



# Interconnection System Impact Study Report Request # BHCT-G5

## 100 MW Generator at Airport Tap in Pueblo, Colorado

### Black Hills Corporation Transmission Planning

July 7, 2010

#### Executive Summary

Black Hills Colorado Electric received an interconnection request (BHCT-G5) to install a 100 MW gas turbine generator facility near Pueblo, Colorado. The proposed project consists of two (2) 40 MW GE LM6000 gas turbines and a 20 MW steam turbine with a Point of Interconnection (POI) at Airport Tap (renamed to Baculite Mesa). The proposed interconnect in-service date is October 1, 2011.

The request was studied with the full 100 MW rated output with heavy summer and light winter loads for the year 2012. Steady-state, transient stability, and short circuit analysis were performed to evaluate the potential impact of the proposed interconnection on the Black Hills Colorado Electric transmission system and identify upgrades required to mitigate any performance criteria violations.

#### Interconnection Requirements

The System Impact Study identified no additional Network Upgrades beyond those required by the Feasibility Study Report. Based on the results of the Feasibility Study, the proposed 100 MW facility can be interconnected to the 115kV transmission system at the Baculite Mesa POI with the following Network Upgrades:

- Expansion of the Baculite Mesa 115 kV substation by two (2) positions.
- Build a new three (3) position 115kV substation at Nyberg.
- Rebuild 5 miles of 115kV line from Baculite Mesa to Nyberg.

The Network Upgrades are estimated to cost **\$9,870,000**.

The Interconnection Request will require the following Interconnection Facilities:



- 115 kV metering, communications, protection and other typical equipment at Baculite Mesa for generator POI (1 position)

The Interconnection Facilities are estimated to cost **\$18,812**.

All Network Upgrades and Interconnection Facilities have an expected in-service date prior to October 1, 2011.

### **Introduction**

Black Hills Colorado Electric received a Large Generator Interconnection request (BHCT-G5) to interconnect a 100 MW gas turbine generator facility near Pueblo, Colorado. The purpose of this System Impact Study is to evaluate the potential impact on the Black Hills Colorado Electric transmission system and identify upgrades required to mitigate any performance criteria violations.

The proposed project consists of two (2) 40 MW GE LM6000 gas turbines and a 20 MW steam turbine with a primary Point of Interconnection (POI) at Baculite Mesa.

### **Power Flow and Stability Study Models**

Power flow and stability studies for the proposed interconnection were performed using PSS/E simulation software, version 30.3.3. The heavy summer base case originated from the WECC approved 13HS1AP base case. The light winter base case originated from the WECC approved 13LW1SAP base case. These cases were updated to include 2012 heavy summer and light winter loading and projects with in-service dates prior to the facility in-service date. The included projects, which were determined to have an impact on system performance, included:

- 200 MW Interconnection Request BHCT-G3 at Baculite Mesa 115kV
- Baculite Mesa to West Station double circuit 115kV line identified in BHCT-G3 Feasibility Study
- 100 MW Interconnection Request BHCT-G4 at Baculite Mesa 115kV
- Rebuild Baculite Mesa to Airport Industrial Park to Airport Memorial 115kV line as identified in BHCT-G4 Feasibility Study
- 100 MW Interconnection Request BHCT-G5 at Baculite Mesa 115kV
- Baculite Mesa to Nyberg 115kV line identified in BHCT-G5 Feasibility Study
- Comanche 230/115 kV transformer updates

To simulate the worst-case generation output, the 100 MW of generation was dispatched by lowering the generation at Pawnee, while Comanche 3 was



modeled with a net output of 750MW in the heavy summer case. The 100 MW facility was modeled as one (1) 20 MW and two (2) 40 MW generators. The three machines were modeled at a common 13.8 kV generator terminal bus with a single 13.8/115 kV step-up transformer with a maximum nameplate capacity of 125 MVA connected to the Baculite Mesa 115 kV bus. The estimated machine reactive capability curves provided with the application were used to set the reactive capability of each generator.

**Power Flow Analysis**

Power flow analysis was used to determine the impacts, if any, of the proposed 100MW of generation on the Black Hills Colorado Electric transmission system. The voltage and thermal performance of the system was evaluated with and without the proposed project from the Feasibility Study of BHCT-G5 in-service. Table 1 displays the voltage criteria used in this power flow analysis. Thermal loading on all transmission lines were not allowed to exceed 100% of their normal rating, while thermal loading on transformers were allowed to overload up to 120% as shown in Table 2.

**Table 1** Steady-State Voltage Criteria

<b>BHCT-G5 System Impact Study</b>		
<b>Steady-State Voltage Criteria</b>		
<b>Acceptable Voltage Range</b>		
<b>Voltage Class</b>	<b>Pre-Contingency</b>	<b>Post-Contingency</b>
69kV and Above	0.95 to 1.05 p.u.	0.90 to 1.10 p.u

**Table 2** Maximum Transformer Overloads

<b>BHCT-G5 System Impact Study</b>	
<b>Maximum Transformer Overloads</b>	
<b>Maximum Hours at Overload</b>	<b>Allowable Transformer Overload</b>
1/2 Hour	153%
1 Hour	135%
2 Hours	120%

The steady state analysis was performed with pre-contingency solution parameters that allowed adjustment of load tap-changing transformers, static VAR devices including switched shunt capacitors and reactors, and DC taps. Post-contingency solution parameters allowed for adjustment of DC taps only. Area interchange control was disabled and generator VAR limits were applied immediately for all solutions. A fixed-slope decoupled Newton solution method



was implemented for all cases. Tables 3 and 4 list all of the prior outages and contingencies, respectively.

**Table 3** Prior Outages Studied for Steady-State Analysis

<b>BHCT-G5 System Impact Study</b>					
<b>Prior Outages Studied for Steady-State Analysis</b>					
<b>PO#</b>	<b>Prior Outage</b>	<b>PO#</b>	<b>Prior Outage</b>	<b>PO#</b>	<b>Prior Outage</b>
1	Burnt Mill - Freemary 115	16	W. Canon - Ponchbar 230	32	MidwayBR - W. Canon 230
2	Burnt Mill - W. Station 115	17	Comanche - MidwayPS #1	33	Comanche - Reader 115 #1
3	Freemary - Reader 115	18	Comanche - Walsenburg 230	34	MidwayPS - Northridge 115
4	Overton – Baculite Mesa 115	19	Ftn Valley - Desert Cove 115	35	Boone 230/115 #T1
5	Overton - Northridge 115	20	Ftn Valley - Midway BR 115	36	Comanche 230/115 #T1
6A	Apt Mem - Nyberg 115	21	Hyde Park - Pueblo Plant 115	37	Comanche 345/230 #T3
6B	Nyberg – DOT Tap 115	22	Hyde Park - W. Station 115	38	MidwayPS 230/115 #T1
7	Apt Park – Baculite Mesa 115	23	MidwayPS - W. Station 115 #1	39	MidwayPS 345/230 #T2
8	Apt Park - Apt Mem 115	24	MidwayPS - MidwayBR 230	40	W.Canon 230/115 #T1
9	Boone - DOT Tap 115	25	Portland - Skala 115	41	MidwayBR 230/115 #1
10	Boone - LaJunta W 115	26	Portland - W. Station 115	42	Baculite Mesa Gen 100MW #1
11	Boone - Comanche 230	27	Pueblo Plant - Reader 115	43	Comanche Gen #1
12	Boone - Lamar CO 230 #1	28	Reader - Apt Mem 115	44	Comanche Gen #3
13	Boone - MidwayPS 230	29	Smelter - W. Canon 115	45	Lamar DC
14	Canon City - Skala 115	30	Desert Cove - W. Station 115	46	W. Station – Baculite Mesa 115 #1
15	Canon City - W. Canon 115	31	DanielPK - Comanche 345 #1		



**Table 4 Contingencies Studied for Steady-State Analysis**

BHCT-G5 System Impact Study											
Contingencies Studied for Steady-State Analysis											
#	Contingency			#	Contingency			#	Contingency		
1	DANIELPK	345.00-COMANCHE	345.00 #1	29	W STATION	115.00-BACULITE MESA	115.00 #1	57	COMANCHE	230.00-COMANCHE	345.00 #T3
2	DANIELPK	345.00-COMANCHE	345.00 #2	30	W STATION	115.00-BACULITE MESA	115.00 #2	58	COMANCHE	230.00-COMANCHE	345.00 #T4
3	BOONE	230.00-COMANCHE	230.00 #1	31	CANONCTY	115.00-SKALA	115.00 #1	59	MIDWAYPS	230.00-MIDWAYPS	345.00 #T2
4	BOONE	230.00-LAMAR_CO	230.00 #1	32	CANONCTY	115.00-W.CANON	115.00 #1	60	COMANCHE	115.00-COMANCHE	230.00 #T1
5	BOONE	230.00-MIDWAYPS	230.00 #1	33	COMANCHE	115.00-READER	115.00 #1	61	COMANCHE	115.00-COMANCHE	230.00 #T2
6	COMANCHE	230.00-MIDWAYPS	230.00 #1	34	COMANCHE	115.00-READER	115.00 #2	62	MIDWAYPS	115.00-MIDWAYPS	230.00 #T1
7	COMANCHE	230.00-MIDWAYPS	230.00 #2	35	BOONE	115.00-LAJUNTAT	115.00 #1	63	W.CANON	115.00-W CANON	230.00 #T1
8	COMANCHE	230.00-WALSENBG	230.00 #1	36	BOONE	115.00-LAJUNTAW	115.00 #1	64	BOONE	115.00-BOONE	230.00 #T1
9	VILAS	230.00-LAMAR_CO	230.00 #1	37	HYDEPARK	115.00-PUEBPLNT	115.00 #1	65	BOONE	230.00-BOONE	115.00 #T2
10	LAMAR_CO	230.00-LAMAR_DC	230.00 #1	38	HYDEPARK	115.00-W.STATON	115.00 #1	66	WALSENBG	115.00-WALSENBG	230.00 #T2
11	LAMAR_CO	230.00-CO_GRN	230.00 #1	39	LAJUNTAT	115.00-LAJUNTAW	115.00 #1	67	WALSENBG	115.00-WALSENBG	230.00 #T3
12	MIDWAYPS	230.00-MIDWAYBR	230.00 #1	40	LAJUNTAT	115.00-WILOW_CK	115.00 #1	68	STMBEACH	115.00-STMBEACH	230.00 #T1
13	MIDWAYPS	230.00-FULLER	230.00 #1	41	MIDWAYPS	115.00-W.STATON	115.00 #1	69	MIDWAYBR	115.00-MIDWAYBR	230.00 #1
14	SANLSVLY	230.00-PONCHABR	230.00 #1	42	PONCHA	115.00-SMELTER	115.00 #1	70	RD_NIXON	115.00-RD_NIXON	230.00 #1
15	MIDWAYBR	230.00-RD_NIXON	230.00 #1	43	PONCHA	115.00-N.GUNNSN	115.00 #1	71	LAMAR_CO	115.00-LAMAR_CO	230.00 #T1
16	MIDWAYBR	230.00-W CANON	230.00 #1	44	PORTLAND	115.00-SKALA	115.00 #1	72	DESERTCOV - FTN VAL - MIDWAYBR	115.00	
17	RD_NIXON	230.00-KELKER S	230.00 #1	45	PORTLAND	115.00-W.STATON	115.00 #1	73	MIDWAYPS - NORTHRIDGE - OVERTON	115.00	
18	RD_NIXON	230.00-FULLER	230.00 #1	46	PUEB_W	115.00-PUEB_TP	115.00 #1	74	BOONE	115.00 - NYBERG	115.00
19	RD_NIXON	230.00-FRTRANGE	230.00 #1	47	PUEB_TP	115.00-STMBEACH	115.00 #1	75	NYBERG	115.00 - APT MEM	115.00
20	W CANON	230.00-PONCHABR	230.00 #1	48	PUEB_TP	115.00-W.STATON	115.00 #1	76	BACULITE MESA - W. STATION	115 DOUBLE CIRCUIT	
21	PONCHABR	230.00-PARLIN	230.00 #1	49	PUEBPLNT	115.00-READER	115.00 #1	77	MIDWAY - W.STATION AND MIDWAY	NORTHRIDGE	115
22	LAMAR_CO	115.00-WILOW_CK	115.00 #1	50	READER	115.00-APT_MEM	115.00 #1	78	BACULITE MESA GEN #1	- 100MW	
23	BURNTMIL	115.00-FREEMARY	115.00 #1	51	AREQUGCH	115.00-W.CANON	115.00 #1	79	BACULITE MESA GEN #2	- 100MW	
24	BURNTMIL	115.00-W.STATON	115.00 #1	52	SMELTER	115.00-W.CANON	115.00 #1	80	COMANCHE GEN #1		
25	FREEMARY	115.00-READER	115.00 #1	53	STMBEACH	115.00-WALSENBG	115.00 #1	81	COMANCHE GEN #2		
26	OVERTON	115.00-BACULITE MESA	115.00 #1	54	DESRTCOV	115.00-W.STATON	115.00 #1	82	COMANCHE GEN #3		
27	APT_PARK	115.00-BACULITE MESA	115.0 #1	55	W.STATON	115.00-MIDWAYBR	115.00 #1	83	LAMAR DC		
28	APT_PARK	115.00-APT_MEM	115.00 #1	56	MIDWAYBR	115.00-RD_NIXON	115.00 #1	84	NYBERG	115.00 - BACULITE MESA	115.00



## Power Flow Results

Category B outages were studied for the heavy summer and light winter cases using the methods described above. With the identified projects from the Feasibility Study of BHCT-G5 in-service, there were no Category B criteria violations for the light winter case. The Category B violations for the heavy summer case can be seen in Table 5.

**Table 5** Category B Thermal Overloads for Heavy Summer Case

Heavy Summer - Category B Thermal Overloads - %Ratings				
Overloaded Element	Rated MVA	Outage Description	System Intact	Baculite Mesa 100MW
MidwayBR 230/115	100	MidwayBR – RD Nixon 230	101.8	101.5
Comanche – Walsenburg 230	239	Pueblo Tap – W. Station 115	119.2	120.4
Lamar CO 230/115	100	Boone – Lamar 230	129.3	129.3
LaJunta – Phillips Tap 69	24	Boone – Lamar 230	140.5	140.9
Pueblo Tap – W. Station 115	95	Comanche-Walsenburg 230*	139.8	139.9
Pueblo Tap – W. Station 115	95	Desert Cove – MidwayBR 115	95.8	100.0
Pueblo Tap – W. Station 115	95	MidwayPS – Overton 115	96.5	100.0
Pueblo Tap – W. Station 115	95	Boone – Nyberg 115	94.8	99.6
Pueblo Tap – W. Station 115	95	Portland – W. Station 115	97.5	101.4
Pueblo Tap – W. Station 115	95	Desert Cove – W. Station 115	97.2	101.2
Pueblo Tap – W. Station 115	95	MidwayPS 230/115	95.3	99.6
Pueblo Tap – W. Station 115	95	Walsenburg 230/115 #T2	97.1	100.5
Pueblo Tap – W. Station 115	95	Walsenburg 230/115 #T3	97.0	100.4

\* Through a RAS, the loss of the Comanche – Walsenburg 230kV line opens the Walsenburg – Gladstone 230kV line.

As can be seen in Table 5, the MidwayBR 230/115kV transformer, Lamar CO 230/115kV transformer and LaJunta – Phillips Tap 69kV line heavy summer Category B thermal overloading violations present with the identified projects in-service also existed in the system intact case. PSCo and Tri-State have an operating procedure to mitigate the Category B violation on the Lamar 230/115kV transformer following the loss of the Boone – Lamar 230kV line. The Category B thermal overloading violation on the Comanche – Walsenburg 230kV line following the loss of the Pueblo Tap – West Station 115kV line is a pre-existing problem, and can be mitigated by upgrading terminal equipment. Tri-State is currently working with PSCo to change this terminal equipment by the end of 2010, which will increase the rating from 239MVA to 612MVA, eliminating this overload. The proposed project resulted in new Category B thermal overloading violations on the Pueblo Tap – West Station 115kV line; however, the maximum violation on this line of 139.8% remained unchanged for the Comanche – Walsenburg 230kV Category B outage.



Category C outages were studied for the heavy summer and light winter cases using the methods described above. With the identified projects from the Feasibility Study of BHCT-G5 in-service, there were no Category C criteria violations for the light winter case. The Category B heavy summer violations for both the system intact case and with the identified projects in-service were also seen in Category C outages. Table 6 shows the Category C heavy summer violations on the Pueblo Tap – West Station 115kV line that are not included in Category B violations.

**Table 6** Category C Thermal Overloads on Pueblo Tap – West Station 115kV Line for Heavy Summer Case

Heavy Summer - Category C Thermal Overloads - %Ratings				
Overloaded Element	Rated MVA	Prior Outage	Outage Description	Baculite Mesa 100MW
Pueblo Tap-W. Station 115	95	Baculite Mesa – Overton 115	Baculite Mesa – Airport Park 115	100.6
Pueblo Tap-W. Station 115	95	Baculite Mesa – Overton 115	Airport Park – Airport Memorial 115	100.1
Pueblo Tap-W. Station 115	95	Baculite Mesa – Overton 115	MidwayPS – W. Station 115	101.2
Pueblo Tap-W. Station 115	95	Baculite Mesa – Overton 115	Reader – Airport Memorial 115	100.5
Pueblo Tap-W. Station 115	95	Northridge – Overton 115	Baculite Mesa – Airport Park 115	100.5
Pueblo Tap-W. Station 115	95	Northridge – Overton 115	Airport Park – Airport Memorial 115	99.9
Pueblo Tap-W. Station 115	95	Northridge – Overton 115	MidwayPS – W. Station 115	100.7
Pueblo Tap-W. Station 115	95	Northridge – Overton 115	Reader – Airport Memorial 115	100.2
Pueblo Tap-W. Station 115	95	Nyberg – Airport Memorial 115	Baculite Mesa – Airport Park 115	100.0
Pueblo Tap-W. Station 115	95	Baculite Mesa – Airport Park 115	Baculite Mesa – Overton 115	100.6
Pueblo Tap-W. Station 115	95	Baculite Mesa – Airport Park 115	Airport Park – Airport Memorial 115	100.0
Pueblo Tap-W. Station 115	95	Baculite Mesa – Airport Park 115	Nyberg – Airport Memorial 115	100.0
Pueblo Tap-W. Station 115	95	Baculite Mesa – Airport Park 115	MidwayPS 345/230 #T2	100.1
Pueblo Tap-W. Station 115	95	Airport Memorial – Airport Park 115	Baculite Mesa – Overton 115	100.1
Pueblo Tap-W. Station 115	95	Airport Memorial – Airport Park 115	Baculite Mesa – Airport Park 115	100.0
Pueblo Tap-W. Station 115	95	Boone – DOT Tap 115	Baculite Mesa – Overton 115	100.0
Pueblo Tap-W. Station 115	95	Boone – DOT Tap 115	Reader – Airport Memorial 115	100.2
Pueblo Tap-W. Station 115	95	MidwayPS – W. Station 115	Baculite Mesa – Overton 115	101.2
Pueblo Tap-W. Station 115	95	Reader – Airport Memorial 115	Baculite Mesa – Overton 115	100.5
Pueblo Tap-W. Station 115	95	MidwayPS – Northridge 115	Baculite Mesa – Overton 115	100.6
Pueblo Tap-W. Station 115	95	MidwayPS 345/230 #T2	Baculite Mesa – Airport Park 115	100.1

The proposed project resulted in multiple Category C thermal overloading violations on the Pueblo Tap – West Station 115kV line. The maximum Category C violation of 103.1% was the result of a prior outage on the Baculite Mesa – Airport Industrial Park 115kV line followed by the loss of the Portland – West Station 115kV line. This maximum Category C violation is significantly less than the 139.8% thermal loading for the Comanche – Walsenburg 230kV Category B



outage. Table 7 shows the remaining Category C thermal overload violations not included on the Pueblo Tap – West Station 115kV line in Table 6.

**Table 7** Category C Increased Thermal Overloads for Heavy Summer Case

Heavy Summer - Category C Increased Thermal Overloads - %Ratings					
Overloaded Element	Rated MVA	Prior Outage	Outage Description	System Intact	Baculite Mesa 100MW
MidwayBR 230/115	100	Desert Cove-W. Station 115	MidwayBR-RD Nixon 230	140.6	145.5
MidwayBR 230/115	100	Ftn Valley-Desert Cove 115	MidwayBR-RD Nixon 230	127.3	132.2
MidwayBR 230/115	100	Ftn Valley-MidwayBR 115	MidwayBR-RD Nixon 230	126.2	131.1
MidwayBR 230/115	100	MidwayPS 345/230 #T2	MidwayBR-RD Nixon 230	112.9	114.5
MidwayBR 230/115	100	Desert Cove-W. Station 115	RD Nixon 230/115 #1	98.8	100.8
MidwayBR 230/115	100	Baculite Mesa-Airport Park 115	MidwayBR-RD Nixon 230	99.3	100.6
Desert Cove-W. Station 115	120	MidwayPS – MidwayBR 230	MidwayPS – Fuller 230	90.0	102.2

The thermal overloading violations on the MidwayBR 230/115kV transformer in Table 7 can all be mitigated by closing the 115kV bus tie breaker at Midway. Planned maintenance outages will not typically be scheduled during peak loading conditions, and if necessary, temporary operating guides will be developed and coordinated with neighboring utilities to address any potential transmission system performance issues.

**Stability Analysis**

The objective of stability analysis is to analyze the impact of the project on transient stability performance of the power system for various disturbances. Stability simulations were conducted with the identified projects from the Feasibility Study of BHCT-G5 for both 2012 heavy summer and 2012 light winter load level scenarios.

The disturbance performance criteria for this study requires that the transient low voltage swing shall not be lower than 0.70 p.u. at any load or non-load bus and the system shall exhibit positive damping following any contingency. Table W-1 of the TPL-(001 thru 004)-WECC-1-CR-System Performance Criteria states that for a NERC Category B contingency, the frequency at a load bus must not dip below 59.6 HZ for more than 6 cycles.

The current NERC/WECC Low Voltage Ride-Through (LVRT) Standard requires generators to remain in-service for 3-phase faults with normal clearing (4-9 cycles) and single line-to-ground faults with delayed clearing that result in a GSU high side voltage of 0.15 p.u. or greater.

Tables 8 and 9 list the prior outages and 3-phase faults, respectively.



**Table 8** Prior Outages Studied for Stability Analysis

<b>BHCT-G5 System Impact Study</b>					
<b>Prior Outages Studied for Stability Analysis</b>					
<b>PO#</b>	<b>Prior Outage</b>	<b>PO#</b>	<b>Prior Outage</b>	<b>PO#</b>	<b>Prior Outage</b>
1	Reader – Comanche 115 #2	7	Apt Mem - DOT Tap 115	13	W. Station – Hyde Park 115
2	Overton – Baculite Mesa 115	8	Boone - DOT Tap 115	14	W. Station – Portland 115
3	W. Station–Baculite Mesa 115 #2	9	Reader – Freemary 115	15	Comanche – Midway 230 #2
4	Apt Park – Baculite Mesa 115	10	Reader – Pueblo 115	16	Comanche – Boone 230
5	Apt Park - Apt Mem 115	11	Midway – Northridge 115	17	Boone 230/115 #2
6	Reader – Apt Mem 115	12	W. Station – Burnt Mill 115		

**Table 9** Stability Analysis Fault Description

<b>BHCT-G5 System Impact Study</b>		
<b>Stability Analysis Fault Description</b>		
<b>3 PH Bus Fault</b>	<b>Cleared Element</b>	<b>Fault Duration</b>
Comanche 115	Reader – Comanche 115 #1	5 Cycles
Baculite Mesa 115	Overton – Baculite Mesa 115	5 Cycles
Baculite Mesa 115	W. Station – Baculite Mesa 115 #1	5 Cycles
Baculite Mesa 115	Apt Park – Baculite Mesa 115	5 Cycles
Airport Industrial Park 115	Apt Park - Apt Mem 115	5 Cycles
Airport Memorial 115	Reader – Apt Mem 115	5 Cycles
Airport Memorial 115	Apt Mem - DOT Tap 115	5 Cycles
DOT Tap 115	Boone - DOT Tap 115	5 Cycles
Reader 115	Reader – Freemary 115	5 Cycles
Reader 115	Reader – Pueblo 115	5 Cycles
Midway 115	Midway – Overton 115	5 Cycles
W. Station 115	W. Station – Burnt Mill 115	5 Cycles
W. Station 115	W. Station – Hyde Park 115	5 Cycles
W. Station 115	W. Station – Portland 115	5 Cycles
Comanche 230	Comanche – Midway 230 #1	5 Cycles
Comanche 230	Comanche – Boone 230	5 Cycles
Boone 230	Boone 230/115 #1	5 Cycles
Baculite Mesa 115	W. Station – Baculite Mesa 115 Double Circuit	5 Cycles

**Stability Analysis Results**

Category B outages were studied for the heavy summer and light winter cases using the methods described above. With the identified projects from the Feasibility Study of BHCT-G5 in-service, there were no Category B criteria violations for the light winter case. Faults on the Comanche 230kV bus resulted in voltage and frequency instability on the Gladstone and Walsenburg 230kV



buses for the heavy summer case; however, these problems also existed with the identified projects out-of-service.

The Category B heavy summer stability violations at Gladstone 230kV and Walsenburg 230kV were also seen in Category C outages. In the heavy summer and light winter cases, voltage and frequency instability was observed in the Boone to Lamar region following the loss of the Boone 230/115kV transformer with a prior outage on either the Nyberg – DOT Tap or DOT Tap – Boone 115kV lines. The instability in the Boone to Lamar region also existed with the identified projects out-of-service. The addition of a LaJunta 115kV tie and a second Boone 230/115kV transformer are being investigated to mitigate these violations.

### **Short Circuit Analysis**

With the identified projects from the Feasibility Study of BHCT-G5 in-service, maximum fault currents were determined at local substations of interest. These buses can be seen in Table 10. The resulting fault currents were compared to the circuit breaker interruption ratings of the breakers at the substations of interest.

**Table 10** Short Circuit Buses Studied

<b>BHCT-G5 System Impact Study</b>
<b>Short Circuit Buses Studied</b>
Airport Industrial Park 115kV
Airport Memorial 115kV
Baculite Mesa 115kV
Baculite Mesa Generator #1 13.8kV
Baculite Mesa Generator #2 13.8kV
Baculite Mesa Generator #3 13.8kV
Baculite Mesa Generator #4 13.8kV
Boone 115kV
Comanche 230kV
Comanche 115kV
Northridge 115kV
Reader 115kV
West Station 115kV

### **Short Circuit Results**

With the identified projects from the Feasibility Study of BHCT-G5 in-service, no fault currents were produced that reached the circuit breaker interruption ratings.

### **Conclusions**

This report describes the power flow, stability and short circuit studies performed to determine the impacts of interconnecting a 100 MW gas turbine generator



facility near Pueblo, Colorado to the Black Hills Colorado Electric transmission system at Baculite Mesa 115kV.

Based on the simulations from the Feasibility and System Impact Studies, the total estimated costs for the required interconnection at Baculite Mesa would be **\$9,888,812**. The cost of facilities which are considered Customer-funded, BHCE-owned Interconnection Facilities, and are NOT subject to refund through transmission service, is estimated to be **\$18,812**. The cost of facilities which are considered Customer-funded, BHCE-owned Network Upgrades, and subject to refund through transmission service, is estimated to be **\$9,870,000**. Table 11 lists the required upgrades to accommodate the interconnection of 100MW at Baculite Mesa 115kV.

All facilities have an expected in-service date of October 1, 2011.

**Table 11 Upgrade Costs for 100MW Interconnection at Baculite Mesa 115kV**

<b>BHCT-G5 System Impact Study</b>	
<b>Costs for 100MW Interconnection at Baculite Mesa 115kV</b>	
<b>Cost in Millions \$</b>	<b>Description</b>
0.02	Test protection settings and install and calibrate communications for each generator POI (1 position)
<b>0.02</b>	<b>Total Customer-funded, BHCE-owned Interconnection Facilities</b>
<b>Cost in Millions \$</b>	<b>Description</b>
5.25	Build new 115kV substation at Nyberg 115kV (3 positions)
3.12	Rebuild 5 miles of 115kV line from Baculite Mesa to Nyberg
1.50	Expand Baculite Mesa 115kV substation (2 positions)
<b>9.87</b>	<b>Total Customer-funded, BHCE-owned Network Upgrade Facilities</b>
<b>9.89</b>	<b>Total Interconnection Costs</b>