System Impact Study

Steel Park Project

Phase I - 15MW
Interconnected to UniSource 69kV
System near Kingman

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EXECUTIVE SUMMARY

Western Wind Energy proposes to construct 15 – 1MW wind generators located just south of Kingman, Arizona by late 2006. The proposed generation, known as the Steel Park Project, is located within approximately 1 mile of the UniSource Kingman 69kV system. Specifically, this impact study reviews the interconnection to the Griffith to South Kingman 69kV line, approximately 6.5 miles from the Griffith 69kV substation. This particular 69kV line (known as Griffith 69kV circuit 152) is a radial system with the Griffith 230/69kV transformer as the primary source for the 69kV Kingman area system. This analysis reviewed both 2006 on-peak and off-peak system conditions.

Based on the results of this System Impact Study, the addition of 15MW of wind generation to the Griffith – South Kingman 69kV system may be interconnected with little to no impact to the Kingman area regional system. Interconnecting close to the source has an effect of reducing the source flow, and losses, from the Griffith 230/69kV transmission station and provides for an additional source for this area. An injection of 15MW at the point of interconnection was found to also increase the overall voltage profile of the 69kV Kingman system. Loss of the generator step-up transformer at the point of interconnection did not cause significant voltage deviations to the Kingman 69kV or interconnected transmission system.

The addition of the 15 1-MW wind generation turbines was found to add approximately 179A and 153A (for three-phase and single-line-to-ground respectively) to the fault current at the Griffith 230kV bus, or approximately a 1% increase. The increase in fault current at the point of interconnection was found to increase by 730A and 675A (for three-phase and SLG respectively). At the Griffith 69kV bus, the increase in fault current was found to be approximately 675A for both three-phase and SLG (approximately a 13.5% incremental increase in fault current).

Due to the radial nature of the Kingman 69kV system, for the loss of the Griffith 230/69kV transformer (primary source), or for the loss of the 69kV line from Griffith to South Kingman, the Steel Park Project should also be disconnected from the system to prevent having the wind generation be "islanded" to serve the Kingman area loads. This would require the appropriate communication systems from the Steel Park Project interconnection station to the Griffith substation, as well as the appropriate protective relay and control systems.

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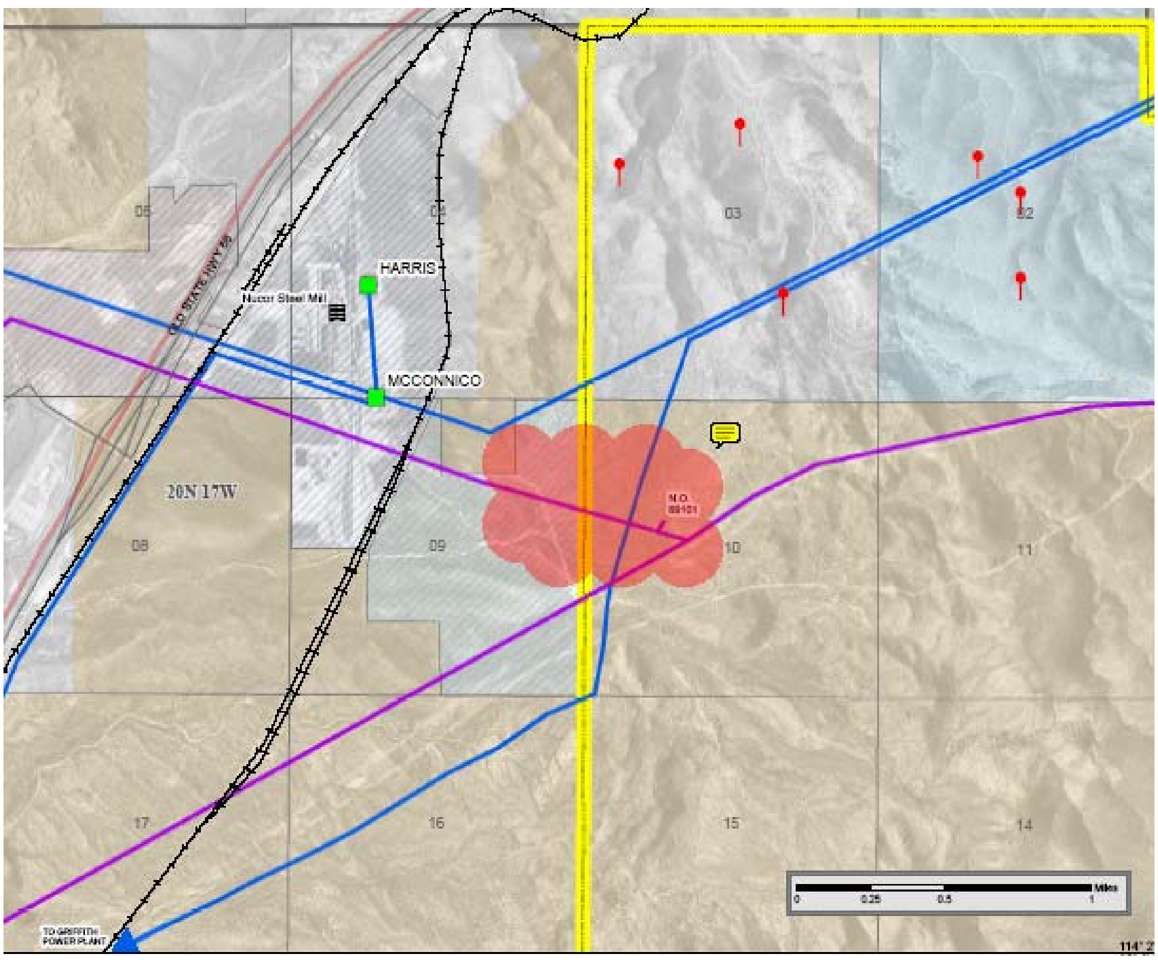
INTRODUCTION

Western Wind Energy ("WND") requested an interconnection to the Griffith 69kV system for 15MW of wind generation. WND proposes to construct 15 – 1MW wind generators located just south of Kingman, Arizona by late 2006. The proposed generation, known as the Steel Park Project, is located within approximately 1 mile of the UniSource Kingman 69kV system. Specifically, this feasibility study reviews the interconnection to the Griffith to South Kingman 69kV line, approximately 6.5 miles from the Griffith 69kV substation. This particular 69kV line is a radial system with the Griffith 230/69kV transformer as the primary source for the 69kV Kingman area system. This analysis reviewed both on-peak and off-peak system conditions.

The following area map shows the approximate location of the interconnection to the 69kV system (a larger area map is also included in Appendix A):



STUDY METHODOLOGY

A Heavy Summer 2006 and Light Winter 2006 WECC bulk cases for this analysis. The detailed 69kV representation from Griffith to Dolan Springs and Gold Strike substations was added to the bulk cases. The detailed 69kV line lengths and conductor information was provided by UES in AutoCAD format and converted to PSLF values using the ASPEN line constants program. The data supplied by UES and the ASPEN detailed conductor parameters are included in Appendix A.

Loads and power factor were adjusted for loads in the region per UES. Arizona's internal generation offset both the load changes in the pre and post project cases and the addition of the Western Wind generation in the post project cases.

Pre and post project cases were developed to identify the impacts due to the interconnection. Power Flow, Transient Stability and Short Circuit analysis is included with this System Impact Study.

STUDY ASSUMPTIONS

The starting cases provided by UES from WECC were modified to include the detailed 69kV model for the Griffith 152 69kV circuit with expected loads, and typical power factor of loads in the region.

Modeling Assumptions:

- Transformer models for load serving transformers and step-up transformer for the turbine was provided by Western Wind as a realistic estimate at the point of interconnection. The detailed wind turbine step-up transformers were also provided by Western Wind from existing nameplate data for similar units.
- The addition of the 15MW wind turbines was offset with a reduction of APS West Phoenix generation.
- Loads are non-coincident peak loads, showing worst case loads were provided by TEP for the Heavy Summer (peak) season. A Light Winter (off-peak) WECC case was also reviewed in detail and included approximately 65% of the load level from the peak case; this load level is not necessarily the minimum load on this circuit, however acceptable for this level of generation (15MW) to be interconnected and is expected to be less that the minimum load on this circuit.
- Conductor information and lengths provided were accurate based on the UES data (refer to the Kingman area system one-line in Appendix A).
- Length from the point of interconnection (69/34.5kV substation near the 69kV disconnect 69-101) to the 34.5kV Steel Park collector system was estimated at approximately 4000 feet. The distance between the collector system and the units was assumed to be approximately 500 feet.

Contingency Analysis Assumptions:

- Local and selected regional contingencies were conducted to test the impact of the interconnection to the system.
- Voltage deviation greater than 5% as well as voltage less than .95 or greater than 1.05 p.u. was flagged with contingencies.
- Loadings on elements greater than or equal to 90% of normal rating pre and post contingency were flagged as included in the contingency tables.

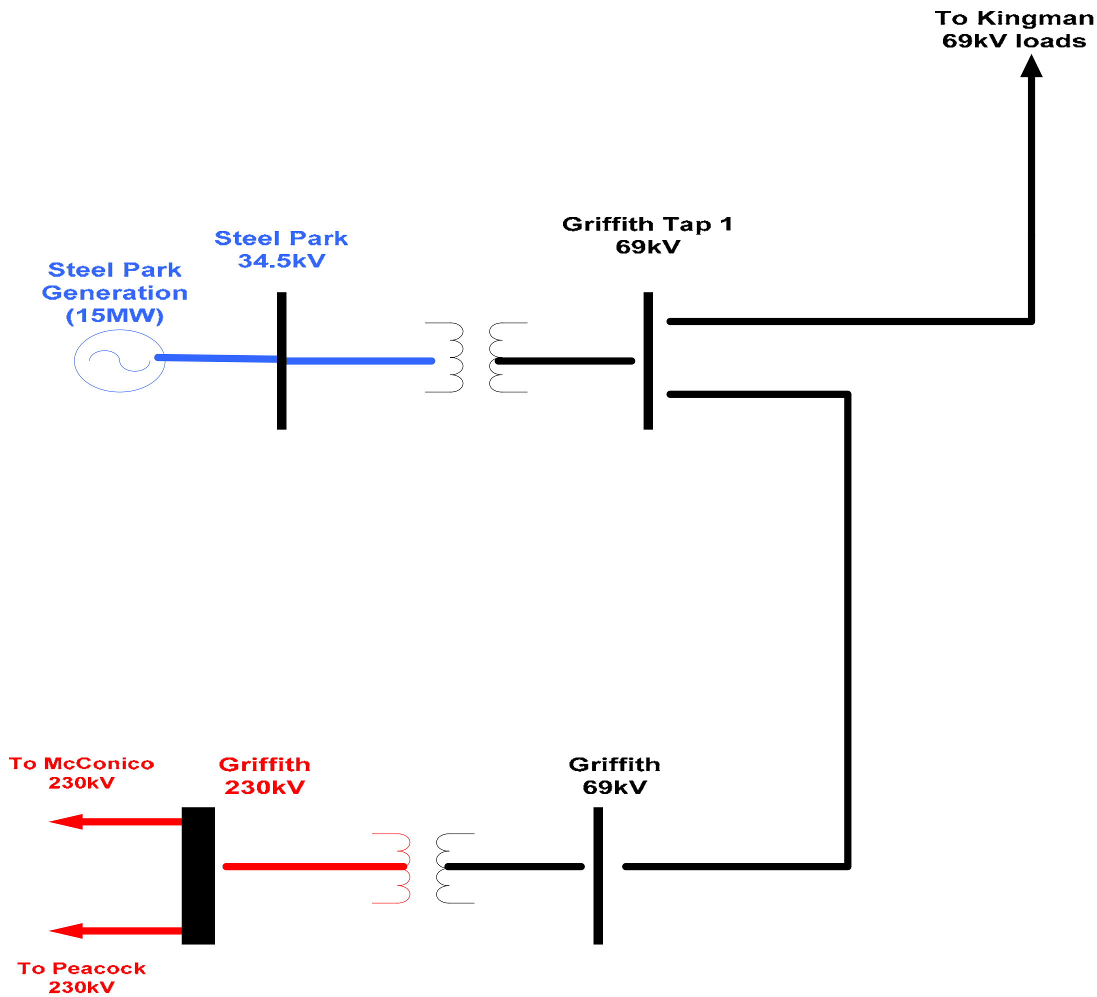
MODEL DETAILS

The wind turbines were represented for the power flow analysis as a single 15MW generator interconnected via a 7.5% impedance 34.5/69kV, 20MVA transformer to the Griffith Tap 1 (located near the normally open 69-101 69kV disconnect switch). For the stability and short circuit analysis, a more detailed model was prepared to represent the more realistic 34.5kV collector system for the wind turbines.

Appendix A contains additional modeling details, including lines modeled with associated line lengths, conductors and impedances.

ONE-LINE DIAGRAM

A simplified diagram of the interconnection to the Griffith 69kV circuit 152 below shows the configurations modeled for the power flow analysis.



STUDY EVALUATION CRITERIA

POWER FLOW

The following load-flow related criteria were used:

- Pre-disturbance bus voltage should be between 0.95 per unit and 1.05 per unit.
- Allowable voltage deviation of five (5) percent for N-1 Contingencies (deviation from pre-disturbance voltage).
- Allowable voltage deviation of ten (10) percent for N-2 contingencies (deviation from pre disturbance voltage).
- Post contingency bus voltage must be at least 0.90 per unit.
- Pre and post disturbance loading to remain within the emergency ratings of all equipment and line conductors. The emergency ratings are determined by the owner/operator of each equipment item.

In clarification of the above list, all tables and results for loading criteria were based on the normal or continuous rating (Rating 1) as identified in the cases.

STABILITY

The following stability criteria, per NERC/WECC criteria were used to evaluate the impact of the project:

WECC DISTURBANCE-PERFORMANCE TABLE OF ALLOWABLE EFFECTS ON OTHER SYSTEMS

NERC and WECC Categories	Outage Frequency Associated with the Performance Category (outage/year)	Transient Voltage Dip Standard	Minimum Transient Frequency Standard	Post Transient Voltage Deviation Standard (See Note 2)
A	Not Applicable	Nothing in addition to NERC		
B	≥ 0.33	Not to exceed **25%** at load buses or **30%** at non-load buses. Not to exceed **20% for more than 20 cycles** at load buses.	Not below **59.6** Hz for 6 cycles or more at a load bus.	Not to exceed **5%** at any bus.
C	0.033 – 0.33	Not to exceed **30%** at any bus. Not to exceed **20% for more than 40 cycles** at load buses.	Not below **59.0** Hz for 6 cycles or more at a load bus.	Not to exceed **10%** at any bus.
D	< 0.033	Nothing in addition to NERC		

[1]

[1] (Reference: Western Electricity Coordinating Council NERC/WECC Planning Standards, Revised August 9, 2002, page 12-13)

LOADS AND RESOURCES

The table below summarizes the load, generation, losses and flow changes in the cases.

	Summer (On Peak)		Winter (Off Peak)	
	Pre Project	Post Project	Pre Project	Post Project
Loads (MW)				
UES Griffith 69kV bus	22.67	22.67	15.41	15.41
UES Circuit 152	36.5	36.5	24.07	24.07
Generation (MW)				
WW Steel Park	0	15	0	15
Flow (MW)				
Griffith 230/69kV	60.6	45.5	40.1	25
Losses (MW)				
Losses 69kV	1.4	1.3	0.6	0.5
Area Interchange (MW)				
Arizona	2683.4	2683.4	6672.1	6672.1

POWER FLOW ANALYSIS

The following sections detail the results of power flow and contingency analysis. The back-up material for this analysis is included in the respective appendix.

2006 HEAVY SUMMER – ON PEAK

Please refer to Appendix C for the detailed power flow maps and contingency tables for the
The findings related to the summer peak case include:

- The pre-Project base case created for the on-peak analysis for the Griffith 152 circuit had low voltages (below 0.95 p.u.) near the end of the 69kV line (e.g. Dolan Springs, etc.). The power factor for the loads along this circuit was assumed to be 0.99; for the purposes of this analysis to determine the impacts of the interconnection closer to the loads, no additional voltage control devices or improvements to the power factor was modeled to correct the pre-Project voltage profile.
- The voltage improvement for the post-Project case was less than 1%; but the interconnection was found to improve the voltage profile along the circuit.
- The flow through the Griffith 230/69kV transformer was found to be about 15.1MW less for the post-Project cases, and was found to reduce losses by approximately 0.1MW on the 69kV system.
- Other than the outages related to the Griffith 230/69kV transformer and any outage along the radial 69kV line, no other incremental facility overloads or voltage violations were noted. An outage of the Griffith 230/69kV transformer or along the 69kV line will require a transfer trip mechanism to take the turbines off-line to prevent the turbines feeding the “islanded” system”.

2006 LIGHT WINTER – OFF PEAK

The findings related to the off peak cases include:

- No pre- or post contingency voltage violations in the study region were noted with or without the addition of the Project.
- The voltages along the 69kV circuit were greater than 0.975 p.u. for all cases primarily due to the reduced loads along the circuit compared to the on-peak cases.
- The voltage improvement for the post-Project case was less than 1%; but the interconnection was found to improve the voltage profile along the circuit.
- The flow through the Griffith 230/69kV transformer was found to be about 15.1MW less for the post-Project cases, and was found to reduce losses by approximately 0.1MW on the 69kV system.
- Other than the outages related to the Griffith 230/69kV transformer and any outage along the radial 69kV line, no other incremental facility overloads or voltage violations were noted. An outage of the Griffith 230/69kV transformer or along the 69kV line will require a transfer trip mechanism to take the turbines off-line to prevent the turbines feeding the "islanded" system".

TRANSIENT STABILITY ANALYSIS

MODEL DETAILS

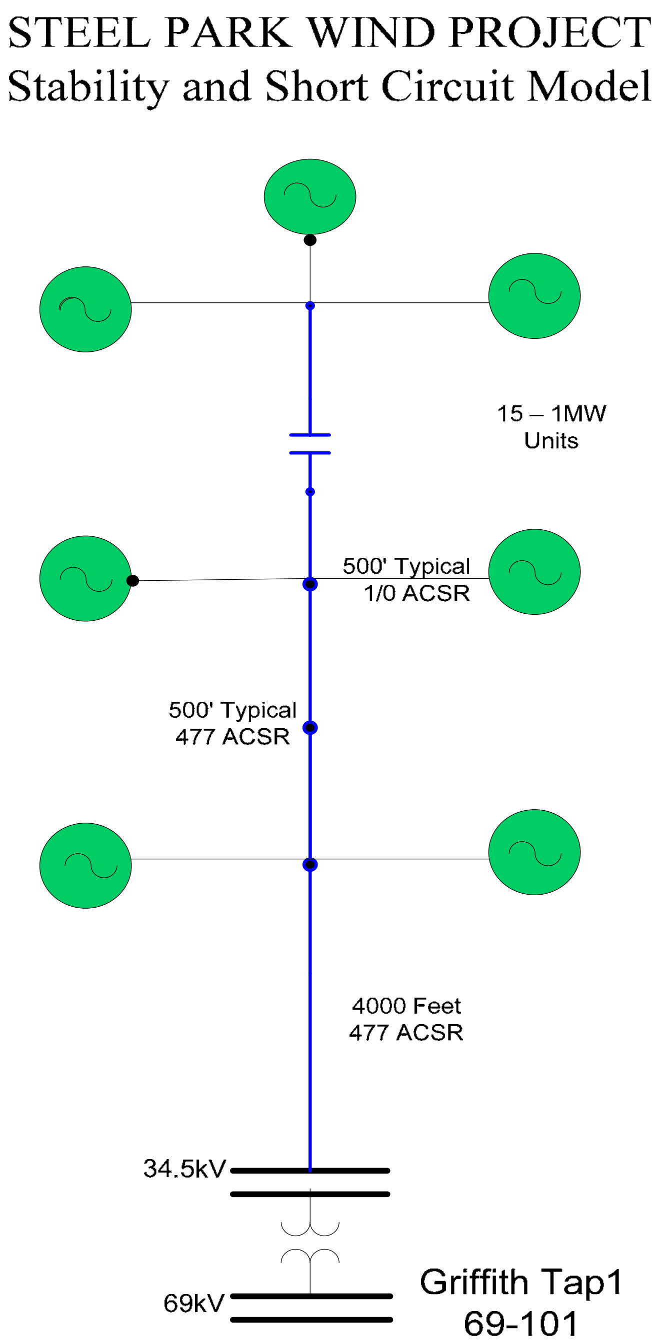
Wind Turbine Model Dynamics Parameters

For the transient stability analysis, a more detailed Project representation was used to accurately reflect the interaction of the units under various system conditions. The wind turbine dynamics parameters, provided by Mitsubishi, contained both a Level I model and a Level II model as the reference model for this System Impact Study. The primary difference is that the Level II model also contains detailed dynamics data for the "pitch controller" and other information for the fine tuning of the machines. The Level I model, according to Mitsubishi's data, will likely comply with WECC model requirements. The Level I model was used for the stability analysis of this System Impact Study. The detailed data for the Mitsubishi units is excluded from the report due to confidentiality agreements with Mitsubishi, however a copy has been transmitted to UniSource.

The 15 1-MW wind turbines were modeled in detail to represent the approximate location and collector system to cover approximately one square mile. From the 69/34.5kV interconnection station to the start of the collector system was assumed to be approximately 4000 feet. From each turbine to the collector system was assumed to be approximately 500 feet. The 34.5kV collector system conductor was modeled as 477 ACSR, and the individual drops to each of the units were modeled as 1/0 ACSR. The final distances and detailed collector system, as well as the 69kV interconnection requirements, should be reviewed in the Steel Park Facilities Study.

One Line Diagram – 15 1-MW Wind Turbines

The following diagram shows the modeled collector system for the wind turbine field.



OUTAGES STUDIED

The following transient stability outages were run for this portion of the impact study:

In Study Region:	External to Study region:
<u>In-region outages:</u> Griffith 69kV bus fault, followed by clearing, circuit 152, or the Griffith 69kV bus load Griffith 230kV bus fault, followed by clearing of the Griffith 230/69kV xfmr Steel Park 34.5kV fault, followed by clearing; single generator, or 34.5/69kV step-up xfmr and tripping of all generators Griffith-Peacock 230kV line Griffith-McConnico 230kV line	Palo Verde-Westwing 500kV (2 lines) McConnico-Davis 230kV McConnico-Hilltop 230kV Peacock-Liberty 230kV Peacock-Mead 230kV

MONITORED BUSSES

The following busses were monitored for their voltage response to an outage, with and without the wind turbine detailed model. Note that busses that represent tapped lines were not monitored.

In Study Region:	External to Study region:
*Griffith 230kV *Griffith 69kV *Steel Park 34.5 *Steel Park Unit 1 *North Kingman 69kV *Dolan Springs 69kV	*Peacock 230kV *Hilltop 230kV *McConnico 230kV *Davis 230kV

MONITORED CHANNELS

For Generators, the following parameters were monitored:

- Angle
- Speed
- Voltage
- Frequency

For Busses (with and without load) the following parameters were monitored:

- Voltage
- Frequency

WORST CONDITION ANALYSIS (WCA)

Worst Condition Analysis, the “WCA” option in the plot portion of PSLF did not note any deviations outside of the stability criteria.

FACILITY CLEARING TIMES

Per UES staff, the breaker clearing times in the Kingman area are 3.5 cycles. KRSA assumed a 5 cycle clearing time to account for relay and other delays when the outage is in the study region. All other clearing times reflect a 4-cycle clearing time.

STABILITY ANALYSIS FINDINGS

Outage Stability Summary

The following table indicates, for each outage studied, whether the outage resulted in a stable or unstable condition. Peak represents the Heavy Summer case while off-peak represents the Light Winter case. The "X" indicates the outage was not taken due to the element(s) did not exist in the "pre-project" cases.

Outage Description	Case			
	Peak Pre-Project	**Peak Post-Project**	**Off-Peak Pre-Project**	**Off-Peak Post-Project**
No outage	Stable	Stable	Stable	Stable
Bus Fault at Steel Park 1 34.5 w/ single generator trip	X	Stable	X	Stable
Bus Fault at Steel Park 34.5 w/, trip 34.5/69kV xfmr, Trip all Gens	X	Stable	X	Stable
Bus Fault at Griffith 69kV	Stable	Stable	Stable	Stable
Bus Fault at Griffith 69kV – trip Griffith-Griffith Tap 1	Stable	Stable	Stable	Stable
Bus Fault at Griffith 69kV – trip load at Griffith 69kV,	Stable	Stable	Stable	Stable
Bus Fault at Griffith 230kV – trip Griffith 230/69kV xfmr	Stable	Stable	Stable	Stable
Bus fault at Griffith 230kV – trip Griffith –McConnico 230kV line	Stable	Stable	Stable	Stable
Bus Fault at Griffith 230kV – trip Griffith- Peacock 230kV line	Stable	Stable	Stable	Stable
Bus Fault at McConnico 230kV – trip McConnico-Davis	Stable	Stable	Stable	Stable
Bus Fault at McConnico 230kV – trip McConnico-Hilltop	Stable	Stable	Stable	Stable
Bus Fault at Peacock 345kV – trip Peacock-Liberty	Stable	Stable	Stable	Stable
Bus Fault at Peacock 345kV – trip Peacock-Mead	Stable	Stable	Stable	Stable
Bus Fault at Westwing 500kV – trip two Westwing-Palo Verde 500kV lines (includes capacitor flashing and reclosing)	Stable	Stable	Stable	Stable

TRANSIENT STABILITY SUMMARY

The addition of the wind generators connected to the Griffith Tap 1 69kV bus along the radial system connected to Griffith 69kV system is stable but will require some mitigation of tripping the units for the loss of the Griffith 230/69kV system or the 69kV line from Griffith to the point of interconnection to avoid the Steel Park generation serving the local "islanded" system. The dynamic model used for this analysis appears to be a stable model and the system is well damped following the disturbances modeled in this study.

Due to the configuration of breakers in the UES system, it is already anticipated that an outage anywhere along the Griffith to Goldstrike 69kV line, including load busses beyond the wind turbines, will result in a transfer trip scheme to disconnect the wind turbines from the grid.

The following outages would cause the wind turbines to trip to avoid feeding the islanded system:

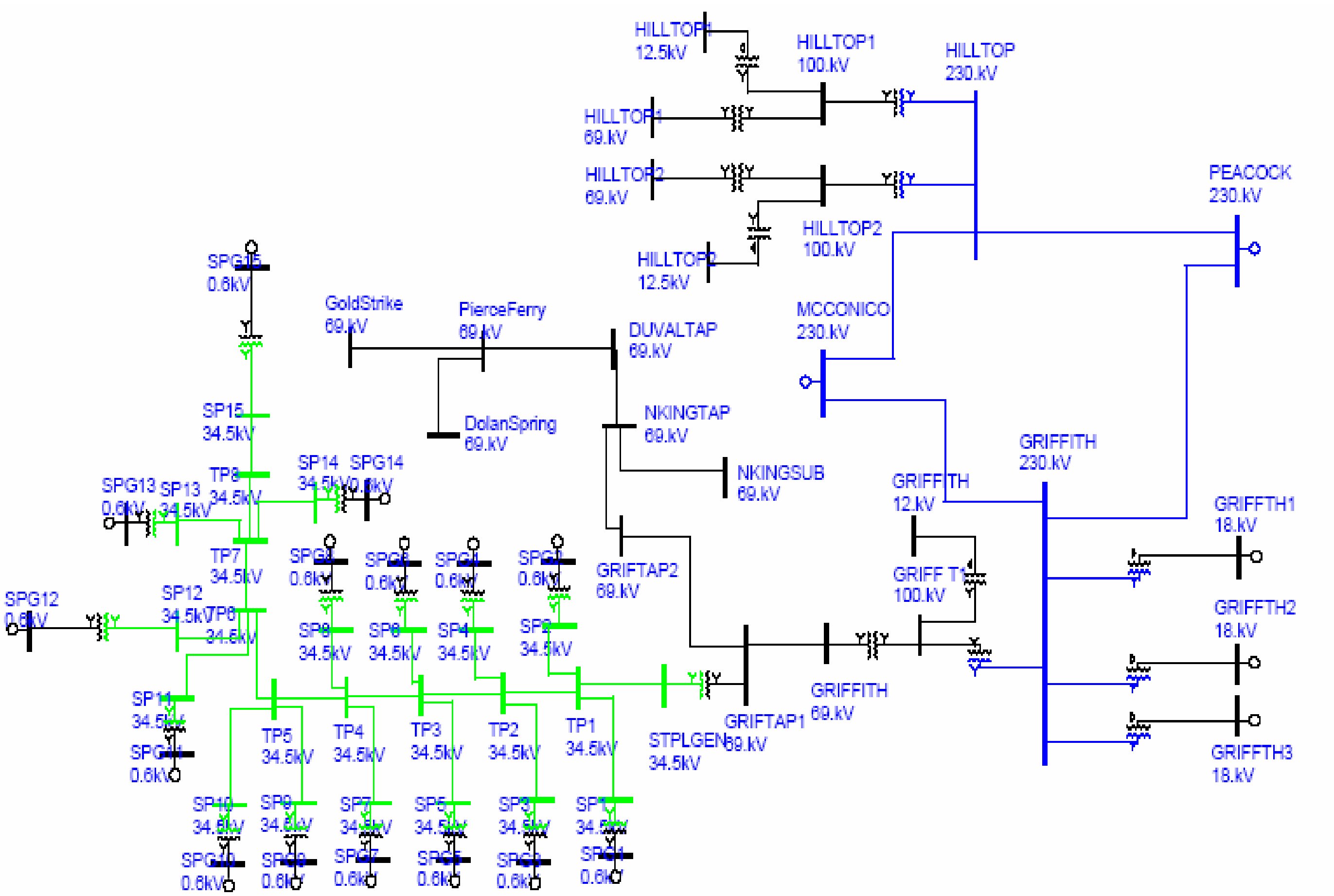
- Bus fault at Griffith 69kV bus and tripping of the 69kV line to Kingman;
- Bus fault at Griffith 230kV bus and tripping of the Griffith 230/69kV transformer;
- Bus fault at Steel Park 34.5kV bus or 69/34.5kV transformer

SHORT CIRCUIT ANALYSIS

The ASPEN One-Liner was used for the short circuit analysis of the interconnected system near Griffith under the Pre-Project and Post-Project conditions. Western Area Power Administration provided the equivalent network at both Peacock and McConnico, and the details of the model back to and including the Griffith 230kV substation and generation. The additional details from Griffith 230kV to Dolan Springs were added and compared to the analysis provided by Western for verification at the Griffith 69kV bus. The information provided by Western and the detailed modeling assumptions are included in Appendix G.

MODELING PARAMETERS

The following diagram depicts the model that was represented in ASPEN for the Short Circuit analysis.



SHORT CIRCUIT RESULTS

The following table summarizes the results from the Short Circuit Analysis:

	Pre-Project (amps)		Post-Project (amps)					
Faulted Bus	Three Phase	SLG	Three Phase	delta	percent	SLG	delta	percent
Peacock 230kV	11242	9930	11301	59	0.52%	9962	32	0.32%
Hilltop 230kV	9887	8837	9951	64	0.65%	8873	36	0.41%
McConnico 230kV	12206	11204	12318	112	0.92%	11271	67	0.60%
Griffith 230kV	13085	14233	13264	179	1.37%	14386	153	1.07%
Griffith 69kV	4746	5558	5420	674	14.20%	6233	675	12.14%
N. Kingman 69kV	1759	1216	1973	214	12.17%	1351	135	11.10%
Pierce Ferry 69kV	821	534	862	41	4.99%	558	24	4.49%
Goldstrike 69kV	446	286	457	11	2.47%	292	6	2.10%
Dolan Springs 69kV	642	401	667	25	3.89%	415	14	3.49%
GRIFTAP1 69kV	3079	2547	3809	730	23.71%	3222	675	26.50%
STPLGEN 34.5kV	2348	2178	4720	2372	101.02%	4254	2076	95.32%
SP#15 Turbine 34.5kV	2082	1786	4447	2365	113.59%	3846	2060	115.34%

Note: The Pre-Project values for STPLGEN 34.5kV and SP#15 Turbine are shown for the contribution of fault current from the 230/69kV system. Likewise for these same busses, for the Post-Project, the delta is representative of only the incremental fault contribution from the wind turbines.

UniSource will review the magnitude and incremental fault current data attributed to the interconnection. Western Area Power Administration should also review the incremental fault current at the 230kV level (highest at Griffith 230kV of 179 amps of incremental fault current).

LIST OF APPENDICES