

# Supplemental Study Report - Part A for Xcel Energy OASIS Request 74515

Xcel Energy Transmission Planning  
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## A. Executive Summary

OASIS Request 74515 is a request for 35 MW of firm north-to-south point-to-point transfer capability from Craig/Hayden to Four Corners starting in 2008 and increasing annually by 35 MW up to a total of 176 MW in 2012. The study called T-2003-1 System Impact that was posted on OASIS in November 2003 determined that there would be insufficient transmission capacity on the jointly-owned western Colorado transmission system to accommodate the 176 MW request in 2012. The study also identified the system enhancements that would be needed on the western Colorado system in order to accommodate the 176MW request in 2012.

The purpose of this study called T-2003-1 System Impact Supplement A is to determine how much the firm point-to-point north-to-south transfer capability from Craig/Hayden to Four Corners would increase in 2012 above the 176 MW request if the enhancements listed in Table No. 1 of the T-2003-1 System Impact study were constructed. In addition, the purpose of the study is to identify the enhancements needed to accommodate a 35 MW transfer in 2008. A second study called T-2003 System Impact Supplement B will identify the enhancements needed to accommodate a 70 MW transfer in 2009, a 105 MW transfer in 2010, and a 140 MW transfer in 2011.

The supplemental study called T-2003-1 System Impact Supplement A concludes the following:

- Firm north-to-south point-to-point transfers from Craig/Hayden to Four Corners could be increased in 2012 an additional 14 MW (above the 176 MW accommodation) if the projects listed in Appendix B of the T-2001-1 System Impact study are constructed. If PSCo's Cameo-Vineland 69 kV line is uprated, an additional 40 MW could be accommodated (TOT2A flow at 920 MW).
- A 35 MW firm point-to-point transfer from Craig/Hayden to Four Corners could be accommodated in 2008 if the projects listed in Appendix B of the T-2001-1 System Impact study are constructed.

## **B. Introduction**

On April 30, 2004, representatives from Public Service Company of Colorado (PSCo), Western Area Power Administration (Western) and Tri-State G&T (Tri-State) met to discuss the technical report called T-2001-1 System Impact that was completed by PSCo in response to OASIS Request 74515 and posted on OASIS in November 2003. The report provided technical justification for the system enhancements identified in the study for firm north-to-south point-to-point transmission service from Craig/Hayden in northwest Colorado to Four Corners in northwest New Mexico. The request was for 35 MW starting in 2008 and increasing to each year in 35 MW increments up to a total of 176 MW in 2012.

The representatives reviewed the technical study and requested that PSCo perform additional studies to answer questions about the study. The following additional studies were requested:

- Determine the amount of additional firm point-to-point north-to-south transfer capability from Craig/Hayden to Four Corners that would be possible with the transmission improvements listed in the report in Table No. 1. These improvements include the conversion of the Curecanti-Lost Canyon-Shiprock 230 kV line to 345-kV, the addition of a third 300-MVA 345-kV phase-shifting transformer at San Juan, a third 300-MVA 345-kV phase-shifting transformer at Shiprock, a third 75-MVA 230-115 kV transformer at Curecanti, and the uprate of the Meeker-Rifle 138 kV line to a higher rating. These enhancements would be needed to accommodate the 176 MW request in 2012. (Study: T-2003-1 System Impact Supplement A)
- Determine the minimum enhancements required in the 2008 heavy summer season to accommodate a 35 MW firm point-to-point north-to-south transfer from Craig/Hayden to Four Corners. (Study: T-2003-1 System Impact Supplement A)
- Determine the minimum enhancements required to accommodate a 70 MW request in the year 2009, a 105 MW request in the year 2010, and a 140 MW request in the year 2011. (Study: T-2003-1 System Impact Supplement B)

## C. Case Development

The WECC 2008 HS2-SA case (approved: February 11, 2004) was used as a starting point for developing the 2008, 2009, 2010 and 2011 heavy summer cases. The following adjustments were made to the cases:

### 1. Tri-State G&T

The loads in western Colorado in the 2008 heavy summer case were examined by Tri-State and the demands at the busses in the case were adjusted to reflect the most up-to-date forecast. Tri-State used actual 2003 summer load data and escalated the loads to the 2008 summer time frame assuming a 2% load growth factor. The Florida River 115 kV bus demand was decreased in the 2008 heavy summer case from 73.6 MW down to 29.3 MW. The removal of the 40 MW project reflects the removal of the Florida River Gas Project that is now projected to in-service in 2012. The Cahone 115 kV bus demand was corrected in the 2008 heavy summer case to reflect the projected load at Empire's Cahone 46 kV distribution bus of 5.5 MW. This is consistent with the Cahone 115 kV demand in the 2004 heavy summer operating case of 4.3 MW. The 2009, 2010, and 2011 Tri-State demands in western Colorado were escalated from the 2008 levels assuming a 2% per year growth factor. The rest of the Tri-State load data in other areas was adjusted in accordance with the Western RMR control area growth between 2008 and 2012.

The study noted that the 2008 heavy summer base case includes the Montrose-ROUBT Tap-Garnet Mesa 115 kV line. The ROUBT Tap was originally envisioned as a tap on Tri-State's Grand Junction-Montrose 115 kV line to provide looped transmission service to the Garnet Mesa 115 kV load. The project was modified in the 2008 heavy summer base case to eliminate the tap on the Grand Junction-Montrose 115 kV line. Looped transmission service is accomplished with a Montrose-ROUBT-Garnet Mesa 115 kV line. This modification reduces the impact on the Grand Junction-Montrose 115 kV line.

### 2. Western

Western load data was approximated by using the data in the 2008 case and the 2012 case and interpolating between the values for the appropriate year.

### 3. PSCo

The latest PSCo demand forecast (date: April 11, 2004) for the years 2008 through 2011 summer seasons was used in the cases. Detailed representations of the Grand Valley System with the proposed Adobe Substation and the Shoshone-Rifle 69 kV to 115 kV Uprate Project were added in western Colorado.

The 2008 heavy summer case was modified with the Western RM control area (Area 73) generation re-dispatched to reduce the generation at Craig to make more resources in northwest Colorado available for transfers. The TOT2A flow was 134 MW, the TOT5 flow was 381 MW and the COI flow was 1870 MW. The San Juan 345 kV, Shiprock 230 kV, Pinto PST 345 kV, and Sigurd 230 phase-shifting transformers were operating at zero degrees fixed phase. The Walsenburg-Gladstone 230 kV line flow was 121 MW north-to-south and 30 MVAR south-to-north. A Gladstone 230-kV phase-shifting transformer was not added to the model.

#### **D. Study Results (See Appendix A for detailed study results)**

The study determined that firm transfers could be increased an additional 14 MW (above the 176 MW accommodation with TOT2A at 880 MW) before a system enhancement would be needed. At a TOT2A level of 880 MW, the Cameo-Vineland 69 kV line would require a design temperature increase, larger conductor or a voltage uprate. If the Cameo-Vineland 69 kV line rating were increased, the study determined that an additional 40 MW of firm point-to-point north-to-south transfer capability from Craig/Hayden to Four Corners could be available (with TOT2A at 920 MW). The new limiting element is Western's Rifle WA-North Fork 230 kV branch that loads to 100.7% of its 478 MVA thermal rating for an outage of the Grand Junction-Montrose 345 kV line.

The study determined that the 35 MW firm point-to-point request in 2008 can be accommodated if the projects listed in Appendix B of the T-2003-1 System Impact study are constructed. Those same enhancements (without the minor modifications to the Craig-Rifle 230 kV line) will be needed to achieve a TOT2A rating of 690 MW in 2008. The study determined that capacitor banks will be needed in 2008 as they would be in 2012 to achieve the rating. From this it was concluded that no additional enhancements would be needed in 2008 to accommodate the 35 MW firm point-to-point request.

## Appendix A

**A. Increase in firm point-to-point transfer capability in 2012 due to the additions to accommodate a 176 MW increase**

The purpose of the T-2003-1 System Impact Supplement A study was to determine the increase in firm north-to-south point-to-point transfer capability between Craig/Hayden to Four Corners after the addition of the preferred alternative. The preferred alternative consists of the uprate of the Curecanti-Lost Canyon-Shiprock 230 kV line to 345 kV, the addition of a third 300-MVA San Juan PST 345-kV bank, the addition of a third 300-MVA Shiprock PST 345-kV bank, the addition of a third Curecanti 230-115 kV transformer, and the Meeker-Rifle CU 138 kV line uprate to 124 MVA. The 2012 heavy summer case that included the preferred alternative was used for the study. The addition of the third San Juan PST 345-kV 300-MVA bank and the third Shiprock PST 345-kV 300-MVA bank decreases the impedance of the phase-shifting transformer installations at San Juan and Shiprock increasing the flow across TOT2A 14 MW to 880 MW. The Shiprock PST flow increased to 460 MW and the San Juan PST flow increased to 420 MW. The phase-shifting transformers were set to hold these flow levels in the case. The Shiprock PST angle was  $-0.5$  degrees and the San Juan PST angle was  $+0.3$  degrees. Outage simulations of branches in the study area were conducted and Cameo-Vineland 69 kV line flow reached 101.5% of its 82.0 MVA rating for an outage of the Grand Junction-Montrose 345 kV line. The Cameo-Vineland-Grand Junction 69 kV line had been re-conducted with 477 MVA conductor in the T-2003-1 System Impact study to increase the rating from 65 MVA (36 MCM conductor) to 82 MVA (477 MCM conductor rated at 684 amps at 2 feet per second wind speed) to allow the TOT2A flow to reach 690 MW. At 880 MW on TOT2A, the overload on the Cameo-Vineland 69 kV line would require re-conducting again with 636 MCM conductor to increase the line rating to 98 MVA (821 amps at 2 fps wind). Alternatives to re-conducting include increasing the design temperature increase or uprating to 115 kV using 477 MCM conductor at a rating of 136 MVA. For this study, the Cameo-Vineland-Grand Junction conductor was increased to 636 MCM. The Blue Mesa-Curecanti 115 kV line flows exceed the 100 MVA rating for an outage of the Grand Junction-Montrose 345 kV line. The Blue Mesa-Curecanti 115 kV line flow can be reduced by operating practices.

The transfer across TOT2A was increased to 920 MW. The following table summarizes the criteria violations with TOT2A at 920 MW.

Table No. 1 – Criteria violations, 2012 heavy summer, TOT2A = 920 MW

Monitored Element	Ckt	Limiting Contingency	Rating	Ln.Flow	% O/L	V-Cont.	Case Name
RIFLE WA 230-NORTHFRK 230	1	GRANDJCT_345MONTROSE_345_1	478.0	458.7	100.7		TOT2A=920

The Western Rifle WA-Northfork 230 kV line and Northfork-Curecanti 230kV line are 52.4 miles long and 28.5 miles long, respectively. Both lines are constructed with single 1272 MCM conductor and rated at 478 MVA.

**B. Enhancements required in 2008**

The transfers from Colorado to New Mexico were increased to verify the enhancements required to achieve a TOT2A flow of 690 MW. A Gladstone phase-shifting transformer was not added to the case. The previous study posted in November 2003 demonstrated the need for the Gladstone 230-kV transformer to reduce the inadvertent flow through New Mexico. The impact of high inadvertent flow on the system in northern New Mexico was ignored in this supplemental study. The San Juan, Shiprock, Pinto and Sigurd phase-shifting transformers were operated at zero degrees, fixed phase throughout this supplemental study. Inadvertent flow for outages was allowed to flow in New Mexico and in Utah. To increase the TOT2A flow, a 200 MW schedule from Craig/Hayden to Four Corners was simulated and the TOT2A flow increased to 242 MW. To increase the flow across TOT2A and to be consistent with the 2012 heavy summer case, a schedule of 800 MW from Idaho (Area 60) to Arizona (Area 14) was simulated and a schedule of 155 MW from Montana (Area 62) to Arizona (Area 14) was added. The north-to-south TOT2A flow increased to 381 MW, the COI path increased to 2504 MW, and the north-to-south flow on Path TOT2B increased to 276 MW. At this level, contingencies were simulated and the following system enhancements were added to mitigate criteria violations:

- Add a second PSCo Grand Junction 42-MVA 115-69 kV transformer
- Uprate Tri-State’s Hotchkiss-Garnet Tap 115 kV line to 174.3 MVA using 477 MCM conductor

A 200 MW schedule from PSCo to Arizona was simulated increasing the TOT2A level to 470 MW. The north-to-south flow on the Walsenburg-Gladstone 230 kV line increased from 152 MW to 170 MW. At the new level, a series of contingencies were conducted in western Colorado and the following system enhancements were added to mitigate criteria violations:

- Open the El Paso Tap-Glade Tap 115 kV line
- Add a second Lost Canyon 230-115 kV transformer. Tri-State has indicated that the addition of a second Lost Canyon 230-115 KV transformer is a planned project. This project had been added to the 2012 heavy summer case and was added to the 2008-2011 heavy summer cases.

A 445 MW schedule from PSCo (Area 70) to Arizona (Area14) was simulated. The TOT2A flow increased to 650 MW. The flow on the San Juan PST increased to 450 MW (north to south) and 112 MVAR (south to north). The Shiprock PST increased to 200 MW (north to south) and 47 MVAR (south to north). Reactive flow was increasing into southwest Colorado from the south to support voltages in the southwest Colorado area as the TOT2A flow was increased. The TOT5 flow decreased to -87 MW, west to east and the Walsenburg-Gladstone 230 kV line increased to 207 MW. Two 115-kV busses in New Mexico were below criteria for system intact conditions. They include the Springer 115 kV voltage at 0.94 p.u. and the York Canyon 115 kV voltage at 0.92 p.u.

At the new level, a series of contingencies were conducted in western Colorado and the following system enhancements were added to mitigate criteria violation:

- Add a second Hesperus 345-115 kV transformer to prevent 115-kV bus voltage violations for the loss of the Hesperus 345-115 kV transformer. Tri-State has indicated that the addition of a second Hesperus 345-115 KV transformer is a planned project. This project had been added to the 2012 heavy summer case and was added to the 2008-2011 heavy summer cases.
- Uprate the Grand Junction-Montrose 115 kV line rating to 146.4 MVA by increasing the design temperature to 75 degrees C.
- Uprate the Curecanti-South Canal-Montrose 115 kV line from 120 MVA to 244 MVA by re-conductoring the line with 795 MCM conductor from the present 477 MCM conductor.
- Add a second Montrose 250 MVA 345-115 kV transformer
- Uprate the Cameo-Vineland-Grand Junction 69 kV line rating to 82 MVA by re-conductoring the line with 477 MCM conductor

- Uprate the Hotchkiss-North Fork 115 kV line rating to 174.3 MVA by increasing the design temperature to 100 degrees C.
- Add a second Curecanti 75 MVA 230-115 kV transformer
- Uprate the North Mesa-Garnet Tap 115 kV line rating to 154.4 MVA by increasing the design temperature to 100 degrees C.

The following transformers experience flows over their rating for outage conditions but less than 110% of their nominal rating. The Shiprock and San Juan phase-shifting transformers are allowed to overload to 115% for emergency conditions.

- Grand Junction 50-MVA 138-115 kV transformer
- Shiprock 400-MVA 230-kV PST
- San Juan 600-MVA 345-kV PST

The Craig generation was increased by increments of 50 MW and scheduled to Four Corners and outages were conducted. The following enhancements were added to mitigate criteria violation:

- Add a second Grand Junction 50 MVA 138-115 kV transformer with TOT2A at 690 MW.
- Uprate the North Mesa-Spring Creek Tap 115 kV rating to 130.5 MVA by increasing the design temperature to 75 degrees C.
- Add reactive support to the case with TOT2A at 690 MW to reduce the flows on the Shiprock and San Juan PST's and to improve voltages in southwest Colorado. Add a 2-20 MVAR capacitor bank at Lost Canyon 230 kV.
- In the case with TOT2A at 708 MW, make minor modifications to increase the Curecanti-Lost Canyon 230 kV line rating to its thermal limit of 478 MVA.

The demand in southwest Colorado in the 2008 heavy summer case was 224.2 MW. The Animas-LaPlata Project (20.5 MW at Durango 115 kV) was not included in the case. The 2012 heavy summer case with a TOT2A level of 690 MW had a southwest Colorado demand of 288.8 MW. That amount included the Animas-LaPlata Project (20.5 MW at the Durango 115kV bus). The Lost Canyon-Shiprock PS 230 kV line loaded to 101.6% of its 442 MVA rating; therefore, minor modifications will be needed to increase the Curecanti-Lost Canyon 230 kV line rating to its thermal limit of 478 MVA. This is consistent with the 2012 heavy summer case with the TOT2A flow at 690 MW.

The TOT2A flow was increased an additional 35 MW to simulate the first accommodation of the customer's request. The Shiprock PST flow increased to 221.2 MW north-to-south with 48.6 MVAR flowing south-to-north to support the southwest Colorado system. The San Juan PST flow increased to 501.7 MW north-to-south with 165.8 MVAR flowing south-to-north to support the southwest Colorado system. Contingencies of lines in the study area were simulated. An outage of the San Juan PS-Hesperus 345 kV line resulted in an overload of the Shiprock PST with the flow reaching 398.8 MW north-to-south and the reactive flow reaching 179.4 MVAR south-to-north to support the southwest Colorado system. The flow represents 116% of the Shiprock PST 400 MVA rating. An outage of the Shiprock PST resulted in the flow on the San Juan PST reaching 641.6 MW north-to-south with the reactive flow reaching 245.3 MVAR south-to-north. The flow represents 115% of its 600 MVA rating. Voltages are less than criteria and must be improved with the addition of capacitor banks. With the TOT1A flow at almost 400 MW, an outage of the Craig-Bears 345 kV line or the Bears-Bonanza 345 kV line resulted in an overload of the San Juan PST of approximately 106% of its 600 MVA rating.

Capacitors were added at Grand Junction 345 kV (for a total of 80 MVAR) and Lost Canyon 230 (for a total of 60 MVAR). The pre-disturbance bus voltage at the Grand Junction 345 kV bus was the lowest in the study area at 0.95 p.u. A total of 60 MVAR of capacitors were added at Grand Junction 345 kV and raised the bus voltage to 0.98 p.u.

The Western (Area73) to Arizona (Area14) interchange was reduced by 20 MW to bring the TOT2A flow level to 727.2 MW. A 7.5 MVAR cap was added at Uintah 69 kV bus.

The reduction in schedule reduced the flow on the San Juan-San Juan PS 345 kV transformer to approximately 115%. A 20-MVAR capacitor at Hesperus 345 kV was added. The 7.5 MVAR capacitor bank at the Uintah 69 kV bus did not significantly improve voltages at Uintah 69 kV and Fruita 69 kV busses. The outage of the Uintah transformer separates these busses from the Fruita generating station that provided reactive support for the area.

The Hesperus capacitors were increased to 40 MVAR. At this point, the TOT2A flow was at 729 MW and the San Juan PST and Shiprock PST were at approximately 115% for an outage of the other transformer. The 115% level is the maximum allowed loading on the transformers.

To summarize, for the 2008 case with TOT2A at approximately 725 MW to accommodate the 35 MW schedule from Craig/Hayden to Four Corners, the following capacitor banks were added to the case:

- Add 4-20 MVAR capacitors at Grand Junction 345 kV
- Add 2-20 MVAR capacitors at Lost Canyon 230 kV (added to the two 20-MVAR capacitors added to achieve 690 MW in the 2008 case.
- Add 2-20 MVAR capacitors at Hesperus 345 kV

The study posted in November 2003 identified 100 MVAR of capacitors placed at busses in western Colorado that would be needed in 2012 to achieve 690 MW on TOT2A. If one assumes that capacitors will be added in western Colorado by the three transmission owners in western Colorado as part of the enhancements needed to achieve 690 MW on TOT2A by 2012, then no additional enhancements would be needed in 2008 to accommodate a 35MW firm north-to-south point-to-point from Craig/Hayden to Four Corners.

It should be emphasized that this supplemental study did not attempt to protect the New Mexico system with a phase-shifting transformer at Gladstone for high transfers from eastern Colorado to Four Corners. The study did not rely on the TOT2A transformers to hold schedules across TOT2A. With the system enhancements listed in Appendix B of the T-2003-1 System Impact study added and with TOT2A at approximately 725 MW (690 MW plus the 35 MW request), the San Juan 345 kV phase-shifting transformer flow reaches 115.1% of its 600 MVA rating for an outage of the Lost Canyon-Shiprock PS 230 kV line. In addition, the Shiprock 230 kV phase-shifting transformer flow reaches 115.0% for an outage of the San Juan phase-shifting transformer. The Shiprock and San Juan phase-shifting transformers are allowed to overload to 115% under outage conditions.