



## Interconnection Feasibility Study Report Request # GI-2008-29

256 MW Generator, Platteville, Colorado

Public Service Company of Colorado  
Transmission Planning  
March 19, 2009

### Executive Summary

Public Service Company of Colorado received an interconnection request (GI-2008-29) to install a 256 MW steam turbine generator facility at Platteville, Colorado. The proposed interconnection point is the Fort Saint Vrain 230 kV substation owned by PSCo (see Figures 1 & 2 below). The generator would add to the existing generation already at the station and would convert the Unit 5 & 6 simple cycle combustion turbines to combined cycle operation. The requested in service date is June 30, 2013 with a projected backfeed date of December 31, 2012.

This request was studied as a Network Resource<sup>1</sup> at the full 256 MW rated output. These investigations included steady-state power flow and short circuit analyses. 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 Large Generator Interconnection Request (LGIR) queue, other than the generation projects that are already approved and planned to be in service by June 2013. The main purpose of this Feasibility Study was to evaluate the potential impact on the PSCo transmission infrastructure as well as that of neighboring utilities when injecting the proposed 256 MW of generation at the interconnection point at the Fort Saint Vrain Substation, and delivering the additional generation to native PSCo loads. The costs to interconnect the project with the transmission system have been evaluated by PSCo Engineering.

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<sup>1</sup> **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.



### Network Resource

Based on the results of the study, the Network Resource analysis indicates that the developer can provide 256 MW if the following is completed:

- Upgrade the Fort St. Vrain-Ft. Lupton 230 kV circuit #5311.
- Upgrade the Fort St. Vrain-Ft. Lupton 230 kV circuit #5329.
- Upgrade equipment at the JL Green 230 kV substation associated with the JL Green-Ft. Lupton 230 kV circuit. JL Green Substation is owned by Tri-State Generation & Transmission. The developer should contact TSG&T directly to develop plans to mitigate the reported overloads. Our results will be communicated to TSG&T.

The cost for the transmission interconnection (in 2009 dollars):

#### **Transmission Proposal**

The total estimated cost of the recommended system improvements to interconnect the project is approximately **\$3,265,000** and includes:

- \$ 1.650 million for PSCo-Owned, Developer-Funded Attachment Facilities
- \$ 1.065 million for PSCo-Owned, PSCo-Funded Attachment Facilities
- \$ 0.550 million<sup>2</sup> for PSCo Network Upgrades for Delivery to PSCo Loads

This work can be completed in 18 months following receipt of authorization to proceed.

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<sup>2</sup>Does not include potential costs to address TSG&T overload concerns.

Figure 1 Network Diagram

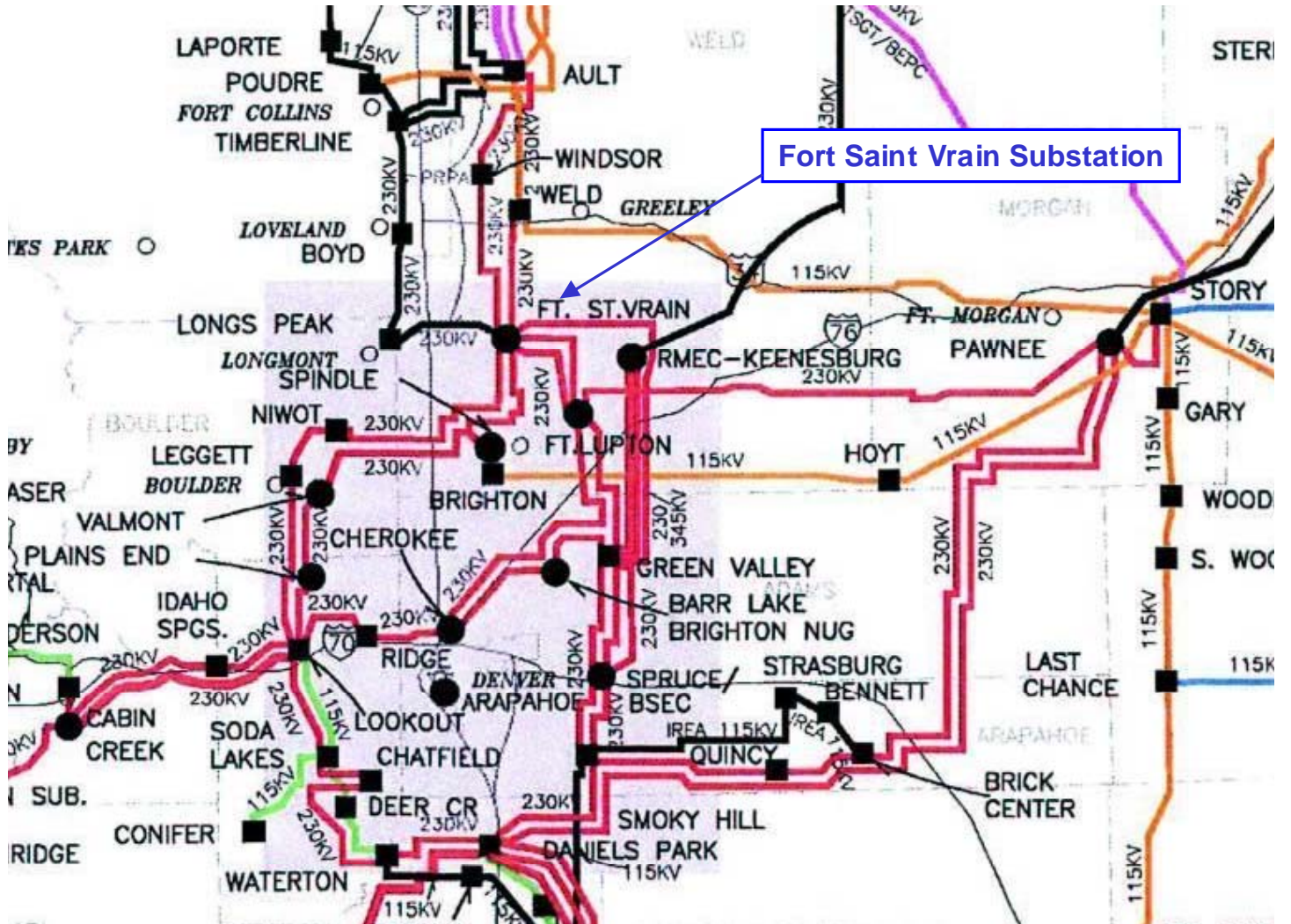
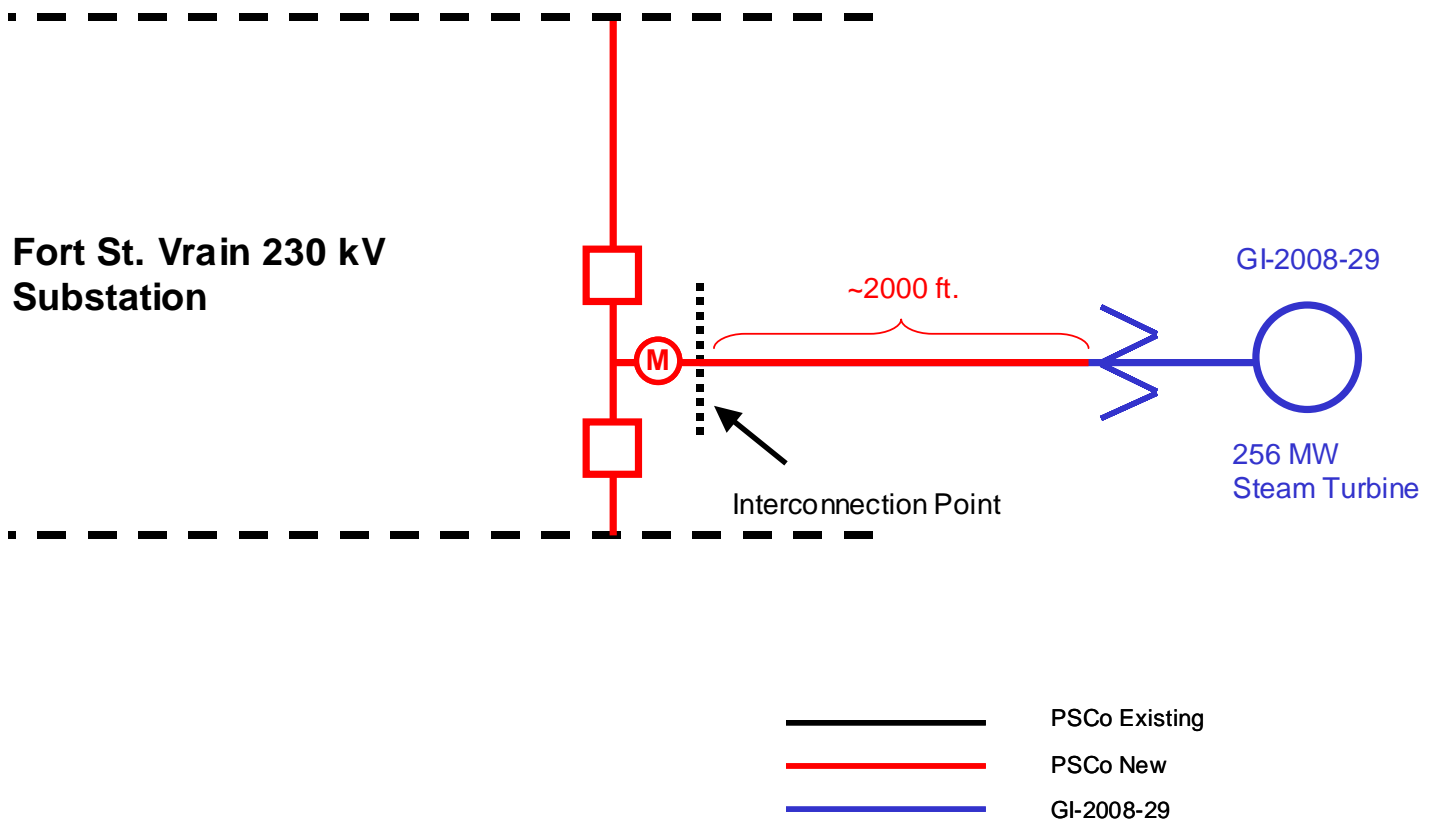


Figure 2 Proposed Interconnection Facilities @ Fort St. Vrain (PSCo upgrades Marked in Red)

### GI-2008-29





## **Introduction**

Public Service Company of Colorado received an interconnection request (GI-2008-29) to install a 256 MW steam turbine generator facility at Platteville, Colorado. The proposed interconnection point is the Fort Saint Vrain 230 kV substation owned by PSCo (see Figures 1 & 2). The generator would add to the existing generation already at the station and would convert the Unit 5 & 6 simple cycle combustion turbines to combined cycle operation. The requested in service date is June 30, 2013 with a projected backfeed date of December 31, 2012.

This study determined the system reinforcements and associated costs required to facilitate the addition of the new generator to the transmission system as a Network Resource. The reinforcements include the direct connection of the generator to the system and any network upgrades required to maintain the reliability of the transmission system.

## **Study Scope and Analysis**

The Feasibility Study evaluated the transmission impacts associated with the proposed generating station. It consisted of power flow and short circuit analyses. The power flow analysis identified any thermal or voltage limit violations resulting from the interconnection and an identification of network upgrades required to deliver the proposed generation to PSCo loads. The short circuit analysis identified any circuit breakers that might exceed their fault interruption capability due to addition of the new generation.

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 nominal, and steady-state power flows below the thermal ratings of all facilities. Operationally, PSCo tries to maintain a transmission system voltage profile ranging from 1.02 per unit or higher at regulating (generation) buses to 1.0 per unit or higher at transmission load buses. Following a single contingency, transmission system steady state bus voltages must remain within 0.90 per unit to 1.10 per unit, and power flows within 100% of the facilities' continuous thermal ratings.

For this project, potential affected parties include Tri-State Generation & Transmission (TSG&T).

## **Power Flow Study Models**

The power flow studies were based on the WECC approved 13HS1AP base case. Load levels reflect 2013 heavy summer peak system conditions.



The Project's steam turbine generator was modeled as a conventional 256 MW machine (300 MVA , 0.85 pf) connected to an 18.0 kV generator bus. The generator model includes an 18.0/230.0 kV, 300 MVA generator step-up transformer connected to the Fort Saint Vrain 230 kV bus. The reactive capability of the generator was based on the machine reactive capability curves provided by the project developer and generator scheduled voltage was set to match the scheduled voltage of the other units at Fort Saint Vrain.

Two main power flow case model generation dispatch scenarios were evaluated. One was created as a reference case and the other was created with the new generation modeled at Fort Saint Vrain. To evaluate the capabilities of the existing transmission system and the potential reinforcements that would be required, the power flow models were modified to simulate high flows from northern Colorado to the south. To accomplish this, generation in Wyoming was dispatched to increase flows over the TOT 3 transmission path. Generation at Rawhide was also dispatched to increase flows over the TOT 7 transmission path. In addition, the existing generation at Fort Saint Vrain was redispached to maximum output. The Comanche generating plant was used as a sink for these dispatch changes.

In the WECC 13HS1AP case, TOT 3 & TOT 7 flow levels were 1188.1 MW & 278.3 MW, respectively. In the GI-2008-29 benchmark case, TOT 3 & TOT 7 flow levels were 1451.7 MW & 486.9 MW, respectively. In the GI-2008-29 generator case, TOT 3 & TOT 7 flow levels were 1441.5 MW & 440.8 MW, respectively.

PSCo control area (Area 70) wind generation facilities were dispatched to approximately 12% of facility ratings, consistent with other similar planning study models.

### **Power Flow Study Process**

Automated contingency power flow studies were completed on the reference model and the model with the proposed generation using PTI's PSS<sup>TM</sup>MUST program, switching out single branches one at a time for all of the transmission facilities (lines and transformers) in control areas 70 (PSCo) and 73 (WAPA RM). Limited double circuit tower contingencies in the area of Fort Saint Vrain were also included. Results from the two cases were compared and new overloads or overloads that increased by greater than 5% in the new generator case were noted.

### **Power Flow Results**

A list of the transmission facilities that experienced new or significantly increased overloads in the case with the new generation as compared to the reference case can be found in Tables 6 & 7 in the Appendix.

Based on these results, the overloaded facilities are:





- Fort Lupton 230/115 kV T-3 transformer.
- Fort St. Vrain-Ft. Lupton 230 kV circuit #5311.
- Fort St. Vrain-Ft. Lupton 230 kV circuit #5329.
- JL Green-Ft. Lupton 230 kV circuit. The limit is at JL Green Substation, which is owned by Tri-State Generation & Transmission. Our results will be communicated to TSG&T.

The Fort Lupton 230/115 kV T-3 transformer is overloaded at 103.1% of its 280 MVA normal rating, but its emergency rating is 322 MVA. Therefore, an operating procedure can be used to unload the transformer during contingency situations.

The limiting element associated with the two Fort St. Vrain-Ft. Lupton 230 kV circuits is the 1033.5 kcmil 45/7 ACSR line conductor. These circuits will require upgrade.

The limiting element associated with the JL Green-Ft. Lupton 230 kV circuit is a 1200 A CT located at the JL Green Substation. JL Green is owned by Tri-State Generation & Transmission. Therefore, the developer should contact TSG&T directly to develop plans to mitigate the overload.

Table 7 in the Appendix illustrates the results associated with the limited double circuit tower contingencies that were tested. As can be seen, already overloaded facilities would experience higher overloads due to the more severe contingencies. Additional facilities are also overloaded. Since these are N-2 contingencies, these results are provided for information only and are not being used to determine required system upgrades.

### **Network Resource (NR)**

This Study has determined that the requested generation increase injected at the interconnection point at the Fort Saint Vrain 230 kV substation causes overloads on the PSCo and TSG&T systems. Therefore, the 256 MW Network Resource value requested will require Transmission Network Upgrades.

**NR = 256 MW (with required Network Upgrades)**

### **Short Circuit Study Results**

Short circuit calculations were performed to evaluate the impact of the proposed generation. The results indicate that no new circuit breakers are expected to exceed their capabilities following installation of the new generation. Table 1 contains the short circuit parameters that were calculated with the proposed generation in service.



**Table 1 Short Circuit Parameters at the Point of Interconnection**

System Condition	Three-Phase Fault Level (Amps)	Single-Line-to-Ground Fault Level (Amps)	Thevenin System Equivalent Impedance (R +j X) (ohms)
All Facilities in Service	I <sub>1</sub> = 42,617.3 I <sub>2</sub> =I <sub>0</sub> = 0 I <sub>A</sub> =I <sub>B</sub> =I <sub>C</sub> = 42,617.3	I <sub>1</sub> =I <sub>2</sub> = 15,174.4 I <sub>0</sub> = 45,523.3 I <sub>A</sub> = 45,523.3 I <sub>B</sub> =I <sub>C</sub> = 0	Z <sub>1</sub> (pos)= 0.19762 +j 3.10961 Z <sub>2</sub> (neg)= 0.23413 +j 3.10908 Z <sub>0</sub> (zero)= 0.21686 +j 2.50818

**Costs Estimates and Assumptions**

GI-2008-29 (Feasibility Study Report)

March 17, 2009

The Customer has requested to evaluate the installation of a new 256 MW steam turbine addition (creating a combined cycle plant using Unit 5 and 6 simple cycle combustion turbines) interconnecting at the Fort St. Vrain 230kV Substation. The estimated total cost for the required interconnection and network upgrades is **\$3,265,000.**

The estimated costs shown are (+/-30%) estimates in 2009 dollars and are based upon typical construction costs for previously performed similar construction. These estimated costs include all applicable labor and overheads associated with the siting, engineering, design, procurement and construction of these new facilities. This estimate does not include the cost for any other Customer owned equipment and associated design, engineering or construction.

The following tables list the improvements required to accommodate the interconnection and the network upgrades for delivery of the Project. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines. System improvements are subject to change upon a more detailed analysis.





**Table 2 – PSCo Owned; Customer Funded Interconnection Facilities**

Element	Description	Cost Est. Millions
<b>Fort St. Vrain 230kV Substation</b>	Interconnect Customer to tap into the Fort St. Vrain 230kV Substation. The new equipment includes: <ul style="list-style-type: none"> <li>• bidirectional metering</li> <li>• Three 230kV combination CT/PT metering units</li> <li>• One 230kV, 3000 amp gang switch</li> <li>• Associated foundations and structures</li> <li>• Associated transmission line communications, relaying and testing materials.</li> </ul>	<b>\$0.415</b>
	Customer Load Frequency/Automated Generator Control and Generator Witness Testing: <ul style="list-style-type: none"> <li>• Load Control RTU</li> <li>• All required cabinets, wiring and associated control equipment</li> </ul>	<b>\$0.140</b>
	Construct approximately 2000' of transmission line to span and connect the new GSU to the Fort St. Vrain Substation	<b>\$1.085</b>
	Siting and Land Rights activities to support the land use permitting process.	<b>\$0.010</b>
	<b>Total Cost Estimate for Customer Interconnection Facilities</b>	<b>\$1.650</b>
<b>Time Frame</b>	Site, design, procure and construct	<b>18 Months</b>

**Table 3: PSCo Owned; PSCo Funded Interconnection Facilities**

Element	Description	Cost
<b>Fort St. Vrain 230kV Substation</b>	Interconnect Customer to tap into the Fort St. Vrain 230kV Substation. The new equipment includes: <ul style="list-style-type: none"> <li>• Two 230kV, 3000 amp, 63KA circuit breakers</li> <li>• Four 230kV, 3000 amp gang switches</li> <li>• Line relaying and testing</li> <li>• Associated foundations and structures</li> <li>• Grounding, station wiring and cabling</li> </ul>	<b>\$1.065</b>
	<b>Total Cost Estimate for PSCo Interconnection Facilities</b>	<b>\$1.065</b>
<b>Time Frame</b>	<b>Site, design, procure and construct</b>	<b>18 Months</b>



**Table 4 – PSCo Network Upgrades for Delivery**

Element	Description	Cost Est. Millions
<b>Ft. Lupton-Fort St. Vrain 230kV OH Line</b>	Install cage extensions to 16 structures to uprate the line for 640 MVA operation.	<b>\$0.500</b>
<b>Ft. Lupton-Fort St. Vrain 230kV OH Line</b>	S&LR's activities to obtain any easements and construction permits and for land and ROW restoration.	<b>\$0.050</b>
	<b>Total Cost Estimate for PSCo Network Upgrades/Delivery</b>	<b>\$0.550</b>
<b>Time Frame</b>	<b>Site, design, procure and construct</b>	<b>18 Months</b>

**Assumptions**

- The cost estimates provided are “scoping estimates” with an accuracy of +/- 30%.
- Estimates are based on 2009 dollars.
- There is no contingency added to the estimates. AFUDC is not included. All other applicable overheads are included
- Labor is estimated for straight time labor only – no overtime labor is included.
- PSCo (or it’s Contractor) crews will perform all construction and wiring associated with PSCo owned and maintained facilities.
- The estimated time to site, design, procure (long lead time materials) and construct the interconnection and network facilities is at least 12 months.
- A CPCN will not be required for the interconnection and network facility upgrades. But, will be required for the PSCo generation addition.
- Spare fiber optics between plant and substation.
- All required transmission outages necessary to support construction would be granted as needed.
- PSCo crews to perform relay and equipment testing and checkout, relay panel construction and final commissioning.
- No new substation land required. Substation work to be completed within existing property boundaries.
- Requested commercial operation date is June 30, 2013.

## Appendix

### A. Generation Dispatch

**Table 5 – Generation Dispatch in the GI-2008-29 Generation Case**

GI-2008-29 Feasibility Study					
Generation Dispatch					
Bus	Name	ID	Status	Pgen	
500	8-29_GEN	18.000	1	1	256.0
70103	CHEROK1	15.500	C1	1	110.0
70104	CHEROK2	15.500	C2	1	110.0
70105	CHEROK3	20.000	C3	1	141.8
70106	CHEROK4	22.000	C4	1	350.0
70119	COMAN_1	24.000	C1	1	333.9
70120	COMAN_2	24.000	C2	0	0.0
70188	FTLUP1-2	13.800	G1	0	0.0
70188	FTLUP1-2	13.800	G2	0	0.0
70310	PAWNEE	22.000	C1	1	505.0
70314	MANCHEF1	16.000	G1	1	130.0
70315	MANCHEF2	16.000	G2	1	130.0
70350	RAWHIDE	24.000	C1	1	290.0
70351	RAWHIDEA	13.800	GA	1	70.0
70406	ST.VR_2	18.000	G2	1	130.0
70407	ST.VR_3	18.000	G3	1	130.0
70408	ST.VR_4	18.000	G4	1	130.0
70409	ST.VRAIN	22.000	G1	1	342.0
70446	VALMONT	20.000	C5	1	150.0
70448	VALMONT6	13.800	G6	1	50.0
70553	ARAP5&6	13.800	G5	1	30.0
70553	ARAP5&6	13.800	G6	1	30.0
70554	ARAP7	13.800	G7	1	40.0
70557	VALMNT7	13.800	G7	1	30.0
70558	VALMNT8	13.800	G8	1	30.0
70561	RAWHIDEF	18.000	GF	1	138.0
70562	SPRUCE1	18.000	G1	1	120.0
70563	SPRUCE2	18.000	G2	1	120.0
70567	RAWHIDED	13.800	GD	1	70.0
70568	RAWHIDEB	13.800	GB	1	70.0



GI-2008-29 Feasibility Study					
Generation Dispatch					
Bus	Name	ID	Status	Pgen	
70569	RAWHIDEC 13.800	GC	1	70.0	
70588	RMEC1 15.000	G1	1	120.0	
70589	RMEC2 15.000	G2	1	120.0	
70591	RMEC3 23.000	G3	1	300.0	
70593	SPNDLE1 18.000	G1	1	120.0	
70594	SPNDLE2 18.000	G2	1	120.0	
70710	PTZLOGN1 34.500	W1	1	25.1	
70712	PTZLOGN2 34.500	W2	1	15.0	
70713	PTZLOGN3 34.500	W3	1	10.0	
70777	COMAN_3 24.000	C3	1	300.0	
70822	CEDARCK1 34.500	W1	1	18.8	
70823	CEDARCK2 34.500	W2	1	18.8	
70934	ARAP_8 16.500	G1	1	140.0	
70935	ARAP_9 16.500	G2	1	140.0	
70936	ARAP_10 18.000	G3	1	160.0	
70950	ST.VR_5 18.000	G5	1	150.0	
70951	ST.VR_6 18.000	G6	1	150.0	
			(1=on)		



## Appendix

### B. Power Flow Contingency Results

The results of the power flow studies are summarized in Tables 6 & 7 below. The facilities identified in this study report as overloaded in the contingency analysis are limited to new or significantly increased overloads and do not address all of the facilities that may have been flagged as overloaded in the contingency runs. The other facilities that may be overloaded, independent of the new 256 MW generation injection at Fort Saint Vrain substation, will be addressed through other separate Transmission Planning project proposals or by other affected utilities.

**Table 6 – Summary Listing of Differentially Overloaded Facilities for N-1 Contingencies<sup>3</sup>**

				Branch N-1 Loading Without GI-2008-29			Branch N-1 Loading With GI-2008-29			
Monitored Facility (Line or Transformer) From Bus To Bus	Type	Line Owner	Branch Rating MVA	N-1 Flow in MVA	N-1 Flow in % of Rating	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rating	Total # of Violations	N-1 Contingency Outage From Bus To Bus
70192 FTLUPTON 230 70191 FTLUPTON 115 T1	TR	PSCo	280	277.2	99.0	1	288.7	103.1	2	70447 VALMONT 230 70592 SPNDLE 230
70192 FTLUPTON 230 70410 ST.VRAIN 230 1	LN	PSCo	506	503.3	99.4	0	583.5	115.2	1	70192 FTLUPTON 230 70410 ST.VRAIN 230 2
70192 FTLUPTON 230 70410 ST.VRAIN 230 2	LN	PSCo	506	503.3	99.4	0	583.5	115.2	1	70192 FTLUPTON 230 70410 ST.VRAIN 230 1
70529 JLGREEN 230 70192 FTLUPTON 230 1	LN	PSCo/Tri-State	478	449.9	94.1	0	483.5	101.2	1	70192 FTLUPTON 230 70605 HENRYLAK 230 1

<sup>3</sup> Newly overloaded elements, or delta overloads > 5% of rating, due to proposed 256 MW generation injection at POI.



**Table 7 – Summary Listing of Differentially Overloaded Facilities for Limited N-2 Double Circuit Tower Outage Contingencies<sup>4</sup>**

				Branch N-2 Loading Without GI-2008-29			Branch N-2 Loading With GI-2008-29			
Monitored Facility (Line or Transformer) From Bus To Bus	Type	Line Owner	Branch Rating MVA	N-2 Flow in MVA	N-2 Flow in % of Rating	Total # of Violations	N-2 Flow in MVA	N-2 Flow in % of Rating	Total # of Violations	N-2 Contingency Outage
70192 FTLUPTON 230 70191 FTLUPTON 115 T1	TR	PSCo	280	309.3	110.5	2	323.9	115.7	2	Isabelle-Niwot 230 kV Spindle-Valmont 230 kV
70192 FTLUPTON 230 70410 ST.VRAIN 230 1	LN	PSCo	506	528.7	104.4	1	599.2	118.3	2	Isabelle-Niwot 230 kV Spindle-Valmont 230 kV
70192 FTLUPTON 230 70410 ST.VRAIN 230 2	LN	PSCo	506	528.7	104.4	1	599.2	118.3	2	Isabelle-Niwot 230 kV Spindle-Valmont 230 kV
70529 JLGREEN 230 70461 WASHINGT 230 1	LN	PSCo/Tri-State	478	484.9	101.4	1	523.8	109.6	2	Isabelle-Niwot 230 kV Spindle-Valmont 230 kV
70529 JLGREEN 230 70192 FTLUPTON 230 1	LN	PSCo/Tri-State	478	493.9	103.3	1	532.9	111.5	2	Isabelle-Niwot 230 kV Spindle-Valmont 230 kV
70447 VALMONT 230 70592 SPNDLE 230 1	LN	PSCo	557	540.8	97.1	0	593.7	106.6	1	Ft St Vrain-Ft Lupton 230 kV #1 Ft St Vrain-Ft Lupton 230 kV #2

<sup>4</sup> Newly overloaded elements, or delta overloads > 5% of rating, due to proposed 256 MW generation injection at POI.





C. Project Schedule

Will be included in the System Impact Study

### D. Proposed Interconnection Station One-line

