Interconnection System Impact Re-Study

Final Report – February 15, 2010

Queue Interconnection Request No. TI-06-0929A
100 MW Wind Generation Facility Located Southwest of Burlington, CO

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1. Executive Summary

The Interconnection Customer (IC) submitted an Interconnection Request (IR) to the Transmission Provider ("TP") Tri-State Generation and Transmission Association, Inc. ("Tri-State") for a proposed Large Generation Project – Phase 1 Project ("Project" or "LGF") designated TI-06-0929A in the Tri-State interconnection request queue. The Project consists of approximately 100 MW of generation utilizing forty nine (49), 2.1 MW Suzlon S88 wind turbines, to be located approximately 40 miles southwest of the existing Burlington Substation, and interconnected to the Big Sandy-Burlington 230kV line. The proposed Commercial Operation Date (COD) of the Project is December 31, 2011, with an assumed In-Service Date (ISD for energization / back-feed service) of September 30, 2011. The IC requested that both Energy Resource (ER) and Network Resource (NR) interconnection service be studied.

Tri-State issued an Interconnection Feasibility Study (IFeS) Report for the Project on May 10, 2007. An Interconnection System Impact Study (SIS) was performed for this project in September 2008. Since that time, several senior-queued IR projects have withdrawn from the neighboring Western area Power Authority ("WAPA" or "Western") IR queue, and the IC has changed the type of wind generator to be used for this proposed project, therefore requiring that a re-study of this SIS be performed.

This SIS re-study has determined the following:

1. Preliminary identification of any thermal overloads, voltage limit violations or transient (dynamic) stability violations resulting from the interconnection of the proposed IC's LGF.
2. Preliminary identification of any circuit breaker short-circuit capability limits exceeded as a result of the interconnection.
3. Preliminary list of facilities, a non-binding good faith estimate of cost responsibility and a non-binding good faith estimated time to construct facilities necessary to interconnect the Project.

The Project was studied with and without the existing Lincoln and Burlington generation units on-line, utilizing 2010 heavy summer and 2010 light winter loading conditions, 2013 heavy summer loading conditions. The 2010 cases represent the expected transmission system at the time of Project interconnection. The 2010 light winter case also included a new 51 MW wind generation facility TI-08-0502 also connected on the Burlington - Big Sandy 230 kV line. The 2013 case models include TP Network Upgrades that are planned to be in-service in the near future, most notably a new 230kV transmission line from Burlington to Wray, a new 51 MW wind generation facility (TI-08-0502) also connected on the Burlington – Big Sandy 230kV line. This IR project has been studied on a "stand alone" basis, in that other projects that have not yet been approved or budgeted for, including other IR projects ahead in the Tri-State IR queue (except TI-08-0502), have not been included in the SIS study models.

There were twelve (12) facilities that have post-project overloads caused by addition of the Project that require mitigation. The most limiting condition is the 2010 light winter scenario with the Lincoln, Burlington and TI-08-0502 units dispatched up to the N-1 thermal limit of the Burlington-Bonny Creek 115 kV line, with the loss of the Lincoln-Midway 230kV line.

For 2010 light winter post-project conditions, with Lincoln and Burlington units dispatched, there are voltage deviations that were flagged using the WECC System Performance Criteria. Eleven (11) load buses had voltage deviations greater than 25% and had voltage deviations greater than 20% for 20 cycles or more for the Lincoln-Midway 230 kV line outage. For 2010 light winter post-project conditions, with Lincoln, Burlington and TI-08-0502 dispatched, there are voltage deviations that were flagged using the WECC System Performance Criteria. Sixteen (16) load buses had voltage deviations greater than 25% for the Lincoln-Midway 230 kV line outage. For all other transient stability simulations, the transmission system was adequately damped and all generators remained synchronized.

Addition of the Burlington-Wray 230 kV line is the recommended Network Upgrade required to mitigate the power flow and transient stability violations. Note however that the Burlington-Wray 230 kV line is presently included in Tri-State's capital budget plans and scheduled to be constructed by Tri-State and in service by the end 2012. Therefore, the IC may need to have its generation output curtailed under certain system operating contingencies between the requested Dec. 31, 2011 COD and the Dec. 31, 2012 completion date for the new Tri-State Burlington – Wray 230kVtransmission line. There is no available transmission capacity for certain system operating contingencies and the Project output could be fully curtailed as shown in Tables 2-4 and 2-5.

The only Network Upgrades necessary to interconnect this Project are those associated with constructing a new TP 230kV Interconnection Switching Station. The total approximate "good faith" estimated cost of constructing this new station, plus some associated communications equipment, is approximately **$ 4.674 million,** $ 0.727 million of which is for IC dedicated and non-refundable TP interconnection facilities, and the remaining $ 3.947 million is for TP Network Upgrades. The estimated time to design and construct this new interconnection switching station is 12 to 14 months after receiving authorization to proceed (E&P or IA signed between Tri-State and IC).

No equipment short circuit ratings in the vicinity of the Project were exceeded due to addition of the Project.

The IC facilities as modeled do not meet the TP operational requirements for voltage regulation and reactive power support at the POI but do meet the Low Voltage Ride Through Requirements. The IC shall provide additional data and study results as to the specific additional reactive support equipment (capacitors, DVAR, etc.) that will be installed in order to demonstrate that this IC facility can meet these operational requirements.

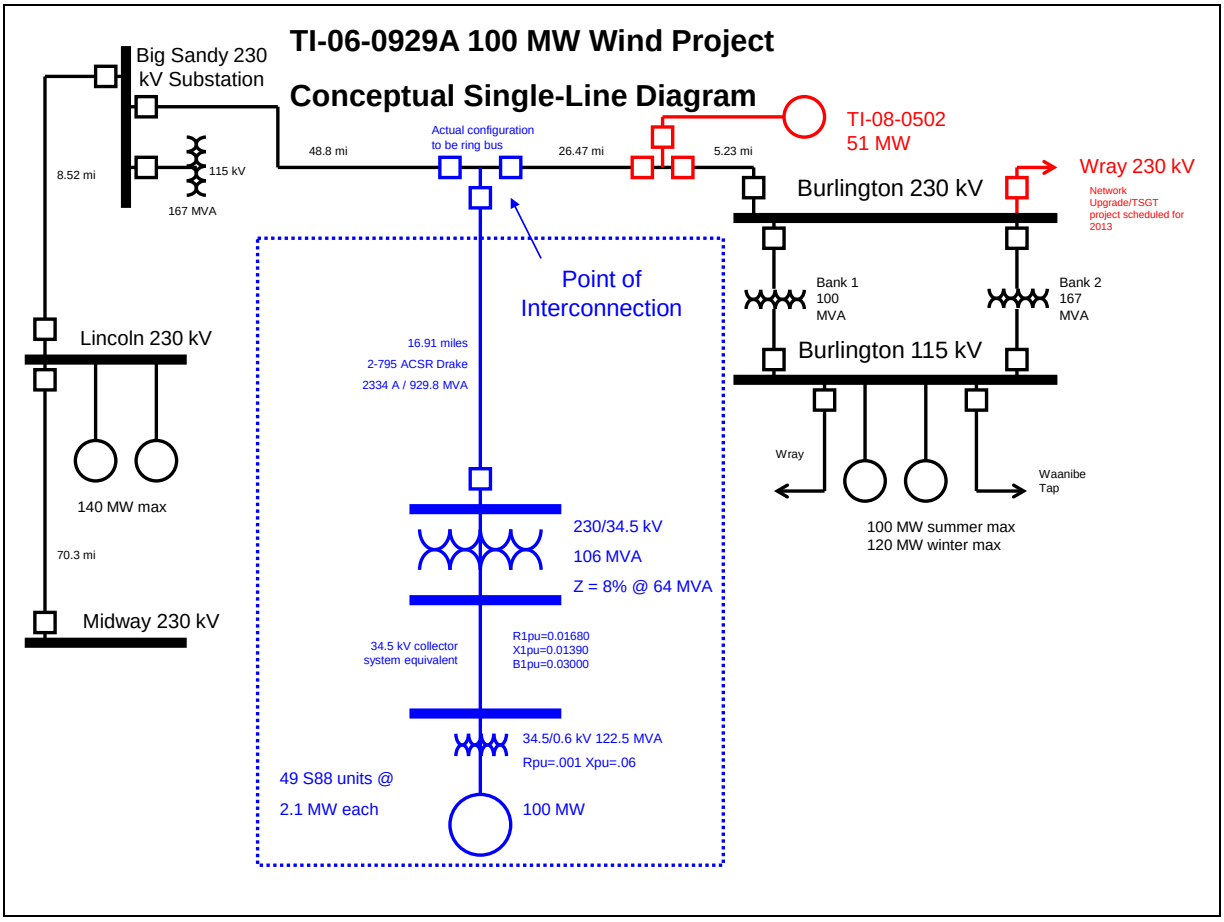
Nothing in this report shall constitute a request for transmission service, confers upon an Interconnection Customer any right to receive transmission service or implies transmission service is available. Note that the IC has initiated a request for evaluating point to point transmission service utilizing the Tri-State transmission system, under a separate Transmission Services Facility Study Request with Tri-State (TSR-08-1023). This TSR study is presently in progress.

2.0 Study Scope, Assumptions, and Results

2.1 Background – Basic Project Description & Study Scope

The IC's Phase 1 Project consists of forty nine (49), 2.1 MW Suzlon S88 wind turbines for a maximum net output of 100 MW. The Project is located approximately 40 miles southwest of the Burlington substation, to be interconnected to the TP's Big Sandy-Burlington 230 kV line at a new switching station located approximately 31.7 miles west of the Burlington substation. This study assumed an IC's 16.91-mile, 230kV radial interconnection transmission line, however the final constructed line length will depend on the line route used. The IC proposed Commercial Operation Date (COD) of the Project is Dec. 31, 2011, with an assumed corresponding In-Service Date (ISD) of approximately 3 months prior to the ISD, or September 30, 2011. For purposes of this SIS, the generation output of the Project will be scheduled as an NR to serve Tri-State's network load. Figure 2-1 shows a conceptual single-line diagram.

Figure 2-1: TI-06-0929A 100 MW Wind Project Conceptual Single-Line Diagram



This SIS consists of power flow (steady state), transient stability (dynamics), and short-circuit studies in order to identify a preliminary list of facilities, provide a non-binding

good faith estimate of cost responsibility and a non-binding good faith estimated time to construct facilities necessary to interconnect the Project.

Nothing in this report shall constitute a request for transmission service, confers upon an Interconnection Customer any right to receive transmission service or implies transmission service is available.

2.2 Steady-State Power Flow Studies:

2.2.1 Model Assumptions:

The following general assumptions were used for this study:

1. The Project consists of forty nine (49), 2.1 MW Suzlon S88 wind turbines for a maximum output of 100 MW modeled as one equivalent generator. The equivalent generator was modeled at 102.9 MW in order to obtain 100 MW net flow at the Point of Interconnection (POI).

2. The reactive capabilities of the generator was modeled at Qmax/Qmin=0.0 MVAr. 10 MVAr of shunt support was modeled at the Project 230kV bus to obtain unity power factor at the POI for power flow studies only.

3. The project was interconnected to the TP's Big Sandy - Burlington 230kV line at a new switching station located 31.7 miles west of the Burlington substation, through an IC-owned 16.91-mile 230kV line with bundled (2) 795 ACSR Drake conductor rated at 2,334A (929.8 MVA) as indicated by the IC. The final IC line length will likely increase slightly due to the final routing not being finalized, however this should not impact the results of these studies.

4. The main step-up transformer was modeled as a 230/34.5 kV transformer rated at 106 MVA with 8% impedance at 64 MVA. Individual unit 2.5 MVA, 34.5/0.600kV step-up transformers were modeled as one equivalent 122.5 MVA transformer with R1pu = 0.001 and X1pu = 0.06.

5. Detailed collector system information was not available so the collector system was modeled as a 34.5kV equivalent transmission line with R1pu=0.01680, X1pu=0.01390, B1pu=0.03000 with a continuous/emergency rating of 111 MVA using WECC typical values for a wind project of this size.

6. The Project was studied with the 100 MW output scheduled to Tri-State.

7. The preferred method to account for power injection is to reduce generation at one or more generating units in the area where the Project output is scheduled for delivery.

8. Regional transmission projects that will be operational by 2010 were modeled for the 2010 analysis.

9. Regional transmission projects that will be operational by 2013 were modeled for the 2013 analysis.

10. The project was studied as a stand-alone generation interconnection project for 2010 heavy summer conditions. The 51 MW wind generation facility TI-08-0502 was modeled for 2010 light winter and 2013 heavy summer conditions.

2.2.2 Power Flow Base Cases:

Seven (7) pre-project power flow cases were developed using available Western Electricity Coordinating Council (WECC) base cases.

1. 2010 Heavy Summer with Lincoln and Burlington Dispatched.
2. 2010 Heavy Summer without Lincoln and Burlington Dispatched.
3. 2010 Light Winter with Lincoln and Burlington Dispatched.
4. 2010 Light Winter with Lincoln, Burlington and TI-08-0502 Dispatched.
5. 2010 Light Winter without Lincoln, Burlington and TI-08-0502 Dispatched.
6. 2013 Heavy Summer with Lincoln, Burlington and TI-08-0502 Dispatched
7. 2013 Heavy Summer without Lincoln, Burlington and TI-08-0502 Dispatched.

These seven (7) cases were developed using the approved WECC 2009 Heavy Summer case 09hs3ap.sav and the approved WECC 2012 Heavy Summer case 12hs2ap. Updates were made to the Colorado area in the 2009 and 2012 power flow cases, to model the expected 2010 and 2013 transmission system and load levels, respectively.

For heavy summer cases, the Lincoln units are dispatched at 70 MW each (140 MW total) and the Burlington units were dispatched at 50 MW each (100 MW total). For the light winter cases, the Lincoln units are dispatched at 70 MW each (140 MW total) and the Burlington units were dispatched at 51 MW each (102 MW total). The output of the Burlington units is limited from the winter ratings of 60 MW each (120 MW total) due to thermal loading on the Burlington-Bonny Creek 115kV line section for the loss of the Lincoln-Midway 230kV line. For the 2010 light winter case with TI-08-0502 project dispatched, one of the Burlington units was turned off. Power flow cases were created for both heavy summer and light winter conditions with and without Lincoln, Burlington and TI-08-0502 dispatched.

Seven (7) post-project power flow cases were developed from the pre-project cases:

1. 2010 Heavy Summer with Lincoln and Burlington Dispatched, with TI-06-0929A.
2. 2010 Heavy Summer without Lincoln and Burlington Dispatched, with TI-06-0929A.
3. 2010 Light Winter with Lincoln and Burlington Dispatched, with TI-06-0929A.

4. 2010 Light Winter with Lincoln, Burlington and TI-08-0502 Dispatched, with TI-06-0929A.
5. 2010 Light Winter without Lincoln, Burlington and TI-08-0502 Dispatched, with TI-06-0929A.
6. 2013 Heavy Summer with Lincoln, Burlington and TI-08-0502 Dispatched, with TI-06-0929A.
7. 2013 Heavy Summer without Lincoln, Burlington and TI-08-0502 Dispatched, with TI-06-0929A.

The post-project cases were developed by adding the TI-06-0929A 100 MW Project and reducing Tri-State generation by 100 MW. Tri-State generation was reduced as needed/as available in each post-project power flow case in the following order:

1. Rifle (QFAtlas ~85 MW)
2. Nucla (~105 MW)
3. Craig 3 (~400 MW)
4. Craig 2 (~400 MW)
5. Craig 1 (~400 MW)

The loads and resources for all power flow cases area summarized in Tables 2-1 and 2-2.

Table 2-1: 2010 Power Flow Cases Load and Resource Summary (all values shown in MW)

(MW)	2010 Heavy Summer (w/ LNC/BURL)	2010 Heavy Summer (w/out LNC/BURL)	2010 Light Winter (w/ LNC/BURL)	2010 Light Winter (w/ LNC/BURL/TI-08-0502)	2010 Light Winter (w/out LNC/BURL/TI-08-0502)
Generation					
Area 70 PSCO	7012	7247	3517	3437	3581
Area 73 WAPA/Tri-State	6151	5907	5385	5380	5312
Lincoln	140	0	140	140	0
Burlington	100	0	102	51	0
TI-08-0502	0	0	0	51	0
TI-06-0929A	100	100	100	100	100
Load					
Area 70	7553	7553	4146	4146	4146
Area 73	4989	4989	4255	4255	4255
Losses					
Area 70	233	229	145	66	144
Area 73	170	166	138	134	131
Interchange					
Area 70	-782	-542	-781	-782	-717
Area 73	990	750	990	990	925

Table 2-2: 2013 Power Flow Cases Load and Resource Summary (all values shown in MW)

(MW)	2013 Heavy Summer (w/ LNC/BURL/TI-08-0502)		2013 Heavy Summer (w/out LNC/BURL/TI-08-0502)	
	pre	post	pre	post
Generation				
Area 70 PSCO	7823	7821	7832	7829
Area 73 WAPA/Tri-State	6033	6033	6051	6045
Lincoln	140	140	0	0
Burlington	100	100	0	0
TI-08-0502	51	51	0	0
TI-06-0929A	0	100	0	100
Load				
Area 70	8170	8170	8170	8170
Area 73	5676	5676	5676	5676
Losses				
Area 70	237	235	246	243
Area 73	172	172	190	184
Interchange				
Area 70	-593	-593	-593	-593
Area 73	184	184	184	184

2.2.3 TP Steady-State VAR, and Voltage Regulation Requirements:

(Note - while these generally apply to wind generation facilities, the TP requires that PV solar plants also meet these capabilities.)

1. All interconnections are subject to detailed study and may require mitigation in excess of minimums imposed by published standards, according to the best judgement of Tri-State engineers. The IC's Large Generating Facilities (LGF) shall be capable of either producing or absorbing reactive power (VAr) as measured at the POI bus at an equivalent 0.95 p.f., across the range of near 0% to 100% of facility MW rating, with the magnitude of VAr calculated on the basis of nominal POI voltage (1.0 p.u. V). For this **100 MW** rated facility the magnitude of reactive power capability required would range up to **32.9 MVAr** at the IC facility's rated MW output level, as measured at the **230kV** POI bus. This would be the net MVAr able to be either produced or absorbed by the IF facility, depending upon the voltage regulating conditions at the POI (see next item).

2. The POI voltage range where the IC's LGF may be required to produce VAr is from 0.90 p.u. V through 1.04 p.u. V. In this range the IC facilities are being utilized to help support or raise the POI bus voltage.

3. The POI voltage range where the IC's LGF may be required to absorb VAr is from 1.02 p.u. V through 1.10 p.u. V. In this range the IC facilities are being utilized to help reduce the POI bus voltage.

4. Note that the POI voltage range where the IC's LGF may be required to either produce VAr or absorb VAR is 1.02 p.u. V through 1.04 p.u. V, with the typical target regulating voltage being 1.03 p.u. V.

5. The IC's LGF may supply reactive power from the generators, from the generators' inverter systems alone (if capable), or a combination of the generators, generators' inverter systems plus switched capacitor banks and/or reactors, or continuously variable STATCOM or SVC type systems. The IC's LGF is required to supply a portion of the reactive power (VAR) in a continuously variable fashion, such as supplied from either the generators' inverter systems, or a STATCOM or SVC system. The amount of continuously variable VAR shall be a value equivalent to a minimum of 0.95 p.f. produced or absorbed at the generator collector system substation Medium Voltage (MV) bus, across the full range (0 to 100%) of rated MW output. The remainder of VAR required to meet the 0.95 p.f. net criteria at the HV POI bus may be achieved with switched capacitors and reactors, so long as the resultant step-change voltage is no greater than 3% of the POI operating bus voltage. This step change voltage magnitude shall be initially calculated based upon the minimum system (N-1) short circuit POI bus MVA level as supplied by the TP.

6. Under conditions when the IC's LGF is not producing any real power (near 0 MW), the reactive power exchange at the POI shall be near 0 MVAr ("VAr neutral"). This condition assumes that the facility needs to remain energized to supply base-level station-service "house power" for the control facilities, maintain wind turbines on turning gear, etc., and that tripping open the IC transmission line supply is not a normal or acceptable means to create this VAr neutral condition. In this non-generating mode, the IC Facility appears as a transmission connected load customer, and therefore must meet TP's requirements for load p.f., which requires that the load p.f. be 0.95 or better.

7. All interconnections (ICs) are subject to being required to perform additional detailed study, utilizing more complex models and software such as PSCAD, EMTP, or similar, and may require mitigation in excess of minimums imposed by published standards, according to the best judgement of the TP's engineers.

2.2.4 Steady-State Power Flow Analysis Methodology:

For normal conditions, automatic transformer taps, switched shunt devices, area interchange control and phase-shifting transformers were allowed to adjust in solving the power flow cases. For contingency simulations, the power flow analysis considers a snapshot in time where automatic transformer taps and switched shunt devices are allowed to adjust, while phase-shifting transformers remain fixed; in addition, a system swing bus balances the system during each contingency scenario (i.e. area interchange control is disabled).

Power flow analysis was performed using the North American Electric Reliability Corporation (NERC)/Western Electricity Coordinating Council (WECC) planning standards. Power flow analysis was used to evaluate thermal and voltage performance of the transmission system for NERC/WECC Category A normal (all elements in-service) conditions and selected NERC/WECC Category B emergency (one element out of service) conditions. Category A (N-0) normal overloads are those that exceed

100% of normal ratings that occur with all facilities in service. Category B emergency overloads are those that exceed 100% of emergency ratings that occur due to a Category B contingency.

Reported normal and emergency thermal loading was limited to the condition where a modeled transmission component was loaded above 100% of the normal MVA rating (Rating A) or emergency MVA rating (Rating B) as entered in the power flow case, and the incremental increase in component loading, between pre-project and post-project, exceeded 2%.

Reported normal voltage violations were limited to the conditions where per unit (pu) voltages were less than 0.95 or greater than 1.05. Reported Category B emergency voltage violations were limited to the conditions where per unit voltages were less than 0.90 or greater than 1.10. In addition, only Category B voltage deviations greater than 5% between the pre and post-contingency and a 2% increase in voltage deviation between the pre and post-project power flow cases were recorded.

Additional voltage criteria specific to Tri-State are listed in the Table 2-3. Post contingency power transfer capability is subject to voltage constraints as well as equipment ratings. Each option was tested against NERC/WECC reliability criteria and additions/exceptions as listed in the following table:

Table 2-3: *Voltage Criteria for ER and NR Studies

Tri - State Voltage Criteria for Steady State Power Flow Analysis			
Conditions	Operating Voltages	Delta-V	Areas
Normal N-0	0.95 - 1.05		All
Contingency N-1	0.90 - 1.10	7%	Northeastern New Mexico
Contingency N-1	0.90 - 1.10	7%	Southern New Mexico
Contingency N-1	0.90 - 1.10	6%	Other buses in PNM area
Contingency N-1	0.90 - 1.10	7%	Western Colorado
Contingency N-1	0.90 - 1.10	7%	Southern Colorado
Contingency N-1	0.90 - 1.10	6%	Other Tri-State areas

**NOTE: See additional TP reactive power and voltage requirements below.*

In addition, transmission line and transformer ratings were monitored for equipment rating violations using Normal Rating for N-0 and Emergency Rating for N-1 as listed in the power flow data.

2.2.5 Steady-State Power Flow Analysis Results:

Power flow analysis was performed on all pre-project and post-project cases. The results were compared to determine the impacts caused solely by the addition of the Project and to identify the system reinforcements necessary to mitigate the adverse impacts.

The Category B contingencies included all single contingency outages (N-1) located within 7 to 8 transmission buses of the Project. A complete listing of contingencies is included in Appendix A.

Note that comments were received from WAPA after these studies were completed regarding the status (closed or open) of a 115kV line section between Liberty – Hell Creek Tap, and Tri-State determined that the line is actually operated normally open between Anton – Arickaree. In the study models both of these line sections were operated closed, but it is believed that these operating conditions do not impact the primary results regarding the Network Upgrades required for the NR. Additional sensitivity studies may need to be performed when final operating procedures, etc. are being investigated for mitigating overloaded elements until the Network Upgrades have been completed.

2.2.5.1 Thermal Loading Contingency Analysis: 2010 Heavy Summer Case

For 2010 heavy summer conditions with Lincoln and Burlington units dispatched, there were no facilities with Category A normal thermal overloads, ***five (5) facilities with Category B emergency thermal overloads,*** and no voltage violations, caused solely by the addition of the Project. The criteria violations, caused solely by the addition of the Project are shown in Table 2-4.

Table 2-4: Contingency Violation Summary - 2010 Heavy Summer with Lincoln and Burlington Units

2010 Heavy Summer with Burlington/Lincoln CTs-Category B Emergency Percent Loading		Rating (MVA)	Case Percent Loading		Maximum Output w/out Upgrade (MW)
Monitored Element	Contingency Description		Pre	Post	
Big Sandy-Last Chance 115kV Line	Lincoln-Midway 230kV Line Outage	109	64	105	90
Bonny Creek-South Fork 115kV Line	Lincoln-Midway 230kV Line Outage	120	81	128	40
Bonny Creek-South Fork 115kV Line	TI060929A-Big Sandy 230kV Line Outage	120	38	121	70
Burlington-Bonny Creek 115kV Line	Lincoln-Midway 230 kV Line Outage	120	87	134	25
Burlington-Bonny Creek 115kV Line	TI060929A-Big Sandy 230kV Line Outage	120	45	128	65
Last Chance-South Woodrow 115kV Line	Lincoln-Midway 230kV Line Outage	109	53	100	95
South Fork-Idalia 115kV Line	Lincoln-Midway 230kV Line Outage	120	65	106	85

For 2010 heavy summer conditions without Lincoln and Burlington units dispatched, there were no facilities with Category A normal thermal overloads, no facilities with Category B emergency thermal overloads, and no voltage violations, caused solely by the addition of the Project.

2.2.5.2 Thermal Loading Contingency Analysis: 2010 Light Winter Case

For 2010 light winter conditions with Lincoln and Burlington units dispatched, there were no facilities with Category A normal thermal overloads, ***twelve (12) facilities with Category B emergency thermal overloads*** and no voltage violations,

caused solely by the addition of the Project. The criteria violations, caused solely by the addition of the Project are shown in Table 2-5.

Table 2-5: Contingency Violation Summary - 2010 Light Winter with Lincoln and Burlington Units

2010 Light Winter with Lincoln/Burlington Units -Category B Emergency Percent Loading		Rating (MVA)	Case Percent Loading		Maximum Output w/out Upgrade ("ER" MW)
Monitored Element	Contingency Description		Pre	Post	
Anton-Arickaree 115kV Line	TI060929A-Big Sandy 230kV Line Outage	55	57	114	75
Big Sandy-Last Chance 115kV Line	Lincoln-Midway 230kV Line Outage	109	88	127	35
Bonny Creek-South Fork 115kV Line	TI060929A-Big Sandy 230kV Line Outage	120	73	153	35
Bonny Creek-South Fork 115kV Line	Lincoln-Midway 230kV Line Outage	120	99	147	0
Burlington-Bonny Creek 115kV Line	TI060929A-Big Sandy 230kV Line Outage	120	74	154	35
Burlington-Bonny Creek 115kV Line	Lincoln-Midway 230kV Line Outage	120	100	147	0
Gary-Beaver Creek 115kV Line	Lincoln-Midway 230kV Line Outage	109	94	139	20
Idalia-Vernon Tap 115kV Line	Lincoln-Midway 230kV Line Outage	120	85	127	40
Joes-Liberty 115kV Line	TI060929A-Big Sandy 230kV Line Outage	60	54	122	85
Last Chance-South Woodrow 115kV Line	Lincoln-Midway 230kV Line Outage	109	97	142	10
South Fork-Idalia 115kV Line	Lincoln-Midway 230kV Line Outage	120	86	128	35
South Woodrow-Woodrow 115kV Line	Lincoln-Midway 230kV Line Outage	109	96	141	15
Vernon Tap-Wray 115kV Line	Lincoln-Midway 230kV Line Outage	120	84	127	40
Woodrow-Gary 115kV Line	Lincoln-Midway 230kV Line Outage	109	95	140	20

For 2010 light winter conditions without Lincoln, Burlington and TI-08-0502 dispatched, there were no facilities with Category A normal thermal overloads, no facilities with Category B emergency thermal overloads and no voltage violations, caused solely by the addition of the Project. Power flow analysis was not performed for cases with TI-08-0502 dispatched since a thermal limit had already been reached without fully dispatching the Burlington units. The power flow results with TI-08-0502 dispatched with one Burlington unit turned off will be the same as shown in Table 2-5.

2.2.5.3 Thermal Loading Contingency Analysis: 2013 Heavy Summer Case

For 2013 heavy summer conditions both with and without Lincoln, Burlington and TI-08-0502 dispatched, there were no Category A or Category B thermal overloads or voltage violations caused solely by the addition of the Project. Additional 2013 analysis may be required due to recent changes to line ratings of WAPA owned 115 kV lines in the Fort Morgan/Beaver Creek areas.

Selected power flow plots are included in Appendix B. All power flow analysis was conducted with version 30.3.2 of Siemens-PTI PSSE software.

Reactive Support at the POI

For normal operation the wind farm should readily be able to demonstrate whether or not an IC's facilities are able meet the regionally established CCPG / VCG voltage regulation and reactive support (p.f. & MVAr) requirements as measured at the POI. The reactive power capabilities that are required at the 230kV POI in association with the full 100 MW IC facility rating are 32.9 MVAr produced (0.95 p.f. lag) to 32.9

MVAr absorbed (0.95 p.f. lead); see Section 2.3.1.A. Due to the fact that the wind farm's collector substation' main transformer absorbs significant MVAr when power (MW) is flowing through it, the IC facilities must supply enough MVAr to supply both the MVAr being absorbed by the transformer, plus the additional MVAr required to meet the net MVAr required at the POI. Utilizing only the IC generation facilities as supplied by the IC in the power flow models, a steady-state analysis was performed for the POI voltage levels already established by the dispatch in the cases being utilized for these studies. The results are shown in Table 2.6 below. Note that these results only reflect that the maximum reactive power capabilities that could be required for the full range of regulating bus POI voltage set points.

This analysis was done for base cases HS and LS only. Table 2-6 shows net reactive power flow into the system and voltage at both the lumped equivalent model generator terminals, and at the 230kV POI voltage bus, with different levels of wind generation, at fixed generator bus p.f. levels. Note that the POI bus voltage levels were dictated by the power flow case model dispatch conditions (Heavy Summer HS or Light Winter LW) and are only used to illustrate the reactive power (p.f. & MVAr) relationships between the generator bus and POI. Note that it is up to the IC to determine what specific main substation transformer voltage taps may be required, such as 1.025 p.u. or 1.05 p.u with a HV DETC, in order to maintain reasonable MV collector bus operating voltages across the possible range of POI HV bus voltages.

As this Table 2.6 illustrates, the plant does not have the ability to absorb/provide MVAr from/to the transmission system to meet the 0.95 lead to 0.95 lag power factor requirement. Therefore, to meet the 0.95 power factor requirement, some means of additional reactive support equipment, such as switched reactor/capacitor bank(s), STATCOM or SVC, etc. would be necessary to meet the net 0.95 p.f. (lead/lag) requirement for the IC facility, and the amount of supplemental reactive support will also vary depending upon the MW output of the facility. *It is up to the IC to determine the specific type and amount of reactive support equipment that they intend to install to demonstrate that the IC facilities can achieve this net 0.95 pf lead/lag capability across the 0 to 100 MW net generation output rating as measured at the 230kV POI. The results of these additional IC's studies will need to be provided to the TP for review prior to signing an IA and completion of the project. These reactive and voltage control capabilities as will be verified through operational testing to be completed during final project commissioning and before the project is deemed to be ready for Commercial Operation.*

Table 2-6 Reactive Power Capability Summary - HS & LW Base Case Study Conditions, Main WF Sub Transformer Taps at 230-34.5kV (without added MV switched caps or reactors).

Base Case	Fixed PF @ MV Gen Equiv Collector Bus	P, Q, V At Gen Equiv MV Collector Bus			Net P, Q, V, PF At HV POI Bus					
		Pgen (MW)	Qgen (MVAR)	Voltage (p.u.)	P (MW)	Q (MVAR)	PF @ POI	Voltage (p.u.)	Total MVAR Req'd to meet 0.95 PF at POI	Add'l MVAR Req'd to Meet 0.95 PF at POI
HS Base Case – 0.95 pf lag (producing +MVAR)										
	0.95	0	0.00	**0.955**	0.0	**8.7**	0.0	**0.950**	**0.00**	**8.7 (react)**
	0.95	25	8.21	**0.966**	24.9	**15.5**	0.849	**0.950**	**8.2**	**7.3 (react)**
	0.95	50	16.43	**0.975**	49.5	**19.5**	0.930	**0.950**	**16.4**	**3.1 (react)**
	0.95	75	24.65	**0.981**	73.9	**20.9**	0.962	**0.950**	**24.7**	**3.8 (cap)**
	0.95	102.9	32.87	**0.984**	100.8	**18.7**	0.983	**0.950**	**32.9**	**14.2 (cap)**
HS Base Case – *1.0 pf										
	1.00	0	0.00	**1.005**	0.0	**9.6**	0.0	**1.000**	**0.00**	**9.6 (react)**
	1.00	25	0.00	**1.004**	24.9	**8.4**	0.948	**1.000**	**8.2**	**0.2 (react)**
	1.00	50	0.00	**1.001**	49.5	**4.6**	0.996	**1.000**	**16.4**	**11.8 (cap)**
	1.00	75	0.00	**0.996**	73.9	**-1.8**	1.000	**1.000**	**24.7**	**26.5 (cap)**
	1.00	102.9	0.00	**0.986**	100.8	**-12.2**	0.993	**1.000**	**32.9**	**45.1 (cap)**
LW Base Case – 0.95 pf lead (absorbing -MVAR)										
	-0.95	0	0.00	**1.045**	0.0	**10.4**	0.0	**1.04**	**0.00**	**10.4 (react)**
	-0.95	25	-8.21	**1.033**	24.9	**0.9**	0.999	**1.04**	**-8.2**	**9.1 (react)**
	-0.95	50	-16.43	**1.018**	49.5	**-11.3**	0.975	**1.04**	**-16.4**	**5.13 (react)**
	-0.95	75	-24.65	**1.001**	73.9	**-26.7**	0.940	**1.04**	**-24.7**	**0 (2.1 exc)**
	-0.95	102.9	-32.87	**0.979**	99.8	**-46.4**	0.907	**1.04**	**-32.9**	**0 (13.5 exc)**

**NOTES:* *1) The MVAR produced for the 1.0 p.f. gen cases at low MW gen output levels are due to the combined effect of the MV collector system and HV transmission line capacitance in the model.*
2) This data is for is informational purposes; the IC must provide actual design data to show conformance to TP's reactive capability of the IC Facilities.

2.3 Dynamic Stability Studies:

2.3.1 Dynamic Stability Analysis Criteria and Assumptions:

2.3.1.A. Basic WECC Dynamic Criteria:

Dynamic stability analysis was performed in accordance with the NERC/WECC dynamic performance standard shown in Figure W-1 and Table W-1 of the NERC/WECC Planning Standard, Appendix II, and dated April 2003. Additional TP dynamic reactive power and voltage criteria are listed below.

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		

Table W-1: NERC/WECC Planning Standards, April 2003

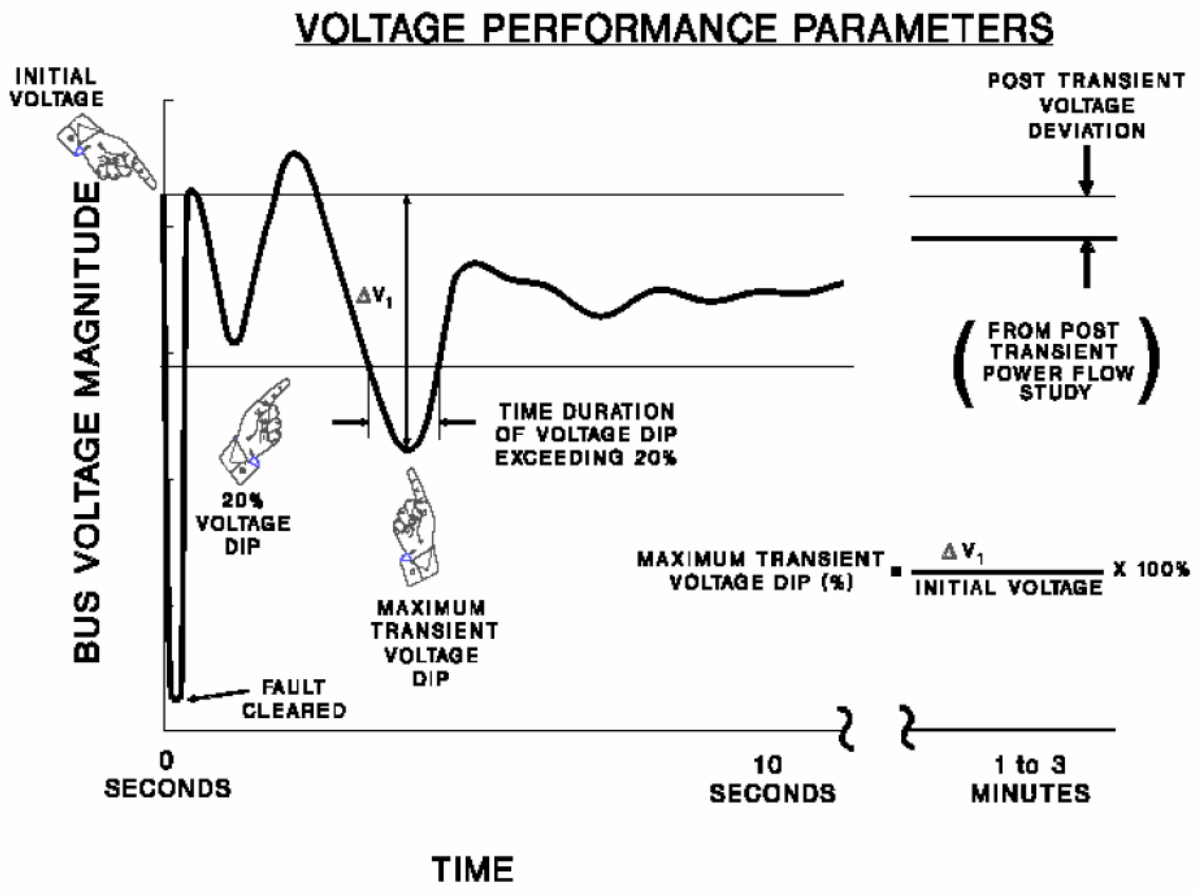


Figure W-1: NERC/WECC Planning Standards, April 2003

In addition, the NERC/WECC standard states:
"Relay action, fault clearing time, and reclosing practice should be represented in simulations according to the planning and operation of the actual or planned systems. When simulating post transient conditions, actions are limited to automatic devices and no manual action is to be assumed."

2.3.1.B. Tri-State's Dynamic VAR and *Voltage Ride-Through Requirements (consistent with FERC Order 661-A):
Note - while these requirements generally make reference to wind generation facilities, they shall apply to all types of generation interconnections., PV solar plants may be exempt if the requirement is not feasible.

1) The IC's LGF shall be able to meet the dynamic response Low Voltage Ride-Through (LVRT) requirements consistent with the latest WECC / NERC criteria. In particular, as per the Tri-State LGIP, Appendix G and FERC Order 661a for LVRT (applicable to Wind Generation Facilities).

2) Generating plants are required to remain in service during faults, three-phase or single line-to-ground (SLG) whichever is worse, with normal clearing times of approximately 4 – 9 cycles, SLG faults with delayed clearing, and subsequent post-fault voltage recovery to pre-fault voltage unless clearing the fault effectively disconnects the generator from the system. The clearing time requirement for a three-phase fault will be specific to the circuit breaker clearing times of the effected system to which the IC facilities are interconnecting. The maximum clearing time the wind generating plant shall be required to withstand for a fault shall be 9 cycles after which, if the fault remains following the location-specific normal clearing time for faults, the wind generating plant may disconnect from the transmission system. A wind generating plant shall remain interconnected during such a fault on the transmission system for a voltage level as low as zero volts, as measured at the Point of Interconnection (POI). To elaborate, before time 0.0, the voltage at the POI is the nominal system voltage. At time 0.0, the voltage drops. The plant must stay online for at least 0.15 seconds regardless of voltage during the fault. Further, if the voltage returns to 90 percent of the nominal system voltage within 3 seconds from the beginning of the voltage drop, the plant must continuously stay online. The Interconnection Customer may not disable low voltage ride through equipment while the wind plant is in operation.

3) This requirement does not apply to faults that would occur between the wind generator terminals and the high side of the GSU.

4) Generating plants may be tripped after the fault period if this action is intended as part of a special protection system.

5) Wind generating plants may meet the LVRT requirements of this standard by the performance of the generators or by installing additional equipment (e.g., Static VAR Compensator) within the wind generating plant or by a combination of generator performance and additional equipment.

2.3.1.C Additional Assumptions:

Transient (dynamic) stability analysis is a time-based simulation that assesses the performance of the power system during (and shortly following) a contingency. Transient stability studies were performed to ensure system stability following critical faults on the system.

The system is considered stable if the following conditions are met:

1. All machines in the WECC interconnected system must remain in synchronism as demonstrated by relative rotor angles.

2. System stability is evaluated based on the damping of the relative rotor angles and the damping of the voltage magnitude swings.

    a. A stability simulation will be deemed to exhibit positive damping if a line defined by the peaks of the machine relative rotor angle swing curves tends to intersect a second line connecting the valleys of the curves with the passing of time.

    b. Corresponding lines on bus voltage swing curves will likewise tend to intersect.

3. Transient voltage dips and duration requirements must meet the criteria of the WECC System Performance Criteria as shown in Table W-1.

4. Transient frequency dips and duration requirements must meet the criteria of the WECC System Performance Criteria as shown in Table W-1.

2.3.2 Dynamic Stability Analysis Methodology:

The following dynamic stability contingencies were applied to evaluate the network's compliance with NERC/WECC criteria for stability before and after the addition of the IC's LGF. Transient stability analysis was performed on all 2010 pre-project and post-project cases. The results were compared to determine the impacts caused solely by the addition of the Project and to identify the system reinforcements, if any, necessary to mitigate the adverse impacts.

Transient stability simulations, with five (5) cycle typical breaker clearing time, included:

1. Three-phase fault on Burlington-Wray 115kV line, near Burlington.
2. Three phase fault on Burlington-Smoky Hill 115kV line, near Burlington.
3. Three phase fault on Burlington 230/115kV transformer bank 2.
4. Three phase fault on Big Sandy 230/115kV transformer bank 1.
5. Three phase fault on Lincoln-Midway 230kV line, near Lincoln.
6. Three phase fault on Big Sandy-Lincoln 230kV line, near Big Sandy.

7. Three phase fault on Burlington-Big Sandy 230kV line, near Burlington.
8. Three phase fault on TI-06-0929A-Big Sandy 230kV line, near TI-06-0929A.
9. Three phase fault on TI-06-0929A-Burlington/TI-08-0502 230kV line, near TI-06-0929A.
10. Three phase fault at TI-06-0929A, 0.6kV, followed by loss of Project.
11. Three phase fault on Burlington-Wray 230 kV line, near Burlington[1].
12. Three phase fault on Burlington-TI-08-0502 230 kV line, near Burlington.
13. Three phase fault on TI-08-0502-Big Sandy 230 kV line, near TI-08-0502.

The duration of each stability simulation run was ten seconds. To allow for initial transient damping in the model, the transient performance analysis started 4 cycles after fault clearing and concluded at the end of the simulation.

Switching sequences for the transient stability simulations are included in Appendix C.

The Suzlon S88 dynamic user model was provided by Suzlon for purposes of this study. The user model was developed for use with PSSE version 30.3.x (S_SFSWT_S88_V418_V3_60.OBJ). For transient stability studies, the generator was modeled with Qmax=7.595 MVAr (producing) and Qmin=-43.884 MVAr (absorbing). This assumes that the generator is in voltage control mode with the minimum amount of fixed capacitors. The 10 MVAr shunt support modeled in the power flow case was turned off for transient stability simulations. The documentation provided by Suzlon with the user model indicates there are options for additional capacitors or a Static Synchronous Compensator (STATCOM) for improved voltage performance.

2.3.3 Dynamic Stability Analysis Results:

For 2010 light winter post-project conditions, with Lincoln and Burlington units dispatched, there are voltage deviations that were flagged using the WECC System Performance Criteria. Eleven (11) load buses had voltage deviations greater than 25% and had voltage deviations greater than 20% for 20 cycles or more for the Lincoln-Midway 230 kV line outage. For 2010 light winter post-project conditions, with Lincoln, Burlington and TI-08-0502 dispatched, there are voltage deviations that were flagged using the WECC System Performance Criteria. Sixteen (16) load buses had voltage deviations greater than 25% for the Lincoln-Midway 230 kV line outage.

The following load buses had voltage deviations greater than 25% and/or had voltage deviations greater than 20% for 20 cycles or more for the Lincoln-Midway 230kV line outage:

1. Anton 115kV (largest voltage deviation 27.9%)
2. Arapahoe 115 kV
3. Arickaree 115kV
4. Bonny Creek 115kV
5. Burlington 13.8 kV
6. Burlington KC 115 kV

[1] Mitigation 1 post-project outage only

7. Burlington PSCO 115 kV
8. Hell Creek 115kV
9. Idalia 115kV
10. Joes 115kV
11. Liberty 115kV
12. Limon 115 kV
13. Sage Brush 115kV
14. Smoky Hill 115 kV
15. South Fork 115kV
16. South Woodrow 115kV
17. Waanibe 115 kV

For all other transient stability simulations, the transmission system was adequately damped and all generators remained synchronized.

The IC facilities as modeled meet the Low Voltage Ride Through Requirements as specified in Section 2.3.1B.

Transient stability plots are included in Appendix D. All transient stability analysis was conducted with version 30.3.2 of Siemens-PTI PSSE software.

2.4 Mitigation Requirements - Network Upgrades

The criteria violations from the power flow and transient stability studies require transmission upgrades and/or additional facilities in order to interconnect the Project to the Tri-State transmission system. These mitigations have been determined through this SIS and TSR study work associated with this IC project.

2.4.3 NR – Mitigations required to eliminate the power flow/stability violations:

- No. 1: Add Burlington-Wray 230kV line (~60 miles Bittern 1272 ACSR 1538A).

2.4.4 ER - Mitigations required to eliminate the power flow/stability violations:

- No. 1: Add Burlington-Wray 230kV line (~60 miles Bittern 1272 ACSR 1538A);
- No. 2: Up-rate Big Sandy-Project-Burlington 230 kV lines[2] or add Big Sandy-Project #2 - 230kV line.

Power flow and transient stability analyses were performed with the Burlington-Wray 230kV line modeled. Addition of the Burlington-Wray 230 kV line is the recommended Network Upgrade required to mitigate the power flow and transient stability violations. Note however that the Burlington-Wray 230 kV line is presently included in Tri-State's capital budget plans and scheduled to be constructed by Tri-State and in service by the end 2012. Therefore, the IC may need to have its generation output curtailed under certain system operating contingencies between the requested Dec. 31, 2011 COD and the Dec. 31, 2012 completion date for the new Tri-State Burlington – Wray 230kV transmission line. Furthermore, based upon comments received from WAPA after these studies were

[2] Up-rating the Big Sandy-Burlington 230 kV line may not be feasible.

completed, additional sensitivity studies may need to be performed to identify for determining any specific may be need

2.5 Short-Circuit Studies:

2.5.1 Short Circuit Analysis Methodology

Short circuit analysis was performed to determine the maximum fault currents on buses in the vicinity of the Project. This study assessed the impact of increased fault duty resulting from the Project for single line-to-ground and three-phase faults. Equipment that may become over-stressed as a result of the added generation was identified if the fault duty exceeds 100% of its applicable interrupting capability.

The Short Circuit Analysis was performed by TP using Aspen's OneLiner Version 10.12 software. Various faults were simulated at the TP Big Sandy and Burlington 230kV buses, with and without the IC's facilities (new transformer and generator) connected into the TP transmission system POI. Fault currents were recorded to monitor any increase to fault duty at Big Sandy and Burlington substation and its equipment. The Thevenin Equivalent Impedance at the new TP Interconnection Switching Station without IC's facilities (new transformer and generator) connected into the TP transmission system POI are as follows.

2.5.2 Short Circuit Analysis Results

2.5.2.1 Faults on TP Interconnection Station POI 230kV Bus (without IC generation connected):

A. Thevenin System Equivalent Impedance (R + jX in ohms):

Z1 (pos. seq.) = 3.8169+j40.3778 ohm

Z2 (neg. seq.) = 3.80875+j40.2998

Z0 (zero seq.) = 12.0567+j62.5344

B. 3-ph Short Circuit MVA = 1,304.3

C. 3-ph Short Circuit Impedance Ratios:

X/R RATIO= 10.5786

R0/X1= 0.2986

X0/X1= 1.5487

Table 2-7: Short Circuit Results – Faults on Interconnection Station POI 230kV Bus

Fault	Current From Big Sandy 230kV	Current From Burlington 230kV	Current From POI SS 230kV	Total Fault Current
1LG w/o Xfmr. (3I0)	1,175 A	1,581 A	0 A	2,756 A
3LG w/o Xfmr. (+ Seq.)	1,826 A	1,448 A	0 A	3,274 A
1LG w/ Xfmr. (3I0)	944 A	1,271 A	967 A	3,177 A
3LG w/ Xfmr. (+ Seq.)	1,826 A	1,448 A	0 A	3,274 A
1LG w/ Xfmr. & Gen (3I0)	1,069 A	1,439 A	1,095 A	3,598 A
3LG w/ Xfmr. & Gen (+ Seq.)	1,826 A	1,448 A	724 A	3,998 A

Table 2-8: Short Circuit Results – Faults on Big Sandy 230kV Bus

Fault	Current From Big Sandy 230kV	Current From Burlington 230kV	Current From POI SS 230kV	Total Fault Current
1LG w/o Xfmr. (3I0)	4,198 A	608 A	0 A	4,806 A
3LG w/o Xfmr. (+ Seq.)	3,876 A	1,017 A	0 A	4,893 A
1LG w/ Xfmr. (3I0)	4,106 A	429 A	326 A	4,861 A
3LG w/ Xfmr. (+ Seq.)	3,876 A	1,017 A	0 A	4,893 A
1LG w/ Xfmr. & Gen (3I0)	4,276 A	447 A	340 A	5,063 A
3LG w/ Xfmr. & Gen (+ Seq.)	3,877 A	885 A	446 A	5,208 A

Table 2-9: Short Circuit Results – Faults on Burlington 230kV Bus

Fault	Current From Big Sandy 230kV	Current From Burlington 230kV	Current From POI SS 230kV	Total Fault Current
1LG w/o Xfmr. (3I0)	491 A	3,111 A	0 A	3,602 A
3LG w/o Xfmr. (+ Seq.)	1,353 A	1,579 A	0 A	3,323 A
1LG w/ Xfmr. (3I0)	349 A	2,962 A	356 A	3,667 A
3LG w/ Xfmr. (+ Seq.)	1,353 A	1,579 A	0 A	3,323 A
1LG w/ Xfmr. & Gen (3I0)	376 A	3,192 A	385 A	3,953 A
3LG w/ Xfmr. & Gen (+ Seq.)	1,229 A	1,579 A	488 A	3,686 A

These results indicate that the fault currents at the new TP Interconnection Switching Station POI 230kV bus are well within the TP equipment ratings, with or without the IC generation facilities connected to the TP transmission system.

2.6 Cost & Schedule Estimates

All network upgrade cost estimates provided are good faith budgetary estimates in 2009 dollars. There are no Network Upgrades identified in this report, other than the costs for design and construction of the new main TP interconnection 230kV Switching Station, connecting into the 230kV transmission line between Burlington and Big Sandy, and located approximately 32 miles from the Burlington Substation. See Figures 2.1, and 3 for reference.

Total Cost: The estimated total cost for this new switching station is:

- **$4.674 Million**. Refer to Figures 4 and 5 for additional details.

Customer Interconnection Facilities Costs: (Reference Fig. 4)

The portion of this total cost that is assigned as Transmission Provider's Interconnection Facilities is basically the equipment identified in the Figure 3 one-line diagram as located between the main bus tap POI and the Point of Ownership Change (POC) located at the dead-end structure terminating the IC's 230kV OHL. The costs for these facilities are assigned to the IC, and is estimated at:

- **$0.727 Million**

Network Upgrades Costs: (Reference Fig. 5)

The remainder of the equipment and costs for this switching station is assignable as Transmission Provider's Network Upgrades, is assignable as refundable over time to the IC, and is estimated to be:

- $**3.947 Million**

Note that there will be some additional Network Upgrades costs associated with the tie into the 230kV TP Big Sandy – Burlington transmission line. These include: possible modifications of the relaying protection at the Big Sandy and Burlington substations; communications circuits including fiber optic additions at Burlington Substation; and fiber optic circuit (OPGW) installation on the Burlington to Mansman Creek transmission line. These costs will be further identified in the Facilities Study Report.

Schedule - it is estimated that it will take approximately 12 to 14 months after authorization to proceed (E&P or IA signed between Tri-State and IC) for Tri-State design, procurement, and construction activities. This also assumes that no special permits, such as a Certificate of Public Convenience & Need (CPCN) are required from the CPUC, and other land permits, etc. are reasonably obtainable.

Figure 2-2 – TP 230kV Interconnection Switching Station One-Line Diagram (Preliminary)

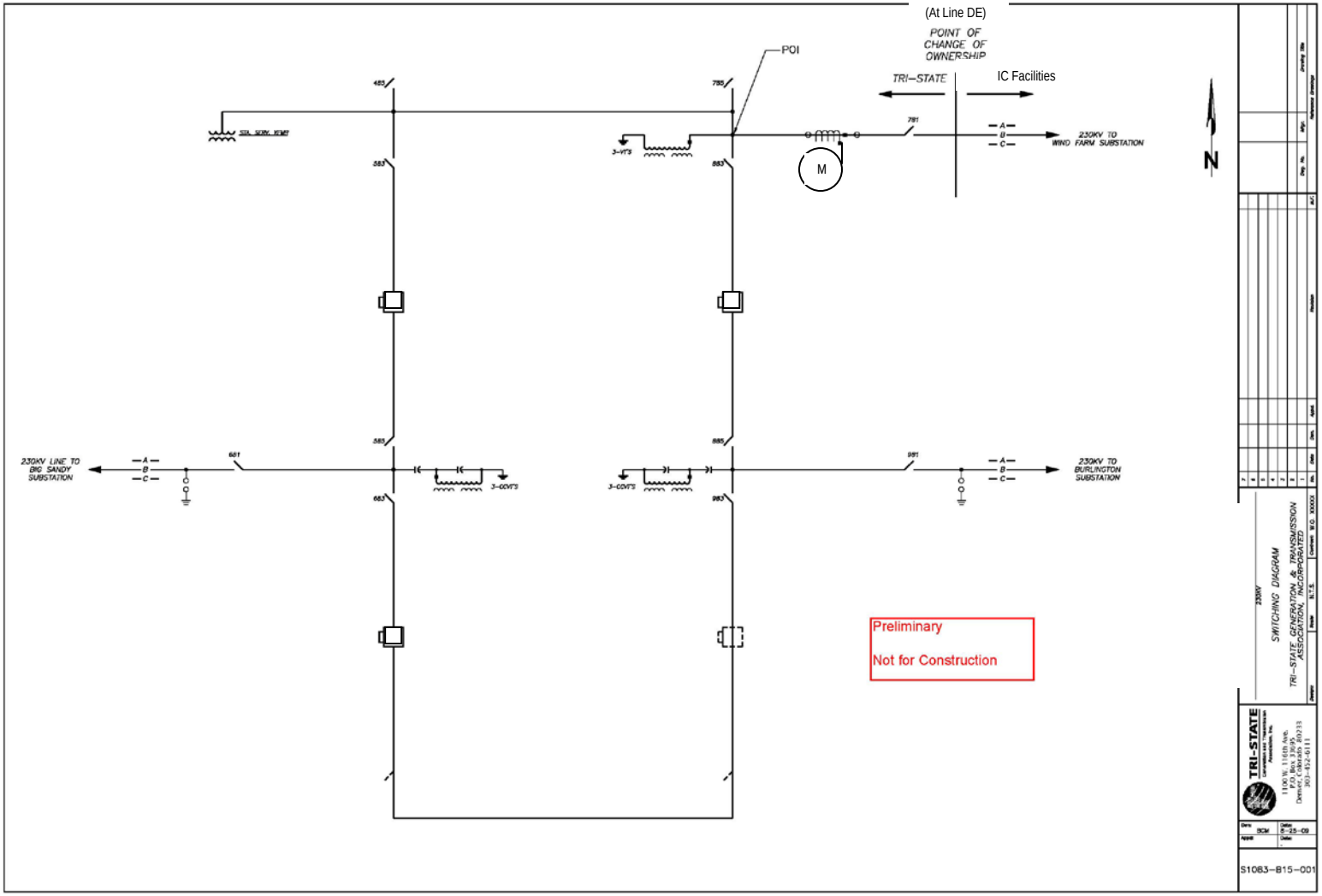


Figure 2-3: Summary Cost Estimate Sheet – Customer Interconnection Facilities Costs at TP Interconnection 230kV Switching Station (Non-Reimbursable)

Tri-State Generation & Transmission Assoc., Inc.
TRANSMISSION CAPITAL PROJECT ESTIMATE

Current Budget Year: 2010 CP# 97XX

Project Title: TP 230kV Intercon SS – TP Intercon Facilities (Non-Reimbursable) *Date Prepared* Rev 2-15-09 RAL

Estimated By: B. McGary/J. Olson / M. French *Estimated In-Service Date* 9-31-2011

Project Scope/Justification:

A new 230kV TP 230kV Intercon SS will be constructed on the Burlington to Big sandy line to serve a new wind generation project. The Interconnection Facilities portion of the switching station are comprised of one 230kV disconnect switch, three 230kV metering VTs, three 230kV metering CTs, a revenue metering panel and other typical yard equipment associated with this portion of the switchyard.

- This estimate does not include the purchase of any land.
- This estimate assumes all county and environmental permits will be obtained by others.
- This estimate assumes the Tri-State yard and the wind facility yard will be connected by adjoining facilities separated by a chain link fence.
- This estimate includes all site work, including grading, fencing, grounding, etc. inside the Tri-State switchyard.
- This estimate does not include access roads or any site work outside the Tri-State yard.
- Estimate includes Telecom work.

This Estimate represents costs to be incurred at the following facilities:

Facility Name	Wind Farm Switching Station	#	Facility Name		#
Facility Name		#	Facility Name		#
Facility Name		#	Facility Name		#
Facility Name		#	Facility Name		#

RUS Loan Category: New Construction/Equipment Purchase (10703) ***System:*** Tri-State East System

Joint Participation: *(Please indicate Joint Project Co. or Member/Non-Member Entity)*

Yampa Project CO 56 ☐ *Contract 0229 - CO 54* ☐ *Delta County - CO 60* ☐

Utility Services Agreement - CO 57 ☐ *Missouri Basin Power Proj - CO 60* ☐

		%	Project Cost
Member		0.00%	$0
Non-Member	Intercon Customer TI-06-0929A	100.00%	$727,000
	Tri-State's Share	0.00%	$0
PROJECT BUDGET		***TOTAL PROJECT ESTIMATE***	$727,000

Approval of Project Estimate:

Project Engineer		Date
Engineering Manager		Date
Senior Manager		Date
Vice President		Date

Wind Farm Switching Station-InterconnectorFacilities091012 - Scope

Figure 2-4: Summary Cost Estimate Sheet – Network Upgrade Facilities Costs at TP Interconnection 230kV Switching Station (Reimbursable)

Tri-State Generation & Transmission Assoc., Inc.
TRANSMISSION CAPITAL PROJECT ESTIMATE

Current Budget Year: **2010** CP# 97XX

Project Title: TP 230kV Intercon SS – TP Network Upgrade Facilities (Reimbursable) *Date Prepared* Rev 11-30-09 RAL

Estimated By: B. McGary/J. Olson / M. French *Estimated In-Service Date* 9-31-2011

Project Scope/Justification:

A new 230kV switching station will be constructed on the Burlington to Big Sandy line to serve a new wind farm. The station will be comprised of three 230kV gas circuit breakers, nine 230kV disconnect switches, six 230kV CCVT's, three 230kV metering CT's and three 230kV metering PT's.

- This estimate does not include the purchase of any land.
- This estimate assumes all county and environmental permits will be obtained by others.
- This estimate assumes two (2), single span transmission line taps on the existing Big Sandy to Burlington 230kV line.
- This estimate assumes the Tri-State yard and the IC WF Sub yard will be adjoining facilities separated by a chain link fence.
- This estimate includes all site work, including grading, fencing, grounding etc. inside the Tri-State yard.
- This estimate does not include access roads or any site work outside the Tri-State yard.
- Estimate includes Telecom work.

This Estimate represents costs to be incurred at the following facilities:

Facility Name	Wind Farm Switching Station	#	Facility Name		#
Facility Name		#	Facility Name		#
Facility Name		#	Facility Name		#
Facility Name		#	Facility Name		#

RUS Loan Category: New Construction/Equipment Purchase (10703) ***System:*** Tri-State East System

Joint Participation: *(Please indicate Joint Project Co. or Member/Non-Member Entity)*

Yampa Project CO 56 ☐ *Contract 0229 - CO 54* ☐ *Delta County - CO 60* ☐

Utility Services Agreement - CO 57 ☐ *Missouri Basin Power Proj - CO 60* ☐

		%	Project Cost
Member		0.00%	$0
Non-Member	Intercon Customer TI-06-0929A	100.00%	$3,947,206
	Tri-State's Share	0.00%	$0
PROJECT BUDGET	***TOTAL PROJECT ESTIMATE***		**$3,947,206**

Approval of Project Estimate:

Project Engineer		Date
Engineering Manager		Date
Senior Manager		Date
Vice President		Date

Wind Farm Switching Station-Network Upgrades - Scope

3.0 Conclusions:

This report presents the power flow, dynamic stability, short circuit and cost estimate components of a System Impact Re-Study to connect 100 MW of new wind generation as described in Interconnection Request No. TI-06-0929A.

Based upon the assumptions and subject to the qualifications stated herein, it has been determined that 100 MW may be interconnected at this location. It has been determined that the planned construction of a new 230kV Burlington to Wray transmission line by the TP for completion by the end of 2012 mitigates the single contingency thermal overloads and voltage violations identified in this Study. The Study provides indicative "good faith" cost estimates for the TP Interconnection and Network Upgrades required to connect the IC's Facilities to the TP's transmission system (new TP 230kV Switching Station and transfer tripping scheme). The Study has further identified that the IC facilities as modeled do not meet the TP operational requirements for voltage regulation and reactive power support at the POI, and that the IC shall provide additional data and study results as to the specific additional reactive support equipment (capacitors, DVAR, etc.) will be installed in order to demonstrate that this IC facility can meet these operational requirements. The Study has also identified that the IC facilities as modeled meet the Low Voltage Ride Through Requirements.

The requested COD is 12/31/2011, and an assumed ISD of 9/30/2011. As an ER study, the maximum output without upgrades for the 2010 light winter with Lincoln and Burlington units is 0 MW. The limiting facilities are Burlington-Bonny Creek and Bonny Creek-South Fork 115 kV line sections, due to the Lincoln-Midway 230 kV line outage. Therefore, if the IC wishes to operate between the 12/31/2011 COD and the completion of the new Burlington – Wray 230kV line that is required as identified in the NR portion of the study, then some type of arrangements and accommodations such as operating schemes, Special Protection Schemes, etc. need to be made between to IC and TP to curtail the IC generation should system conditions arise that could overload system elements. The specific schemes have not been identified in this Study, and would need to be separately performed by the TP in following study work.

The SIS was performed according to the assumptions shown in Section 3. A Re-study may be required if a higher queued project drops out of the queue, there is a modification of a higher queued project or any there are changes to the assumptions in this study. Any cost of Re-study shall be borne by the Interconnection Customer (IC). If a Re-study is required, Tri-State will notify the IC in writing. Such Re-study shall take not longer than sixty (60) Calendar Days from the date of notice.

Appendices

Appendix A: Steady-State Power Flow Study – List of N-1 Contingencies
AVAILABLE UPON REQUEST

Appendix B: Steady-State Power Flow Study – Plots
AVAILABLE UPON REQUEST

Appendix C: Dynamic Stability Study – Switching Sequences
AVAILABLE UPON REQUEST

Appendix D: Dynamic Stability Study – Waveform Plots
AVAILABLE UPON REQUEST

Appendix E: Power Flow Study – List CA 70, CA73 Generation Dispatch Levels
AVAILABLE UPON REQUEST