Transmission Service Request Study

Final Report

TSR-09-0814A
TSR-09-0814B

March 19, 2010

Background

Tri-State received two Transmission Service Requests #73325040 and #73325044 followed by letters of application dated August 18, 2009 which have been assigned OASIS Transmission Service Request Queue numbers of TSR-09-0814A and TSR-09-0814B respectively. The Transmission Customer requested 80 MW of Long-Term Firm Point-to-Point Transmission Service over Tri-State's system from a new 230kV interconnection point located approximately 20 miles north of Gladstone Substation (Point of Receipt) to the Ojo 345kV bus (Point of Delivery) (TSR-09-0814A). The same Transmission Customer requested an additional 20 MW of Long-Term Firm Point-to-Point Transmission Service over the same path (TSR-09-0814B).

An Interconnection System Impact Study (SIS) (TI-07-0301) for the proposed generation project was conducted and the preliminary results were issued on June 3, 2009. The location of the generation source for this request is a wind facility located in Colfax County, New Mexico as illustrated in Figure 1. The Interconnection SIS studied several different project sizes, network upgrade alternatives and dispatch options. In response to those preliminary results, additional study work was performed to address high loop flow conditions and light loading conditions. That study is currently in progress and will include transient stability and short circuit analysis. The Interconnection SIS should be referenced for a discussion of the performance of the transmission system with the proposed generation in service. The Interconnection SIS identifies transmission upgrades and facility additions required to interconnect the project to the Tri-State transmission system. Those facility additions are required to mitigate certain N-1 and fault conditions. The Interconnection SIS will provide a list of those facilities and a good faith estimate of cost and time required to interconnect the project.

In contrast to the Interconnection SIS, this Transmission Service Request Study evaluates the ability of the transmission system to provide the requested Long-Term Firm Point-to-Point Transmission Service taking into consideration Tri-State's native load requirements over the next ten years and existing committed uses for the requested transmission path. This Transmission Service Study will assess and determine the electrical impacts on Tri-State's transmission system and any system upgrades required to provide the transmission service based on steady state circuit limitations. This study does not perform any transient analysis since that is being performed in the Interconnection SIS. Proposed network upgrades indentified in this study are being coordinated with the Interconnection SIS. Actual facility ratings have been verified in this study so that maximum transmission capacity can be offered.

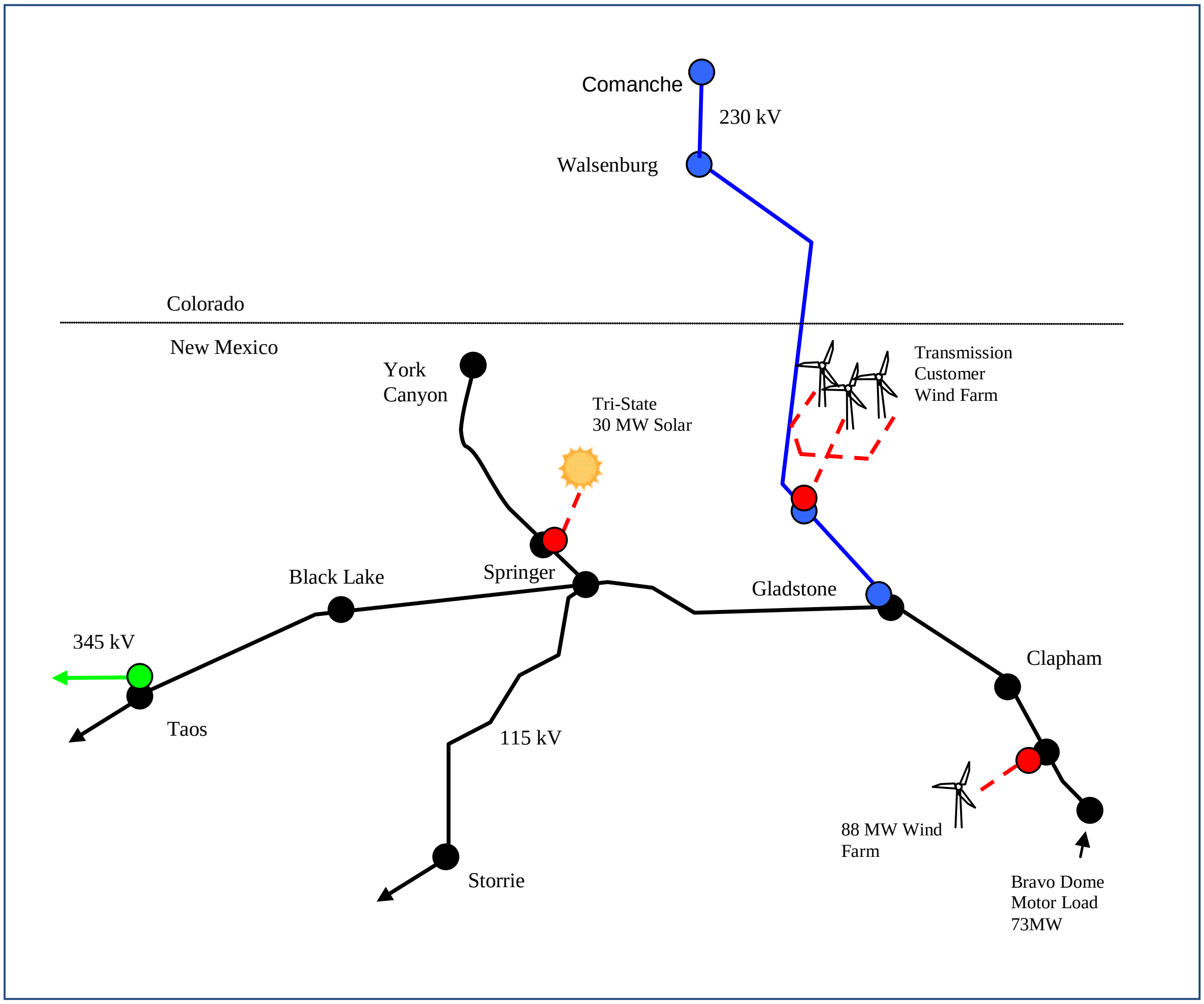

Figure 1– Single line diagram of the study area showing the location of the Transmission Customer.

Study Scope

This study consists of the following:

- Evaluation of the Available Transfer Capability (ATC) of the requested path which begins at a new 230kV interconnection north of Gladstone and continues to Gladstone, Springer, Black Lake, through the Taos 345kV/115kV transformer(s) and to the Ojo 345kV bus.

- Identification of thermal overload or voltage limit violations resulting from providing the Transmission Service along the requested path.

- Impacts of projected Tri-State's member system load growth through the 10 year planning horizon as it will affect the committed uses on the path and the ability of Tri-

State to provide the requested Transmission Service along with higher queued Transmission Service Requests.

- Description and non-binding, good faith estimate of the cost of additional Network Upgrades required to provide the requested Transmission Service.

Methodology

The Point Of Receipt to Gladstone 230kV portion of the requested path is a primary transmission source utilized by Tri-State to serve its native load in the geographical area of northeast New Mexico. Tri-State's native load obligation in this area consists of service to Springer Electric Cooperative, Southwestern Electric Cooperative, Mora-San Miguel Electric Cooperative and Kit Carson Electric Cooperative. Tri-State's total native load obligation is projected to be approximately 225 MW in the ten year planning horizon and is the amount of native load modeled in this Transmission Service Study. A portion of this total load-serving obligation is served over the requested path. Tri-State System Operations provided other firm committed uses for the requested path. There are no confirmed reserve obligations for the path.

Equation 1: ATC Equation

ATC = Total Transfer Capability (TTC) – Existing Transmission Commitments (ETC) – Transmission Reliability Margin (TRM)

- TTC was determined in accordance with Tri-State's *Engineering Standards Bulletin – Reliability Criteria for System Planning and Service Standards* which states the maximum loading criteria for transmission lines as a percent of the continuous rating. Based on that criteria, TTC in this study was defined as 100 percent of the thermal rating of the lowest rated line sections of the requested path. Therefore, TTC was determined to be 169 MVA which is the thermal rating of the Gladstone – Springer 115 kV line, and 230 MVA which is the thermal rating of the Springer to Black Lake to Taos 115kV line.

- ETC is defined as Tri-State native load-serving needs, existing commitments for transmission service and existing commitments for purchase/exchange/delivery. Existing (non native load) commitments for transmission service total 88 MW on the Gladstone 115kV to Ojo 345kV portion of the requested path.

- TRM is defined as loop flow across the requested path and transfer capability required to ensure reliable system operation as system conditions change. WECC operating practice requires transmission providers to accommodate some through-flow which may decrease ATC. TRM is also utilized to deliver and receive reserve obligations associated with a Reserve Sharing Group.

This study was conducted in two steps:

1. A non flow-based analysis of the projected uses of the requested path was conducted. ETC and TRM were determined from a pre-project system normal flow-based analysis. That analysis turned off other generation interconnections utilizing the same point-to-point transmission path as this Transmission Customer. Other existing commitments for transmission service were researched. ATC was calculated.

2. A flow-based analysis was also conducted to verify that actual system performance with the injection of 100 MW at the Point of Receipt was not more limiting than the results obtained from the non flow-based analysis. The flow-based analysis determined the maximum power flow over the requested path with and without the injection of 100 MW at the Point of Receipt.

The following sections of the requested path were identified as the most limiting and were therefore studied separately: 1) the Gladstone to Springer 115kV line, and 2) the Springer to Black Lake to Taos 115 kV line. A non flow-based analysis and a flow-based analysis were conducted for both line sections.

Power flow analysis was performed using the National Electric Reliability Corporation (NERC)/Western Electricity Coordinating Council (WECC) planning standards. Each bus in areas 10, 70, and 73 of the power flow cases was monitored for voltage, frequency and δV violations, and each violation was noted according to the criteria for its specific zone. Contingency loadings were monitored on all transmission elements (lines and transformers) in the region of study. Any contingency loading greater than 100% on lines and 100% on transformers was flagged and addressed. Existing violations which differed from the base case (pre-project) by less than 2% were not considered in the analysis.

Study Assumptions

The study was performed using the WECC approved 2013 Heavy Summer base case. A light load base case was also utilized, however it was determined that the highest loading across the requested path depended on native load-serving needs. A light load scenario reduces the native load demand such that it does not result in the maximum flow across the requested path. Therefore, the 2013 Heavy Summer case was utilized to determine the Available Transfer Capability, since it resulted in the highest loading across the requested path.

1. The Transmission Customer's resource was modeled with an output of 100 MW.
2. The Blackwater HVDC converter was modeled at 0 MW.
3. North to south schedules from Walsenburg to Gladstone were assumed to be approximately 120 MW in the peak case and approximately 50 MW in the off-peak case.
4. A typical wind collector system and step-up transformer were modeled for the Transmission Customer project.

5. The base case was adjusted to maximize the WECC clockwise loop flows by adjusting the northeast-southeast phase shifting transformers (PST's) angles on the following phase shifters: Shiprock, Sigurd, Pinto, San Juan, and both phase shifters at Harry Allen. Sensitivity studies examined two adjustments at 0 degrees and 34 degrees.

Upgrades to be included in base case:

1. Springer-Gladstone Line Upgrade to 169 MVA

Shunt capacitor assumptions:

1. York Canyon 115 kV 2x7.5 Mvar switched capacitors
2. Springer 115 kV 12.5 Mvar switched capacitor
3. Valencia 115 kV 7.5 Mvar switched capacitor
4. Clapham 115 kV +/-50 Mvar SVC
5. Clapham 115 kV 12.25 Mvar switched capacitor
6. Clapham 115 kV 6.25 Mvar switched capacitor
7. Clapham 115 kV 20 Mvar switched capacitor
8. Rosebud 115 kV 20 Mvar switched capacitor
9. Taos 115 kV 15 Mvar switched capacitor

Generation dispatch for existing designated network resources (DNR) or transmission service customers senior in the Tri-State and PNM transmission service queues were modeled for this study as shown below.

Base-line Generation Dispatch

Unit	Nameplate Rating	Peak Output Level	Off Peak Output Level
PNM Reeves DNR	0	0	0
PNM Delta-Person DNR	0	0	0
PNM Valencia Energy Facility DNR	0	0	0
Las Vegas CT DNR	0	0	0
Aragonne Mesa Wind	90	45	90
Taiban Mesa Wind DNR	200	100	200
High Lonesome Mesa Wind	100	50	100
PEGS DNR	230	230	222
First Solar DNR (scheduled to CO)	30	30	0
Wind (Gladstone-Bravo Dome line)	88	88	88
Comanche Generation 1 and 2	664	546	546
Comanche 3	750	750	645
TA-3	30.6	15	0

Power Flow Performance Criteria

Power flow analysis was performed using the National Electric Reliability Corporation (NERC)/Western Electricity Coordinating Council (WECC) planning standards. The following study criteria were applied:

1. All manually operated phase shifting devices were fixed during contingency voltage analysis but were allowed to adjust during contingency loading analysis.

2. SVD devices were allowed to switch during all contingency analysis

3. Tap changing transformers were fixed during contingency voltage analysis but were allowed to adjust during contingency loading analysis.

4. Automatic area interchange control remained on during all contingency analysis.

5. All generators were modeled with regard to self-regulating or remote bus regulating as they are modeled in the submitted WECC power flow data.

6. All generators which control a high side remote bus were set at the pre-disturbance voltage at the terminal bus.

7. All buses, lines and transformers with base voltages greater than or equal to 46 kV in the New Mexico and Colorado area were monitored in all study cases.

8. Shedding of wind farm generation under contingency scenarios was not accepted except for a loss of the requested transmission path.

9. It is assumed that the loss of the Walsenburg – Comanche 230 kV line would result in the cross-tripping of the Walsenburg – Gladstone line, including any customer interconnections with either of those lines.

Voltage and Loading Criteria

Tri-State Voltage Criteria			
Conditions	Operating Voltages	Delta-V	Areas
Normal N-0	0.95 - 1.05		All
Contingency N-1	0.90 - 1.10	7%	North-eastern 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
Contingency N-2	0.90 - 1.10	10%	All

Representative List of N-1 Contingencies

N-1 Contingencies	Pre-TSR	Post-TSR
Four Corners–West Mesa 345 kV	X	X
San Juan–Rio Puerco 345 kV	X	X
BA-Norton 345 kV	X	X
San Juan-Ojo345 kV	X	X
Ojo-Taos 345kV	X	X
Transmission Customer's Project–Walsenburg 230 kV		X
Springer-Storrie Lake 115 kV	X	X
Springer-Black Lake 115kV	X	X
Clapham-Rosebud 115 kV	X	X
Gladstone-Clapham 115 kV	X	X
Loss of all wind at new wind farm	X	X
BA-Guadalupe 345 kV	X	X
Rio Puerco-BA 345 kV	X	X
Rio Puerco-West Mesa 345 kV	X	X
Walsenburg 230/115 kV transformer	X	X
Wals.-Comanche 230 kV (Transfer Trip Wals.-Gladstone 230 kV)	X	X
Walsenburg-Comanche 230 kV only	X	X

Results

<u>Non Flow-based Analysis:</u>

A non flow-based analysis of ATC was conducted for the Gladstone to Springer section of the requested path. The analysis used TTC (the thermal rating of the line) and subtracted native load obligations, TRM and other existing commitments. As stated previously, the total value for ETC and TRM across the Gladstone to Springer line was determined from the pre-project system normal flow-based analysis of the 34 degrees case. That value was determined to be 53.3 MVA. (Reference the attached power flows diagrams.) Tri-State has an existing (non native load) commitment for the requested path of 88 MW. Therefore, ATC for the Gladstone to Springer line <u>prior to the 100 MW injection</u> is as follows:

ATC = TTC – (ETC + TRM) – Existing Commitments
ATC = 169 – 53.3 – 88 = 27.7 MW

Based on the above analysis, inadequate transmission is available over this section of the requested path. This study identified committed uses which, together with Tri-State's native load requirements and TRM, limit the ATC. Therefore, transmission system upgrades are required. In order to meet the transmission request, a second Gladstone – Springer 115kV circuit was assumed. For study proposes, the second circuit was assumed to be constructed at 100 degrees C with 795 MCM ACSR Drake conductor (rated 230 MVA).

With a second Gladstone – Springer 115kV circuit, ATC was recalculated for this portion of the requested path based on the same methodology. Using the 34 degrees case, the ATC <u>prior to the 100 MW injection</u> is as follows:

ATC = TTC – (ETC + TRM) – Existing Commitments
ATC = 169 + 230 – 53.3 - 88 = 257.7 MW

<u>ATC For The Remainder of the Requested Path</u>

TTC is defined as 100 percent of the thermal rating of the lowest rated line section in the requested path. Therefore, after adding the second Gladstone – Springer 115 kV circuit, the next most limiting value of TTC was determined to be 230 MVA, which is the thermal rating of the Taos to Black Lake to Springer 115kV lines. The pre-project system normal flow-based analysis of the 34 degrees case identified the sum of ETC and TRM to be 9.6 MVA for the Springer to Black Lake portion of the line. (Reference the attached power flows diagrams.) Therefore, ATC for the Springer to Black Lake line <u>prior to the 100 MW injection</u> is as follows:

ATC = TTC – (ETC + TRM) – Existing Commitments
ATC = 230 – 9.6 - 88 = 132.4 MW

<u>Flow-based Analysis:</u>

A flow-based analysis was conducted to verify that transmission capacity was not limited by actual system performance with the injection of 100 MW at the Point of Receipt. The proposed interconnection was studied under normal and high loop flow conditions. The high clockwise loop flow conditions were created by setting 6 phase shifters to 34 degrees. For purposes of this study, the 34 degrees phase shifter assumptions were considered appropriate to accommodate a reasonable amount of loop flow across the requested path (TRM). Before the addition of the 100 MW wind project, these phase shifter assumptions increased power flows to the south on the 230 kV line from Walsenburg to Gladstone. The injection of 100 MW at the Point of Receipt also increases flows to the south, however acceptable steady state performance was achieved during system normal conditions for the 0 degrees and 34 degrees phase shifter scenarios. No violations of the NERC/WECC/Tri-State system planning standards were observed and the rating of the lowest rated transmission line conductor was not exceeded.

The worst local N-1 scenario which maximized the flow on the Gladstone to Springer 115kV line was an outage of the C_R Wind – Rosebud 115kV line, which causes the loss of Rosebud load (73MW). (This outage results in flows very similar to the light load case.) During this outage, the pre-project flow on the Gladstone to Springer line was determined to be 120.4 MVA for the 34 degrees case. The post-project flow was 153.8 MVA. (Reference the attached power flows diagrams.)

The worst local N-1 scenario which maximized the flow on the Springer to Black Lake to Taos 115kV line was an outage of the Springer to Rainsville Tap 115 kV line. During this outage, the pre-project flow on the Springer to Black Lake line was determined to be 64.8 MVA for the 34 degrees case. The post-project flow was 93.4 MVA. (Reference the attached power flows diagrams.)

This study investigated all N-1 contingencies that affected the requested path. Only one N-1 contingency along the requested path resulted in thermal overloads or voltage limit violations: a post-project outage of the Springer to Black Lake 115kV line. This outage resulted in an overload of the Springer to Storrie Lake 115kV line. The following table shows that for the 34 degree pre-project case, the flows on the Springer to Storrie Lake 115kV line are well below the 80 MVA thermal rating of the line. The addition of the Transmission Customer's resource and the addition of a second Gladstone – Springer 115kV circuit increases the loading on the line. However, since the Black Lake to Springer 115kV line is a part of the requested path, the loss of the line is not considered reason to mitigate the overloads. For purposes of this study, if an N-1 contingency resulted in criteria violations but also resulted in an interruption of the requested path, the contingency was not considered reason to mitigate the violations. It is expected that the Transmission Customer's resource will be curtailed during the loss of any section of the requested path. Therefore, under such a scenario, those particular criteria violations will be mitigated by curtailment of the Customer's resource. Based on the magnitude of the projected overloads of the Springer to Storrie line, Tri-State may require that the curtailment of the Transmission Customer's resource be automated.

Contingency results with the WECC northeast-southeast phase shifting transformers at 34 degrees

Monitored Element	Contingency	Pre-project	Post-project with system upgrades
SPRINGER 115.00 RAINSVIL_T 115.00	BLACKLAK 115.00 SPRINGER 115.00	63.6 MVA	88.1 MVA (110%)
STORRIE 115.00 RAINSVIL_T 115.00	BLACKLAK 115.00 SPRINGER 115.00	62.0 MVA	85.0 MVA (106 %)
STORRIE 115.00 ARRIBA_T 115.00	BLACKLAK 115.00 SPRINGER 115.00	56.3 MVA	78.9 MVA (99%)

It should be noted that all N-1 contingencies, including those along the requested path, are studied in the Interconnection SIS. The Interconnection SIS will identify and address network upgrades required to mitigate all N-1 and fault conditions.

The flow-based analysis demonstrated that with the injection of 100 MW at the Point of Receipt acceptable steady state performance was achieved during system normal conditions and during the most severe N-1 contingencies for the 0 degrees and 34 degrees phase shifter scenarios. Except as noted above, no violations of the NERC/WECC/Tri-State system planning standards were observed and the rating of the lowest rated transmission line conductor was not exceeded for the worst N-1 scenario.

Conclusions

The Transmission Customer requested a sum of 100 MW of Long-Term Firm Point-to-Point Transmission Service over Tri-State's system beginning at a new interconnection on the 230 kV line between the Walsenburg and Gladstone substations and continuing to Gladstone, Springer, Black Lake, through the Taos 345kV/115kV transformer(s) and to the Ojo 345kV bus (east to west direction only). This study assumed a native load-serving demand that represents the Transmission Providers needs for at least a ten year period. The study also assumed that the 34 degrees phase shifter cases accommodates an adequate amount of Transmission Reliability Margin (TRM) across the requested path and thereby reserves enough transfer capability required for reliable system operation. Based on the results of the non flow-based and the flow-based analyses,

1. The 20 MW TSR can be accommodated without any additional network upgrades.

2. The total 100 MW request can be accommodated for the period covered by this study provided that a second Gladstone – Springer 115 kV line be constructed.

Since this study covered Tri-State's load serving requirements through the 10 year Tri-State planning horizon, any Transmission Service Agreement (TSA) based upon these Long Term Transmission Service Requests will qualify for the Right of First Refusal when renewing such TSA in the future.

Cost Estimates

The following is provided as a good faith estimate of the cost of additional network upgrades required to provide the requested service. No estimate is provided for direct interconnection costs for the wind farm facility. Costs have been escalated to the in-service year. It is assumed that a minimum lead time of four years is required to construct the recommended transmission system upgrades, including environmental, permitting, right-of-way acquisition, design and construction.

Recommended system additions: Construct a new 115 kV line from Gladstone to Springer substation.

Transmission line cost (based on an estimated length of 32 miles)	**$12,307,000**
115 kV substation additions at Gladstone and Springer	**$1,721,000**
Total	**$14,028,000**

The level of accuracy for the cost estimates in this study is considered to be ± 30%. This level of estimate is typical for a project at this budgetary stage in the process. All applicable overheads are included.

Appendix

Steady State Power Flow Diagrams in MVA

(Available Upon Request)