940 G06-49T1 345 1	1.0000	Lag	294.6	0.0
	539679 MULGREN6 230 530582 S HAYS6 230 1	1.0000	Lag	294.6	-0.3
10WP	BASE CASE	0.9956	Lead	294.6	27.8
	560006 GEN-07-25 345 210130 GEN_2008_013 345 1	0.9868	Lag	294.6	-48.3
	560006 GEN-07-25 345 532796 WICHITA7 345 1	0.9894	Lead	294.6	43.2
	532796 WICHITA7 345 532791 BENTON 7 345 1	1.0000	Lead	294.6	1.3
	531469 SPERVIL7 345 531487 COMANCHE 345 1	0.9987	Lag	294.6	-14.8

Season	Contingency Description	PF @ POI	PF	MW @ POI	MVAR @ POI
	531469 SPERVIL7 345 530700 KNOLL 345 1	0.9989	Lag	294.6	-14.1
	531487 COMANCHE 345 515375 WOODWRD7 345 1	0.9945	Lead	294.6	31.1
	539695 SPEARVL6 230 539679 MULGREN6 230 1	0.9998	Lag	294.6	-6.3
	539679 MULGREN6 230 532871 CIRCLE 6 230 1	0.9996	Lag	294.6	-8.8
	532781 MEDLODG 345 531487 COMANCHE 345 1	0.9999	Lag	294.6	-3.3
	531449 HOLCOMB7 345 210400 GEN_2007_40 345 1	0.9999	Lead	294.6	4.4
	530558 KNOLL 6 230 530592 SMOKYHLLS6 230 1	1.0000	Lag	294.6	-2.1
	515375 WOODWRD7 345 515378 TATONGA 345 1	0.9993	Lag	294.6	-10.8
	531451 MINGO 7 345 531465 SETAB 7 345 1	1.0000	Lag	294.6	-1.7
	210400 GEN_2007_40 345 531469 SPERVIL7 345 1	1.0000	Lead	294.6	2.5
	539671 JUD-LRG3 115 103 S AR_4 115 .00 1	1.0000	Lag	294.6	-0.1
	531469 SPERVIL7 345 539695 SPEARVL6 230 1	1.0000	Lead	294.6	2.3
	531449 HOLCOMB7 345 531448 HOLCOMB3 115 1	1.0000	Lead	294.6	1.8
	531449 HOLCOMB7 345 531465 SETAB 7 345 1	1.0000	Lag	294.6	-0.8
	523961 POTTER_CO 7 345 523959 POTTER_CO 6 230 1	1.0000	Lag	294.6	0.0
	51700 G05-017 345 523961 POTTER_CO 7 345 1	1.0000	Lag	294.6	0.0
	539671 JUD-LRG3 115 539659 CUDAHY 3 115 1	1.0000	Lag	294.6	-0.1
	539695 SPEARVL6 230 539694 SPEARVL3 115 2	1.0000	Lead	294.6	0.2
	523853 FINNEY7 345 531449 HOLCOMB7 345 1	1.0000	Lag	294.6	0.0
	560029 G03-13 345 523097 HITCHLAND 7 345 1	1.0000	Lead	294.6	0.1
	523097 HITCHLAND 7 345 51700 G05-017 345 1	1.0000	Lead	294.6	0.1
	560029 G03-13 345 560940 G06-49T1 345 1	1.0000	Lag	294.6	0.0
	539679 MULGREN6 230 530582 S HAYS6 230 1	1.0000	Lag	294.6	-0.2

2.3. Conclusions

In order to hold a voltage schedule at the POI consistent with the voltage schedule in the provided power flow cases, the wind farm should control the power factor at the POI to be within the ± 0.95 range. Additional VAR compensating devices need to be installed for the customer to maintain a power factor at the point of interconnection in the ±-0.95 range.

Section 3. Stability Analysis

3.1. Modeling of the Clipper 2.5 MW Wind Turbine Generators

For the stability simulations, the Clipper 2.5 MW wind turbine generators were modeled using the provided Clipper 2.5 MW wind turbine dynamic model set. Table 3-1 shows the data for Clipper 2.5 MW WTG.

Table 3-1 Clipper 2.5 MW Wind Generator Data

Parameter	Value
Base kV	0.69
WTG MBASE	2.50
Transformer MBASE	2.75
Transformer R on Transformer Base	0.00945
Transformer X on Transformer Base	0.05672
Transformer Tap	1.00
Pmax (MW)	2.50

The Clipper WTGs have ride-through capability for voltage and frequency. Detailed ride through relays' manufacturer settings are shown in Table 3-2 and Table 3-3.

Table 3-2 Over/Under Frequency Relay Settings for Clipper 2.5 MW

Frequency Settings in Hertz	Time Delay in Seconds
F ≤ 57.0	1.0
F ≥ 63.0	1.0

Table 3-3 Over/Under Voltage Relay Settings for Clipper 2.5 MW

Voltage Settings Per Unit	Time Delay in Seconds
0.0 <V ≤ 0.10	0.15
0.10 < V ≤ 0.90	3.0
1.10 < V ≤ 1.20	5.0
1.2 < V ≤ 1.30	0.50
V > 1.30	0.034

3.2. Assumptions

The following assumptions were adopted for the dynamic simulations:

1. Constant maximum and uniform wind speed for the entire period of study.
2. Wind turbine control models with their default values.
3. Under/over voltage/frequency protection use manufacturer settings.

3.3. Faults Simulated

Sixty-six (66) faults were considered for the transient stability simulations which included three phase faults, as well as single phase line faults, at the locations defined by SPP. Single-phase line faults were simulated by applying a 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. Prior queued projects shown in Table 1-1 and units in areas 520, 524, 525, 526, 531, and 534, and 536 were monitored in the simulations. Table 3-4 shows the list of simulated contingencies. The table also shows the fault clearing time and the time delay before re-closing for all the study contingencies.

Table 3-4 List of the Simulated Faults

Cont. No.	Cont. Name	Description
1	FLT09-3PH	3 phase fault on one of the Finney (523853) to Holcomb (531449) 345kV lines, near Finney. a. Apply fault at the Finney 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.
2	FLT10-1PH	*Single phase fault and sequence like previous*
3	FLT11-3PH	3 phase fault on one of the Holcomb (531449) to Finney (523853) 345kV lines, near Holcomb. a. Apply fault at the Holcomb 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.
4	FLT12-1PH	*Single phase fault and sequence like previous*
5	FLT13-3PH	3 phase fault on the Holcomb (531449) to Setab (531465) 345kV line, near Holcomb. a. Apply fault at the Holcomb 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.
6	FLT14-1PH	*Single phase fault and sequence like previous*
7	FLT15-3PH	3 phase fault on the Holcomb (531449) to GEN-2007-040 (210400) 345kV line, near Holcomb. a. Apply fault at the Holcomb 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.
8	FLT16-1PH	*Single phase fault and sequence like previous*
9	FLT17-3PH	3 phase fault on the Holcomb 345kV (531449) to 115kV (531448) transformer, near the 345 kV bus. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
10	FLT18-1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
11	FLT19-3PH	3 phase fault on the GEN-2007-040 (210400) to Holcomb (531449) 345kV line, near GEN-2007-040. a. Apply fault at the GEN-2007-040 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.
12	FLT20-1PH	*Single phase fault and sequence like previous*
13	FLT21-3PH	3 phase fault on the GEN-2007-040 (210400) to Spearville (531469) 345kV line, near GEN-2007-040. a. Apply fault at the GEN-2007-040 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	FLT22-1PH	*Single phase fault and sequence like previous*
15	FLT23-3PH	3 phase fault on the Spearville (531469) to GEN-2007-040 (210400) 345kV line, near Spearville. a. Apply fault at the Spearville 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.
16	FLT24-1PH	*Single phase fault and sequence like previous*
17	FLT25-3PH	3 phase fault on the Spearville (531469) to Comanche (531487) 345kV line, near Spearville. a. Apply fault at the Spearville 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.
18	FLT26-1PH	*Single phase fault and sequence like previous*
19	FLT27-3PH	3 phase fault on the Spearville 345kV (531469) to 230kV (539695) transformer, near the 345 kV bus. a. Apply fault at the Spearville 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
20	FLT28-1PH	*Single phase fault and sequence like previous*
21	FLT29-3PH	3 phase fault on the Spearville 230kV (539695) to 345kV (531469) transformer, near the 230 kV bus. a. Apply fault at the Spearville 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
22	FLT30-1PH	*Single phase fault and sequence like previous*
23	FLT31-3PH	3 phase fault on the Spearville 230kV (539695) to 115kV (539694) transformer #2, near the 230 kV bus. a. Apply fault at the Spearville 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
24	FLT32-1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
25	FLT33-3PH	3 phase fault on the Spearville (539695) to Mullergren (539679) 230kV line, near Spearville. a. Apply fault at the Spearville 230kV 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.
26	FLT34-1PH	*Single phase fault and sequence like previous*
27	FLT35-3PH	3 phase fault on the Mullergren (539679) to South Hays (530582) 230kV line, near Mullergren. a. Apply fault at the Mullergren 230kV 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.
28	FLT36-1PH	*Single phase fault and sequence like previous*
29	FLT37-3PH	3 phase fault on the Mullergren (539679) to Circle (532871) 230kV line, near Mullergren. a. Apply fault at the Mullergren 230kV 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.
30	FLT38-1PH	*Single phase fault and sequence like previous*
31	FLT39-3PH	3 phase fault on the GEN-2007-025 (560006) to Wichita (532796) 345kV line, near GEN-2007-025. a. Apply fault at the GEN-2007-025 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.
32	FLT40-1PH	*Single phase fault and sequence like previous*
33	FLT41-3PH	3 phase fault on the GEN-2007-025 (560006) to Gen-2008-013 (210130) 345kV line, near GEN-2007-025. a. Apply fault at the GEN-2007-025 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.
34	FLT42-1PH	*Single phase fault and sequence like previous*
35	FLT43-3PH	3 phase fault on the Wichita (532796) to Benton (532791) 345kV line, near Wichita. a. Apply fault at the Wichita 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.
36	FLT44-1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
37	FLT45-3PH	3 phase fault on the Comanche (531487) to Woodward (515375) 345kV line, near Comanche. a. Apply fault at the Comanche 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.
38	FLT46-1PH	*Single phase fault and sequence like previous*
39	FLT47-3PH	3 phase fault on the Judson Large (539671) to S Star (103) 115kV line, near Judson Large. a. Apply fault at the Judson Large 115kV 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.
40	FLT48-1PH	*Single phase fault and sequence like previous*
41	FLT49-3PH	3 phase fault on the Judson Large (539671) to Cudahy (539659) 115kV line, near Judson Large. a. Apply fault at the Judson Large 115kV 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.
42	FLT50-1PH	*Single phase fault and sequence like previous*
43	FLT51-3PH	3 phase fault on the GEN-2003-013 (560029) to Hitchland (523097) 345kV line, near GEN-2003-013. a. Apply fault at the GEN-2003-013 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.
44	FLT52-1PH	*Single phase fault and sequence like previous*
45	FLT53-3PH	3 phase fault on the Hitchland (523097) to G03-13 (560029) 345kV line, near Hitchland. a. Apply fault at the Hitchland 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.
46	FLT54-1PH	*Single phase fault and sequence like previous*
47	FLT55-3PH	3 phase fault on the Hitchland (523097) to GEN-2005-017 (51700) 345kV line, near Hitchland. a. Apply fault at the Hitchland 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.
48	FLT56-1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
49	FLT57-3PH	3 phase fault on the GEN-2005-017 (51700) to Potter Co. (523961) 345kV line, near GEN-2005-017. a. Apply fault at the GEN-2005-017 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.
50	FLT58-1PH	*Single phase fault and sequence like previous*
51	FLT61-3PH	3 phase fault on the Potter Co. 345kV (523961) to 230kV (523959) transformer, near the 345 kV bus. a. Apply fault at the Potter Co. 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.
52	FLT62-1PH	*Single phase fault and sequence like previous*
53	FLT63-3PH	3 phase fault on the Woodward (515375) to Tatonga (515378) 345kV line, near Woodward. a. Apply fault at the Woodward 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.
54	FLT64-1PH	*Single phase fault and sequence like previous*
55	FLT65-3PH	3 phase fault on the Spearville (531469) to Knoll (530700) 345kV line, near Mingo. a. Apply fault at the Mingo 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.
56	FLT66-1PH	*Single phase fault and sequence like previous*
57	FLT67-3PH	3 phase fault on the Knoll (530558) to Smoky Hills (530592) 230kV line, near Knoll. a. Apply fault at the Knoll 230kV 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.
58	FLT68-1PH	*Single phase fault and sequence like previous*
59	FLT107-3PH	3 phase fault on the Hitchland (523097) to G05-017 (51700) 345kV line, near Beaver County. a. Apply fault at the Beaver County 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.
60	FLT70-1PH	*Single phase fault and sequence like previous*

Cont. No.	Cont. Name	Description
61	FLT71-3PH	3 phase fault on the GEN-2003-013 (560029) to G06-49T1 (560940) 345kV line, near GEN-2003-013. a. Apply fault at the GEN-2003-013 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.
62	FLT72-1PH	*Single phase fault and sequence like previous*
63	FLT73-3PH	3 phase fault on the Medlodg (532781) to Comanche (531487) 345kV line, near GEN-2007-040. a. Apply fault at the GEN-2007-040 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.
64	FLT74-1PH	*Single phase fault and sequence like previous*
65	FLT75-3PH	3 phase fault on the Woodward (515375) to Comanche (531487) 345kV line, near Beaver County. a. Apply fault at the Beaver County 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.
66	FLT76-1PH	*Single phase fault and sequence like previous*

Simulations were performed with a 0.5-second steady-state run followed by the appropriate disturbance as described in Table 3-4. Simulations were run for a minimum 10-second duration to confirm proper machine damping.

3.4. Simulation Results

The simulations conducted in the study using the Clipper 2.5 MW WTGs did not find any angular or voltage instability problems for the 66 disturbances. The study finds that the interconnection of the proposed 300 MW Project does not impact stability performance of the SPP system for the contingencies tested on the supplied base cases. Table 3-5 presents the results of the dynamic simulations.

Table 3-5 Results of the Simulated Faults

Cont. No.	Description	Results for SP and WP
1	3 phase fault on one of the Finney (523853) to Holcomb (531449) 345kV lines, near Finney. a. Apply fault at the Finney 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.	Stable

Cont. No.	Description	Results for SP and WP
2	*Single phase fault and sequence like previous*	Stable
3	3 phase fault on one of the Holcomb (531449) to Finney (523853) 345kV lines, near Holcomb. a. Apply fault at the Holcomb 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.	Stable
4	*Single phase fault and sequence like previous*	Stable
5	3 phase fault on the Holcomb (531449) to Setab (531465) 345kV line, near Holcomb. a. Apply fault at the Holcomb 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.	Stable
6	*Single phase fault and sequence like previous*	Stable
7	3 phase fault on the Holcomb (531449) to GEN-2007-040 (210400) 345kV line, near Holcomb. a. Apply fault at the Holcomb 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.	Stable
8	*Single phase fault and sequence like previous*	Stable
9	3 phase fault on the Holcomb 345kV (531449) to 115kV (531448) transformer, near the 345 kV bus. a. Apply fault at the Holcomb 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.	Stable
10	*Single phase fault and sequence like previous*	Stable
11	3 phase fault on the GEN-2007-040 (210400) to Holcomb (531449) 345kV line, near GEN-2007-040. a. Apply fault at the GEN-2007-040 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.	Stable
12	*Single phase fault and sequence like previous*	Stable
13	3 phase fault on the GEN-2007-040 (210400) to Spearville (531469) 345kV line, near GEN-2007-040. a. Apply fault at the GEN-2007-040 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.	Stable
14	*Single phase fault and sequence like previous*	Stable

Cont. No.	Description	Results for SP and WP
15	3 phase fault on the Spearville (531469) to GEN-2007-040 (210400) 345kV line, near Spearville. a. Apply fault at the Spearville 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.	Stable
16	*Single phase fault and sequence like previous*	Stable
17	3 phase fault on the Spearville (531469) to Comanche (531487) 345kV line, near Spearville. a. Apply fault at the Spearville 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.	Stable
18	*Single phase fault and sequence like previous*	Stable
19	3 phase fault on the Spearville 345kV (531469) to 230kV (539695) transformer, near the 345 kV bus. a. Apply fault at the Spearville 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.	Stable
20	*Single phase fault and sequence like previous*	Stable
21	3 phase fault on the Spearville 230kV (539695) to 345kV (531469) transformer, near the 230 kV bus. a. Apply fault at the Spearville 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.	Stable
22	*Single phase fault and sequence like previous*	Stable
23	3 phase fault on the Spearville 230kV (539695) to 115kV (539694) transformer #2, near the 230 kV bus. a. Apply fault at the Spearville 230kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.	Stable
24	*Single phase fault and sequence like previous*	Stable
25	3 phase fault on the Spearville (539695) to Mullergren (539679) 230kV line, near Spearville. a. Apply fault at the Spearville 230kV 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.	Stable
26	*Single phase fault and sequence like previous*	Stable
27	3 phase fault on the Mullergren (539679) to South Hays (530582) 230kV line, near Mullergren. a. Apply fault at the Mullergren 230kV 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.	Stable
28	*Single phase fault and sequence like previous*	Stable

Cont. No.	Description	Results for SP and WP
29	3 phase fault on the Mullergren (539679) to Circle (532871) 230kV line, near Mullergren. a. Apply fault at the Mullergren 230kV 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.	Stable
30	*Single phase fault and sequence like previous*	Stable
31	3 phase fault on the GEN-2007-025 (560006) to Wichita (532796) 345kV line, near GEN-2007-025. a. Apply fault at the GEN-2007-025 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.	Stable
32	*Single phase fault and sequence like previous*	Stable
33	3 phase fault on the GEN-2007-025 (560006) to Gen-2008-013 (210130) 345kV line, near GEN-2007-025. a. Apply fault at the GEN-2007-025 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.	Stable
34	*Single phase fault and sequence like previous*	Stable
35	3 phase fault on the Wichita (532796) to Benton (532791) 345kV line, near Wichita. a. Apply fault at the Wichita 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.	Stable
36	*Single phase fault and sequence like previous*	Stable
37	3 phase fault on the Comanche (531487) to Woodward (515375) 345kV line, near Comanche. a. Apply fault at the Comanche 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.	Stable
38	*Single phase fault and sequence like previous*	Stable
39	3 phase fault on the Judson Large (539671) to S Star (103) 115kV line, near Judson Large. a. Apply fault at the Judson Large 115kV 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.	Stable
40	*Single phase fault and sequence like previous*	Stable

Cont. No.	Description	Results for SP and WP
41	3 phase fault on the Judson Large (539671) to Cudahy (539659) 115kV line, near Judson Large. a. Apply fault at the Judson Large 115kV 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.	Stable
42	*Single phase fault and sequence like previous*	Stable
43	3 phase fault on the GEN-2003-013 (560029) to Hitchland (523097) 345kV line, near GEN-2003-013. a. Apply fault at the GEN-2003-013 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.	Stable
44	*Single phase fault and sequence like previous*	Stable
45	3 phase fault on the Hitchland (523097) to G03-13 (560029) 345kV line, near Hitchland. a. Apply fault at the Hitchland 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.	Stable
46	*Single phase fault and sequence like previous*	Stable
47	3 phase fault on the Hitchland (523097) to GEN-2005-017 (51700) 345kV line, near Hitchland. a. Apply fault at the Hitchland 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.	Stable
48	*Single phase fault and sequence like previous*	Stable
49	3 phase fault on the GEN-2005-017 (51700) to Potter Co. (523961) 345kV line, near GEN-2005-017. a. Apply fault at the GEN-2005-017 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.	Stable
50	*Single phase fault and sequence like previous*	Stable
51	3 phase fault on the Potter Co. 345kV (523961) to 230kV (523959) transformer, near the 345 kV bus. a. Apply fault at the Potter Co. 345kV bus. b. Clear fault after 5 cycles by tripping the faulted transformer.	Stable
52	*Single phase fault and sequence like previous*	Stable

Cont. No.	Description	Results for SP and WP
53	3 phase fault on the Woodward (515375) to Tatonga (515378) 345kV line, near Woodward. a. Apply fault at the Woodward 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.	Stable
54	*Single phase fault and sequence like previous*	Stable
55	3 phase fault on the Spearville (531469) to Knoll (530700) 345kV line, near Mingo. a. Apply fault at the Mingo 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.	Stable
56	*Single phase fault and sequence like previous*	Stable
57	3 phase fault on the Knoll (530558) to Smoky Hills (530592) 230kV line, near Knoll. a. Apply fault at the Knoll 230kV 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.	Stable
58	*Single phase fault and sequence like previous*	Stable
59	3 phase fault on the Hitchland (523097) to G05-017 (51700) 345kV line, near Beaver County. a. Apply fault at the Beaver County 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.	Stable
60	*Single phase fault and sequence like previous*	Stable
61	3 phase fault on the GEN-2003-013 (560029) to G06-49T1 (560940) 345kV line, near GEN-2003-013. a. Apply fault at the GEN-2003-013 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.	Stable
62	*Single phase fault and sequence like previous*	Stable
63	3 phase fault on the Medlodg (532781) to Comanche (531487) 345kV line, near GEN-2007-040. a. Apply fault at the GEN-2007-040 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.	Stable
64	*Single phase fault and sequence like previous*	Stable

Cont. No.	Description	Results for SP and WP
65	3 phase fault on the Woodward (515375) to Comanche (531487) 345kV line, near Beaver County. a. Apply fault at the Beaver County 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.	Stable
66	*Single phase fault and sequence like previous*	Stable

Section 4. Conclusions

The findings of the impact study for proposed interconnection Gen-2007-025 (the "Project") considered at 100% the proposed 300 MW installed capacity are:

1. The results of the Power Factor analysis showed that with the MVAR capability of the Clipper 2.5 MW WTGs and without reactive compensation, the wind farm will not be able to keep the voltage schedule at the POI consistent with the voltage schedule in the provided power flow cases for summer and winter. Additional VAR compensating devices need to be installed for the customer to maintain a power factor at the point of interconnection in the ±-0.95 range.
2. Using Clipper 2.5 MW WTGs, the stability simulations for 66 specified test disturbances did not find any angular or voltage instability problems in the SPP system. The study finds that the interconnection of the proposed 300 MW Project does not impact stability performance of the SPP system for the contingencies tested on the supplied base cases.