Interconnection Non Queued Study – Final Report
Request # NQ-2007-2

150 MW CTG #'s 5 & 6 (300 MW total) Additions at Fort St. Vrain Generation Plant in Summer 2009

PSCo Transmission Planning
October 19, 2007

Executive Summary

Public Service Company of Colorado (PSCo) Transmission Planning received on or about August 31, 2007 a generation interconnection request to determine the potential impacts of installing two simple-cycle gas-fired combustion turbine generators (CTG 5 & CTG 6) at its Fort St. Vrain (FSV) generation plant located north of Denver in Weld County, Colorado. Each CTG is to be rated for an output capacity of 150 MW summer and 180 MW winter, with a planned in-service date of no later than June 1, 2009. The request was predicated on the stated assumption that the previously planned new Squirrel Creek Energy 500 MW combined cycle plant to be located south of Denver near Fountain, Colorado may not be completed by the summer of 2009. This request was studied as strictly a Network Resource (NR)[1], with no investigation performed as to the details or costs associated with the installation and interconnection of the two new CTGs and associated transformation and protection (breakers, etc.) into the existing 230 kV station at FSV. This investigation included steady-state power flow studies only, and did not include any transient dynamic stability, or short-circuit analysis. The request was studied as a stand-alone project only, with no evaluations made of other potential new generation requests that may exist in the LGIR queue, other than the generation projects that are already approved and planned to be in service by the summer of 2009. The purpose of this special study was to evaluate the potential impacts on the PSCo transmission infrastructure to inject the additional 300 MW (summer) into the FSV 230 kV bus, and deliver the additional generation to native PSCo loads. This project cost to install the transmission system infrastructure (NR) upgrades necessary to accommodate the added FSV generation has been evaluated by Engineering, with the details of these upgrades identified in the Power Flow Study Results and Conclusions, and the Appendix sections of this report. Refer to Figure 1 for details illustrating the basic transmission system in the FSV region.

Based upon the investigations completed so far, it is believed that the modifications will likely be relatively minor in scope, and should be achievable by the summer of 2009.

[1] **Network Resource Interconnection Service** shall mean an Interconnection Service that allows the Interconnection Customer to integrate its Large Generating Facility with the Transmission Provider's Transmission System (1) in a manner comparable to that in which the Transmission Provider integrates its generating facilities to serve native load customers; or (2) in an RTO or ISO with market based congestion management, in the same manner as all other Network Resources. Network Resource Interconnection Service in and of itself does not convey transmission service.

However, the final scope for some of the network upgrades has not yet finally determined, most notably potential line upgrades for the two Ft. Lupton – FSV 230 kV lines, and the results of these remaining investigations will be included in a supplement to this final study report.

Stand Alone Study Results

The stand-alone results assume that the new generation interconnecting at the FSV 230 kV bus is modeled in the power flow case at full output, or approximately 300 MW, and the rest of the generation and loads in the power flow model reflect a heavy summer load, heavy north-to-south (HSHN) stressed 2009 case (see Power Flow Study Models section below).

Energy Resource (ER):
This special study assumes that the generation equipment can be installed such that it interconnects into the 230 kV transmission bus at FSV. No investigations as to the feasibility of, or costs associated with the interconnection facilities have been done as part of this study.

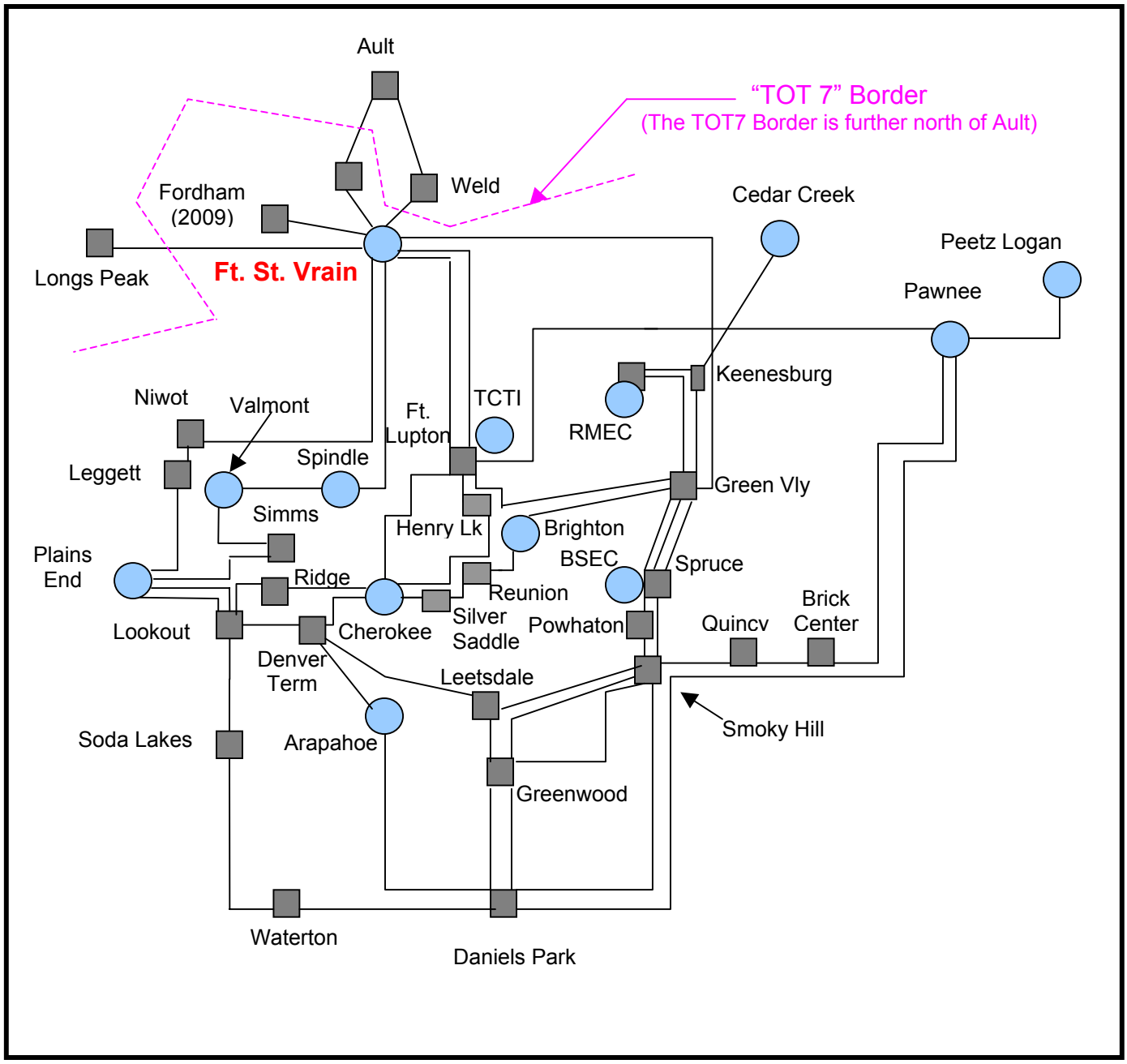
Network Resource (NR):
The Customer can provide the full 300 MW FSV generation additions, once some modifications have been completed to the PSCo transmission system infrastructure. Following is a list of the lines and autos that either incur new single contingency (N-1) overloading, or that become significantly overloaded as a result of adding 300 MW of new generation at FSV (two 150 MW CTGs, G5 & G6 summer rating) in heavy summer 2009 power flow cases (i.e., 5% or more differential loading between the case with FSV new generation at 300 MW vs. 0 MW).

The line ratings and limiting elements identified in the following list are based upon the latest Rev.3 of FAC-009 (Transmission Equipment Facility Ratings). The recommended upgrades and revised line ratings are based upon investigations performed by the XE / PSCo Transmission and Substation Engineering groups, with the items listed here as limited to lines / substations requiring upgrades. Additional details regarding the lines and limiting equipment identified in the preliminary and follow-up power flow studies can be found in the Appendix (Contingency Results Tables).

Overloaded Line / Element	Max HSHN Overload % (latest rate)	Scope of Work and Cost
Cherokee – Lacombe 230 kV (Ckt. # 5057)	119% (cont rate) / 106% (4-hr emerg rate)	Cherokee Sub – line term conductor ($12k)
Ft. Lupton - FSV 230 kV (Ckt. # 5311)	108% (4 FPS)	Transmission line – possible structure mods (***to be confirmed***)
Ft. Lupton - FSV 230 kV (Ckt. # 5329)	108% (4 FPS)	Transmission line – possible structure mods (***to be confirmed***)
Hogback – Lookout 115 kV (Ckt. # 9794)	126% (cont rate) / 109% (4-hr emerg rate)	Hogback Sub– line term conductor ($***to be determ***)
Hogback – Soda Lakes 115 kV (Ckt. # 9794)	113% (cont rate) / 97% (4-hr emerg rate)	Hogback Sub– line term conductor ($***to be determ***)

Overloaded Line / Element	Max HSHN Overload % (latest rate)	Scope of Work and Cost
Lookout – Plains End (Leggett) 230 kV (Ckt. # 5633)	109% (2 FPS)	Transmission line – possible structure mods (***4 FPS rate yet to be determined***)
Valmont 230/115kV, 280 MVA Autotransformer #1	120% (cont rate)	Expedite planned installation of second Valmont autoxfmr from 2010 into 5/2009.

Figure 1: Existing PSCo 230 kV Transmission System in the FSV – Metro Region
(This is a simplified 230 kV system diagram and does not include all system details)



Study Scope and Analysis

The Interconnection Special Study evaluated the transmission impacts associated with the proposed interconnection of 300 MW of additional new generation at FSV 230 kV into the PSCo Transmission System. It consisted of steady-state power flow analyses only. The power flow analysis provided a preliminary identification of any thermal or voltage limit violations resulting for the interconnection, and for a NR request, a preliminary identification of network upgrades required to deliver the proposed generation to PSCo loads.

PSCo adheres to NERC / WECC Reliability Criteria, as well as internal Company criteria for planning studies. During system intact conditions, criteria are to maintain transmission system bus voltages between 0.95 and 1.05 per-unit of system nominal / normal conditions, and steady-state power flows within 1.0 per-unit of all elements' thermal (continuous current or MVA) ratings. Operationally, PSCo tries to maintain a transmission system voltage profile ranging from 1.02 per-unit or higher at generation buses, to 1.0 per-unit or higher at transmission load buses. Following a single contingency element outage, transmission system steady state bus voltages must remain within 0.90 per-unit to 1.10 per-unit, and power flows within 1.0 per-unit of the elements continuous thermal ratings.

For this project, potential affected parties include Western Area Power Administration (WAPA), Tri-State Generation and Transmission (TSGT), and Platte River Power Authority (PRPA). However, due to the expedited schedule required for this special study, none of these parties have been contacted or involved in the study at this time.

Power Flow Study Models

The power flow studies were based on a PSCo-developed 2009 heavy summer base case that originated from the study model developed in early 2007 as part of PSCo's normal annual 5-year transmission capital budget project identification process. These budget case models are developed from Western Electricity Coordinating Council (WECC) approved models, modified as appropriate for PSCo planned and approved projects and associated topology. Load levels reflect 2009 heavy summer peak system conditions. PSCo control area 70 generation was dispatched in the case to simulate two different north-to-south stressed system conditions, with the area 70 swing bus moved to Comanche #1, and generation levels in the north generally increased to near maximum levels. In the initial "Heavy Stressed" (Heavy Summer, Heavy North HSHN) case (see Tables 1 and 3 in the Appendix), the TOT 3 path at the Colorado – Wyoming border, and the TOT 7 path immediately north of FSV (see Figure 1) levels were increased to relatively high levels of approximately 1450 MW for TOT 3 and approximately 550 MW for TOT 7. In the follow-up "Moderately Stressed" (Heavy Summer HS) cases, the cases were re-dispatched for TOT3 path flows for approximately 1250 MW, and TOT7 for approximately 460 MW. The PSCo control area (CA 70) wind generation facilities

were dispatched to 10% of net facility ratings, consistent with other similar planning study models.

The new additional 300 MW of generation at FSV was modeled as two new 150 MW combustion turbine generators (CTGs), similar to the existing FSV 130 MW (206 MVA, 0.85 p.f., Pmax 130 MW, Qmax 85 MVAR,) CTG units 2, 3, and 4. The Customer mentioned that the new generators would be rated for 180 MW winter / 150 MW summer, therefore for this summer case the new generators were conservatively modeled with a maximum capability of 150 MW (Pmax) / 85 MVAR (Qmax), or effectively 172 MVA at 0.87 p.f. These gross MVAR generation capabilities would exceed the amounts necessary to achieve a net HV (230 kV) Point of Interconnection (P.O.I.) +/- 0.95 p.f. Capability, which were calculated to be approximately 150 MW / 64 MVAR gross at the 18 kV gen bus for a resulting 150 MW / 51 MVAR net (0.95 p.f.) on the 230 kV HV bus, with the 13 MVAR differential equating to the MVAR losses in the GSU transformer. Each generator was modeled with an associated 230 – 18 KV, 178 / 222 MVA GSU transformer, with the same impedances / electrical characteristics as the existing GSU #2.

The 2009 case model topology was further modified to remove the Squirrel Creek 500 MW generation facility, previously modeled tapping into the Daniels Park – Comanche 345 kV line, and the associated 230 kV transmission infrastructure additions (namely removing a second 230 kV Daniels Park – Midway 230 kV line). The 345 kV transmission infrastructure additions associated with the new Comanche #3 generation project, which are planned to be in service by summer of 2009, were maintained in the model. This model does not include the new Comanche #3 (750 MW) generation itself, as it will not be in service until after the summer of 2009. The project generation was scheduled to the southern PSCo system by reducing generation in that area. Other generation was re-scheduled during the evaluation the Customer's request to the other entities' native load.

Power Flow Study Results and Conclusions

Two main power flow case model generation dispatch scenarios were evaluated: a reference model without the additional new 300 MW FSV generation GTG5 & GTG6 addition ("FSV 0" case); and a model with the new 300 MW (summer) of generation included at FSV ("FSV 300" case). The FSV 300 case was re-dispatched to lower other PSCo control area generation by 300 MW, mainly in the southern part of the PSCo system in order to maintain or maximize the north-to-south system stressing (and TOT 7 path flows) in the cases. Several generation dispatch "stressed" cases were created to evaluate the sensitivities of various levels of north-to-south system flow levels; the aforementioned "heavy stressed" HSHN, and "moderately stressed" HS cases. An additional case study was performed with the various levels of generation at the nearby 600 MW RMEC generation facility

Automated contingency power flow studies were completed on all four case models using PTI's MUST program routine, switching out single elements one at a time for all of the elements (lines and transformers) in control areas 70 (PSCo) and 73

(WAPA RM). Upon switching each element out, the program re-solves with all voltage taps and switched shunt devices locked, and control area interchange adjustments disabled.

These automated contingency studies were performed for both the FSV 300, and the FSV 0 models, and the results listing the overloaded elements (load flows in excess of their continuous rating) were compared. As previously stated in the Stand Alone Study Results section of this report, these studies indicated that the additional 300 MW of injection into the FSV 230 kV bus could cause new and/or additional load flows in excess of present or planned element ratings on several 230 kV transmission lines, plus one 230-115 kV autotransformer (Valmont), under single-contingency (N-1) conditions. As a result of the investigations performed by Transmission and Substations Engineering, some of the limiting equipment ratings have been revised, resulting in a reduction of the original nine overloaded lines identified in the preliminary Study Report, to six overloaded lines, plus the overloaded Valmont autotransformer. The continuous current ratings for these lines as limited by either the transmission line conductor (sag clearance limitations) or the substation termination equipment (jumpers, switches, relaying / CT limitations, breakers, etc.) have been, or are being investigated by Substation and Transmission Engineering in order to determine the measures (scope, cost, and schedule / time) necessary to bring the ratings up to or exceeding the MVA (e.g. continuous current) conditions identified for these specific overloaded lines.

Based upon the investigations completed so far, it is believed that the modifications will likely be relatively minor in scope, and should be achievable by the summer of 2009. In some cases under the extreme stressed conditions modeled in this study, it is assumed that the 4-hour emergency ratings for some of the limiting substation termination equipment will be utilized, until the system operators are able to adjust generation and/or line switching conditions in order to bring the transmission flows within the continuous thermal ratings of the equipment. Note that the final scope for some of the network upgrades has not yet finally determined, most notably potential line upgrades for the two Ft. Lupton – FSV 230 kV lines, and the results of these remaining investigations will be included in a supplement to this final study report.

As there are several 230 kV lines exiting FSV with shared transmission tower configurations, additional double-contingency (N-2) outage cases were manually run. These runs were completed on a total of four 230 kV double-circuit outage scenarios, with the results summarized in Table 3 of the Appendix.

Appendix

Power Flow Contingency Results Tables

NOTE - the elements identified in this study report as overloaded in these contingency runs, are limited to the new or significantly increased overloads, and do not address all of the elements that may have been indicated as overloaded in the contingency runs. The other elements that may be overloaded, independent of the new 300 MW generation injection at FSV, will be addressed through other separate Transmission Planning project proposals.

Table 1: Heavy North to South Stressed System Case (2009HSHN RL5, TOT3 = 1453, TOT7 = 609):

NOTE: The "Rev" Sub and T-Line % of Ratings shown highlighted in red are the new load flow % re-calculated as based upon the revised element ratings discovered through Engineering's research for the specific lines and subs. The original percentages were based upon the element ratings from FAC-009 and modeled in the power flow cases.

Monitored Line or Element (Name / Ckt. #)	Monitored Line or Element Rating (MVA / Amps)	Line Out (N-1) (Name / Ckt. #)	FSV G5-G6 300 HSHN Heavy Stress Case (N-1) Element Max Loading (% of Amp Rate / MVA / Amps)	FSV G5-G6-0 HSHN Heavy Stress Case (N-1) Element Max Loading (% of Amp Rate / MVA / Amps)	Present Limiting Element, & Scope of Work Required to Meet (N-1) Max Load Flow
Cherokee – Lacombe **(#5057)**	444 MVA / **1114 A**	Lookout – West (#5629)	**123.1%** 546.1 MVA / **1371 A** **(Rev: Sub 119% cont / 106% emer; T-line: 67%)**	**110.5%** 490.4 MVA / **1231 A**	**Cherokee Sub**: Jumper: 1115A Cont. / **1299A 4-Hr Emerg.**; **Lacombe Sub**: **2400A cont.** / 2400A 4-Hr Emerg. **T-Line Cond**: 817 MVA / **2051 A** **Upgrades Required**: **Cherokee** - Replace conductor to bkr 5057 & main 230 kV bus **Cost Est.**: **$12k**.
Ft. Lupton – FSV **(#5311)**	444 MVA / **1114 A** **(Rev 500 MVA / 1255A 4FPS)**	Ft. Lupton – FSV (#5329)	**121.6%** 539.6 MVA / **1355 A** **(Rev: Sub 68% cont / 58% emer; T-line: 108% 4FPS)**	**100.0%** 444 MVA / **1114 A**	**FSV Sub:** Was Jumper: 1114A Cont.; Now Rev as **1981A Cont.** / 2333A 4-Hr. Emerg. **Ft. Lupton Sub**: Now Rev as **1981A Cont.** / 2333A 4-Hr. Emerg. **T-Line Cond**: 500 MVA / **1255A (4 FPS)** **Upgrades Required**: ***To be determined*** – Possibly **T-line** structure phase raisers. **Cost Est.**: $ ***To be determined***
Ft. Lupton – FSV **(#5329)**	444 MVA / **1114A** **(Rev 500 MVA / 1255A 4FPS)**	Ft. Lupton – FSV (#5311)	**121.6%** 539.6 MVA / **1355 A** **(Rev: Sub 68% cont / 58% emer; T-line: 108% 4FPS)**	**100.0%** 444 MVA / **1114 A**	**FSV Sub:** Was Jumper 1114A Cont.; Now Rev as **1981A Cont.** / 2333A 4-Hr. Emerg. **Ft. Lupton Sub**: Now Rev as **1981A Cont.** / 2333A 4-Hr. Emerg. **T-Line Cond**: 500 MVA / **1255A (4 FPS)** **Upgrades Required**: ***To be determined*** – Possibly **T-line** structure phase raisers. **Cost Est.**: $ ***To be determined***
Ft. Lupton – JL Green **(#5183)**	478 MVA / **1200 A** **(Rev 571 MVA / 1433A 4FPS)**	Ft. Lupton – Henry Lake (#5047)	**109.1%** 521.3 MVA / **1309 A** **(Rev: Sub 66% cont / 56% emer; T-line: 91% 4FPS)**	**100.9%** 482.4 MVA / **1211 A**	**Ft. Lupton Sub:** Was 1200A Cont. Relay CTs; Now Rev as **1981A Cont.** / 2333A 4-Hr. Emerg. **JL Green Sub**: Assumed at least **1200A**, TSGT owns sub – ***Final Rate To be determined*** **T-Line Cond**: 571 MVA / **1433A (4 FPS)** **Upgrades Required**: Nothing Required – Meets Max N-1 Flow Modeled **Cost Est.: $0**.
Hogback - Lookout **(#9794)**	138 MVA / **693 A**	Soda Lakes - Lookout (#5851)	**125.2%** 172.8 MVA / **867 A** **(Rev: Sub 126% cont / 108% emer; T-line: 83% 4FPS)**	**117.8%** 162.5 MVA / **816 A**	**Hogback Sub:**: Conductors / Jumpers 691A Cont. / **800A 4-Hr Emerg**. **Lookout Sub**: Bus tube (1-in) 841A Cont. / **981A 4-Hr. Emerg.** **T-Line Cond**: 208 MVA / **1044A (150 deg C)** **Upgrades Required**: **Hogback** - Replace conductor to Bkr 9794 & main 115 kV bus **Cost Est.**: $ ***To be determined***.

Monitored Line or Element (Name / Ckt. #)	Monitored Line or Element Rating (MVA / Amps)	Line Out (N-1) (Name / Ckt. #)	FSV G5-G6 300 HSHN Heavy Stress Case (N-1) Element Max Loading (% of Amp Rate / MVA / Amps)	FSV G5-G6-0 HSHN Heavy Stress Case (N-1) Element Max Loading (% of Amp Rate / MVA / Amps)	Present Limiting Element, & Scope of Work Required to Meet (N-1) Max Load Flow
Hogback – Soda Lakes **(#9794)**	138 MVA / 693A	Soda Lakes - Lookout (#5851)	**112.4%** 155.2 MVA / **779 A** **(Rev: Sub 119% cont / 106% emer; T-line: 67% 4FPS)**	**105.1%** 145 MVA / **728 A**	**Hogback Sub:**: Conductors / Jumpers 691A Cont. / **800A 4-Hr Emerg**. **Soda Lakes Sub: 980A Cont**. / 980A 4-Hr. Emerg. **T-Line Cond**: 208 MVA / **1044A (150 deg C)** **Upgrades Required**: Nothing Required – Meets Max N-1 Flow Modeled **Cost Est.: $0**.
Lookout – Plains End #2 **(#5633)**	435 MVA / **1092 A**	Lookout – Plains End #1 (#5027)	**108.6%** 472.6 MVA / **1186 A** **(Rev: Sub 99% cont / 95% emer; T-line: 109% 2FPS)**	**98.1%** 430.3 MVA / **1071 A**	**Lookout Sub Term**: Line Trap 1200A Cont. / **1248A 4-Hr Emerg**. **Plains End Sub**: 5633 line not presently term into Plains End (goes past on to Leggett); assume will be rated for 1200A min. **T-Line Cond**: 435 MVA / **1092 A (2 FPS)** **Upgrades Required**: T-line 4 FPS rating to be determined; required upgrades (if any) to be determined. **Cost Est**.: $ ***To be determined***.
Smoky Hill – Spruce **(#5171)**	800 MVA / **2000 A** **(Rev Sub 789 MVA / 1981A Cont; 929 MVA / 2333A emerg; T-Line: 850 MVA/ 2140A)**	Spruce - Powhaton (#5177)	**103.2%** 825.7 MVA / **2073 A** **(Rev: Sub 105% cont / 89% emer; T-line: 97% 4FPS)**	**95.8%** 758.5 MVA / **1916 A**	**Smoky Hill Sub: 3000A Cont**. / 3000A 4-Hr Emerg. **Spruce Sub**: Bus (2.5 in tube) 1981A cont. / **2333A 4-Hr Emerg**. **T-Line Cond**: (New uprate planned in 2008) 850 MVA / **2140 A (4 PFS)** **Upgrades Required**: Nothing Required – (4-Hr Emergency Rating) Meets Max N-1 Flow Modeled **Cost Est.: $0.**
Smoky Hill – Powhaton **(#5177)**	800 MVA / **2000 A** **(Rev Sub 789 MVA / 1981A Cont; 929 MVA / 2333A emerg; T-Line: 850 MVA/ 2140A)**	Smoky Hill – Spruce (#5171)	**102.4%** 819 MVA / **2056 A** **(Rev: Sub 104% cont / 88% emer; T-line: 96% 4FPS)**	**95.0%** 758.3 MVA / **1899 A**	**Smoky Hill Sub: 3000A Cont**. / 3000A 4-Hr Emerg. **Spruce Sub**: Bus (2.5 in tube) 1981A cont. / **2333A 4-Hr Emerg**. (Note – Powhaton is new sub in 2009, assumes will meet 2000a or more min. requirement) **T-Line Cond**: (New uprate planned in 2008) 850 MVA / **2140 A (4 PFS)** **Upgrades Required**: Nothing Required – (4-Hr Emergency Rating) Meets Max N-1 Flow Modeled **Cost Est.: $0.**
Spruce - Powhaton **(#5177)**	800 MVA / **2000 A** **(Rev Sub 789 MVA / 1981A Cont; 929 MVA / 2333A emerg; T-Line: 850**	Smoky Hill – Spruce (#5171)	**103.3%** 826.5 MVA / **2075 A** **(Rev: Sub 105% cont / 89% emer; T-line: 97% 4FPS)**	**95.9%** 773.9 MVA / **1918 A**	**Smoky Hill Sub: 3000A Cont**. / 3000A 4-Hr Emerg. **Spruce Sub**: Bus (2.5 in tube) 1981A cont. / **2333A 4-Hr Emerg**. . (Note – Powhaton is new sub in 2009, assumes will meet 2000a or more min. requirement) **T-Line Cond**: (New uprate planned in 2008) 850 MVA / **2140 A (4 PFS)** **Upgrades Required**: Nothing Required – (4-Hr Emergency Rating) Meets Max N-1 Flow Modeled

Monitored Line or Element (Name / Ckt. #)	Monitored Line or Element Rating (MVA / Amps)	Line Out (N-1) (Name / Ckt. #)	FSV G5-G6 300 HSHN Heavy Stress Case (N-1) Element Max Loading (% of Amp Rate / MVA / Amps)	FSV G5-G6-0 HSHN Heavy Stress Case (N-1) Element Max Loading (% of Amp Rate / MVA / Amps)	Present Limiting Element, & Scope of Work Required to Meet (N-1) Max Load Flow
	MVA/ 2140A)				**Cost Est.: $0.**
Valmont 230/115 kV Autoxfmr	**280 MVA**	Valmont – Simms (#5389)	**119.5%** **333.5 MVA**	**110.4%** **309.2 MVA**	**Valmont Sub: Upgrades required**: Add second auto in 2009, vs. 2010. This project has been approved in the 2008 capital budget with an in service date of May 2010, but would likely require using a xfmr already on order for other project (e.g. Waterton, or other Squirrell driven proj).
Washington – JL Green **(#5527)**	413 MVA / **1037 A** **(Rev Sub 489.6 MVA / 1229A Cont; 570.9 MVA / 1433A emerg; T-Line: 579 MVA/ 1453A**	Ft. Lupton – Henry Lake (#5047)	**122.4%** 505.3 MVA / **1269 A** **(Rev: Sub 103% cont / 89% emer; T-line: 87% 2FPS)**	**112.9%** 466.4 MVA / **1171 A**	**Washington Sub**: 1229A Cont. / **1433A 4-Hr Emerg.;** **JL Green Sub**: Assumed at least **1200A**, TSGT owns sub – ***Final Rate To be determined*** **T-Line Cond**: 579 MVA / **1453A (2 FPS assumed)** **Upgrades Required**: Nothing Required – (4-Hr Emergency Rating) Meets Max N-1 Flow Modeled **Cost Est.: $0.**.

Table 2: Moderate North to South Stressed System Case (2009HSHN RL5, TOT3 = 1253, TOT7 = 460):

NOTE: The "Rev" Sub and T-Line % of Ratings shown highlighted in red are the new load flow % re-calculated as based upon the revised element ratings discovered through Engineering's research for the specific lines and subs. The original percentages were based upon the element ratings from FAC-009 and modeled in the power flow cases.

Monitored Line or Element (Name / Ckt. #)	Monitored Line or Element Rating (MVA / Amps)	Line Out (N-1) (Name / Ckt. #)	FSV G5-G6 300 HS Moderate Stress Case (N-1) Element Max Loading (% of Amp Rate / MVA / Amps)	FSV G5-G6-0 HS Moderate Stress Case (N-1) Element Max Loading (% of Amp Rate / MVA / Amps)	Present Limiting Element, & Scope of Work Required to Meet (N-1) Max Load Flow
Cherokee – Lacombe **(#5057)**	444 MVA / **1114 A**	Lookout – West (#5629)	**118.4%** 525.9 MVA / **1320 A** **(Rev: Sub 118% cont / 102% emer; T-line: 64%)**	**108.3%** 480.9 MVA / **1207 A**	**Cherokee Sub**: Jumper: 1115A Cont. / **1299A 4-Hr Emerg**.; **Lacombe Sub**: **2400A cont**. / 2400A 4-Hr Emerg. **T-Line Cond**: 817 MVA / **2051 A** **Upgrades Required**: **Cherokee** - Replace conductor to bkr 5057 & main 230 kV bus **Cost Est**.: **$12k**.
Ft. Lupton – FSV **(#5311)**	444 MVA / **1114 A** **(Rev 500 MVA / 1255A 4FPS)**	Ft. Lupton – FSV (#5329)	**114.6%** 508.8 MVA / **1277 A** **(Rev: Sub 65% cont / 55% emer; T-line: 102%)**	93.8% 424.4 MVA / 1045 A	**FSV Sub:** Was Jumper: 1114A Cont.; Now Rev as **1981A Cont**. / 2333A 4-Hr. Emerg. **Ft. Lupton Sub**: Now Rev as **1981A Cont**. / 2333A 4-Hr. Emerg. **T-Line Cond**: 500 MVA / **1255A (4 FPS)** **Upgrades Required**: ***To be determined*** – Possibly **T-line** structure phase raisers. **Cost Est**.: $ ***To be determined***
Ft. Lupton – FSV **(#5329)**	444 MVA / **1114A** **(Rev 500 MVA / 1255A 4FPS)**	Ft. Lupton – FSV (#5311)	**114.6%** 508.8 MVA / **1277 A** **(Rev: Sub 65% cont / 55% emer; T-line: 102%)**	93.8% 424.4 MVA / 1045 A	**FSV Sub:** Was Jumper 1114A Cont.; Now Rev as **1981A Cont**. / 2333A 4-Hr. Emerg. **Ft. Lupton Sub**: Now Rev as **1981A Cont**. / 2333A 4-Hr. Emerg. **T-Line Cond**: 500 MVA / **1255A (4 FPS)** **Upgrades Required**: ***To be determined*** – Possibly **T-line** structure phase raisers. **Cost Est**.: $ ***To be determined***
Ft. Lupton – JL Green **(#5183)**	478 MVA / **1200 A** **(Rev 571 MVA / 1433A 4FPS)**	Ft. Lupton – Henry Lake (#5047)	**103.9%** 496.6 MVA / **1247 A** **(Rev: Sub 63% cont / 54% emer; T-line: 87%)**	97.4% 469.2 MVA / 1169 A	**Ft. Lupton Sub:** Was 1200A Cont. Relay CTs; Now Rev as **1981A Cont.** / 2333A 4-Hr. Emerg. **JL Green Sub**: Assumed at least **1200A**, TSGT owns sub – ***Final Rate To be determined*** **T-Line Cond**: 571 MVA / **1433A (4 FPS)** **Upgrades Required**: Nothing Required – Meets Max N-1 Flow Modeled **Cost Est.: $0**.
Hogback - Lookout **(#9794)**	138 MVA / **693 A**	Soda Lakes - Lookout (#5851)	**124.2%** 171.3 MVA / **860 A** **(Rev: Sub 125% cont / 108% emer; T-line: 82%)**	**118.1%** 163.0 MVA / **818 A**	**Hogback Sub:**: Conductors / Jumpers 691A Cont. / **800A 4-Hr Emerg**. **Lookout Sub**: Bus tube (1-in) 841A Cont. / **981A 4-Hr. Emerg.** **T-Line Cond**: 208 MVA / **1044A (150 deg C)** **Upgrades Required**: **Hogback** - Replace conductor to Bkr 9794 & main 115 kV bus

Monitored Line or Element (Name / Ckt. #)	Monitored Line or Element Rating (MVA / Amps)	Line Out (N-1) (Name / Ckt. #)	FSV G5-G6 300 HS Moderate Stress Case (N-1) Element Max Loading (% of Amp Rate / MVA / Amps)	FSV G5-G6-0 HS Moderate Stress Case (N-1) Element Max Loading (% of Amp Rate / MVA / Amps)	Present Limiting Element, & Scope of Work Required to Meet (N-1) Max Load Flow
					Cost Est.: $ ***To be determined***.
Hogback – Soda Lakes **(#9794)**	138 MVA / 693A	Soda Lakes - Lookout (#5851)	**111.6%** 153.8 MVA / **772 A** **(Rev: Sub 112% cont / 97% emer; T-line: 74%)**	**105.5%** 145.6 MVA / **731 A**	**Hogback Sub:**: Conductors / Jumpers 691A Cont. / **800A 4-Hr Emerg**. **Soda Lakes Sub: 980A Cont**. / 980A 4-Hr. Emerg. **T-Line Cond**: 208 MVA / **1044A (150 deg C)** **Upgrades Required**: Nothing Required – Meets Max N-1 Flow Modeled **Cost Est.: $0**.
Lookout – Plains End #2 **(#5633)**	435 MVA / **1092 A**	Lookout – Plains End #1 (#5027)	**101.7%** 442.3 MVA / **1110 A** **(Rev: Sub 93% cont / 89% emer; T-line: 102%)**	92.6% 406.5 MVA / 1011 A	**Lookout Sub Term**: Line Trap 1200A Cont. / **1248A 4-Hr Emerg**. **Plains End Sub**: 5633 line not presently term into Plains End (goes past on to Leggett); assume will be rated for 1200A min. **T-Line Cond**: 435 MVA / **1092 A (2 FPS)** **Upgrades Required**: T-line 4 FPS rating to be determined; required upgrades (if any) to be determined. **Cost Est.**: $ ***To be determined***.
Smoky Hill – Spruce **(#5171)**	800 MVA / **2000 A** **(Rev Sub 789 MVA / 1981A Cont; 929 MVA / 2333A emerg; T-Line: 850 MVA/ 2140A)**	Spruce - Powhaton (#5177)	**100%** 793.1 MVA / **2003 A** **(Rev: Sub 101% cont / 86% emer; T-line: 94%)**	93.7% 757.7 MVA / 1874 A	**Smoky Hill Sub: 3000A Cont**. / 3000A 4-Hr Emerg. **Spruce Sub**: Bus (2.5 in tube) 1981A cont. / **2333A 4-Hr Emerg**. **T-Line Cond**: (New uprate planned in 2008) 850 MVA / **2140 A (4 PFS)** **Upgrades Required**: Nothing Required – (4-Hr Emergency Rating) Meets Max N-1 Flow Modeled **Cost Est.: $0.**
Smoky Hill – Powhaton **(#5177)**	800 MVA / **2000 A** **(Rev Sub 789 MVA / 1981A Cont; 929 MVA / 2333A emerg; T-Line: 850 MVA/ 2140A)**	Smoky Hill – Spruce (#5171)	99.3% 792.9 MVA / 1986 A **(Rev: Sub 100% cont / 85% emer; T-line: 93%)**	92.9% 743.3 MVA / 1857 A	**Smoky Hill Sub: 3000A Cont**. / 3000A 4-Hr Emerg. **Spruce Sub**: Bus (2.5 in tube) 1981A cont. / **2333A 4-Hr Emerg**. (Note – Powhaton is new sub in 2009, assumes will meet 2000a or more min. requirement) **T-Line Cond**: (New uprate planned in 2008) 850 MVA / **2140 A (4 PFS)** **Upgrades Required**: Nothing Required – (4-Hr Emergency Rating) Meets Max N-1 Flow Modeled **Cost Est.: $0.**
Spruce - Powhaton **(#5177)**	800 MVA / **2000 A**	Smoky Hill – Spruce	**100.3%** 808.8 MVA / **2005 A**	93.8% 758.5 MVA / 1876 A	**Smoky Hill Sub: 3000A Cont**. / 3000A 4-Hr Emerg. **Spruce Sub**: Bus (2.5 in tube) 1981A cont. /

Monitored Line or Element (Name / Ckt. #)	Monitored Line or Element Rating (MVA / Amps)	Line Out (N-1) (Name / Ckt. #)	FSV G5-G6 300 HS Moderate Stress Case (N-1) Element Max Loading (% of Amp Rate / MVA / Amps)	FSV G5-G6-0 HS Moderate Stress Case (N-1) Element Max Loading (% of Amp Rate / MVA / Amps)	Present Limiting Element, & Scope of Work Required to Meet (N-1) Max Load Flow
	(Rev Sub 789 MVA / 1981A Cont; 929 MVA / 2333A emerg; T-Line: 850 MVA/ 2140A)	(#5171)	**(Rev: Sub 101% cont / 86% emer; T-line: 94%)**		**2333A 4-Hr Emerg**. . (Note – Powhaton is new sub in 2009, assumes will meet 2000a or more min. requirement) **T-Line Cond**: (New uprate planned in 2008) 850 MVA / **2140 A (4 PFS)** **Upgrades Required**: Nothing Required – (4-Hr Emergency Rating) Meets Max N-1 Flow Modeled **Cost Est.: $0.**
Valmont 230/115 kV Autoxfmr	**280 MVA**	Valmont – Simms (#5389)	**115% 322 MVA**	**107.2% 300.2 MVA**	**Valmont Sub: Upgrades required**: Add second auto in 2009, vs. 2010. This project has been approved in the 2008 capital budget with an in service date of May 2010, but would likely require using a xfmr already on order for other project (e.g. Waterton, or other Squirrell driven proj).
Washington – JL Green **(#5527)**	413 MVA / **1037 A** **(Rev Sub 489.6 MVA / 1229A Cont; 570.9 MVA / 1433A emerg; T-Line: 579 MVA/ 1453A**	Ft. Lupton – Henry Lake (#5047)	**116.4%** 480.6 MVA / **1207 A** **(Rev: Sub 98% cont / 84% emer; T-line: 83%)**	**108.9%** 449.7 MVA / **1129 A**	**Washington Sub**: 1229A Cont. / **1433A 4-Hr Emerg.;** **JL Green Sub**: Assumed at least **1200A**, TSGT owns sub – ***Final Rate To be determined*** **T-Line Cond**: 579 MVA / **1453A (2 FPS assumed)** **Upgrades Required**: Nothing Required – (4-Hr Emergency Rating) Meets Max N-1 Flow Modeled **Cost Est.: $0.**.

Table 3: Heavy North to South Stressed System Case (2009HSHN RL5, TOT3 = 1453, TOT7 = 609), Common Tower N-2 Double Contingency Outage Results:

(N-2) Ckts Out	OL Element	FSV 300 Case (N-2) Element Loading (MVA / % of Rate)	FSV 0 Case (N-2) Element Loading (MVA / % of Rate)
#5953 (FSV–Spindle); & #5307 (FSV–Niwot)	#5057 Cher - Lacombe	512.8 MVA / 115.5%	454.6 MVA / 102.4%
	#5311 FSV-Ft.Lupton#1	493.7 / 111.2	419.2 / 92.6
	#5329 FSV-Ft.Lupton #2	493.7 / 111.2	419.2 / 92.6
	#5183 JL Green-FtLupt	521.5 / 109.1	468.1 / 99.7
	#5527 Wash-JL Green	505.6 / 122.4	452.4 / 111.5
	#5527 Glenn-Wash	413.9 / 100.2	362.3 / 89.4
#5327 (FSV–Green Vly); & #5279 (Keenesbg–Green Vly)	#5527 Wash-JL Green	435.3 MVA / 105.4%	393.4 MVA / 96.7%
#5311 (FSV-Ft.Lupton #1); &* #5329 (FSV-Ft.Lupton #2);	#5385 Valmont-Spindle	576.9 MVA / 103.6%	531.2 MVA / 92.6%
#5307 (FSV-Niwot); & #5385 (Spindle-Valmont)	#5057 Cher - Lacombe	555.1 MVA / 125%	496.5 MVA / 111.8%
	#5311 FSV-Ft.Lupton#1	577.8 / 130.1	494.6 / 111.4
	#5329 FSV-Ft.Lupton #2	577.8 / 130.1	494.6 / 111.4
	#5183 JL Green-FtLupt	574.4 / 120.2	528.6 / 110.6
	#5527 Wash-JL Green	466.1 / 112.9	420.7 / 101.9
	#5527 Glenn-Wash	558.4 / 135.2	512.6 / 124.1

NOTE – These additional N-2 double contingency power flow studies were run as an additional sensitivity study only, and do not necessarily reflect any likely or probable events.