Interconnection Feasibility Study Report Request # GI-2008-1

Arapahoe 3-4 Repowering Project - 587 MW Net (GTG's 8 & 9, STG 10) Generation Plant in Summer 2013

PSCo Transmission Planning April 23, 2008

Executive Summary

On or about February 29, 2008 Public Service Company of Colorado (PSCo Transmission) Transmission Planning group received a generation interconnection request to determine the potential impacts of retiring the existing coal-fired generation units #3 (44 MW net) and #4 (109 MW net) at Arapahoe Plant, located near downtown Denver, and replacing these units with two new natural gas-fired combustion turbines (GT8 & GT9, approximately 158 MW gross ea.), and operating in combined-cycle with one steam turbine generator (ST10, approximately 289 MW gross, minus 18 MW station service load), for a total summer & winter net output rating of 587 MW. The proposed commercial operation date is May 30, 2013. The proposed back feed date is January 1, 2013.

This request was studied as both a Network Resource (NR)¹, and as an Energy Resource (ER)², with particular investigations performed in order to determine the most economic and viable installation and interconnection of the two new GTs, and single ST associated transformation and protection (breakers, etc.) into the existing 230 kV and / or 115 kV station at Arapahoe plant switchyard. This investigation included steady-state power flow and short-circuit studies only, and did not include any transient dynamic stability analysis at this time. 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 2013. The main purpose of this feasibility study is to evaluate the potential impact on the PSCo Transmission infrastructure, when

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.

² Energy Resource Interconnection Service (ER Interconnection Service) shall mean an Interconnection Service that allows the Interconnection Customer to connect its Generating Facility to the Transmission Provider's Transmission System to be eligible to deliver the Generating Facility's electric output using the existing firm or non-firm capacity of the Transmission Provider's Transmission System on an as available basis. Energy Resource Interconnection Service in and of itself does not convey transmission service

injecting the new 587 MW of net generation into the Arapahoe 230 kV and/or 115 kV buses, and delivers the additional generation to native PSCo Transmission loads. Note that this new generation is in addition to the other Black Hills Power generation units GT5 & GT6 (approximately 37 MW ea.), and ST7 (approximately 45 MW) that are presently located at the Arapahoe 115 kV switchyard. The project cost to install the transmission system infrastructure (NR & ER) interconnection equipment, and network upgrades necessary to accommodate the added Arapahoe generation have been evaluated by Engineering.

Based upon the investigations completed, the required transmission upgrades should be achievable by the summer of 2013. The work required consists of upgrades at multiple substations, and 115 kV transmission lines. Several of the IREA 115 kV transmission lines are already planned for re-conductoring projects, and scheduled for completion by IREA by the end of 2008. Most of the substation upgrade projects are being included in the FAC09 planned / budgeted substation projects. The new IREA 115 kV Brick Center – Spring Valley – Kiowa line project is in IREA's budget plans, but PSCo Transmission will need to work closely with IREA to assure that the project maintains a schedule for in-service by or prior to May 2013. The details of these upgrades identified in the <u>Power Flow Study Results and Conclusions</u>, and the Appendix sections of this report. Refer to Figure 1 for a Proposed One-line Diagram of the Arapahoe Plant Switchyard, and Figure 3 for a Proposed Schedule for Implementation. The **total project costs** for all of these upgrades is

• \$6.492 million

and are broken out as follows (in 2008 dollars):

• Interconnection Equipment Costs (Arapahoe 230 kV & 115 kV switchyard):

\$ 2,799,000 (includes customer-funded and PSCo Transmission costs)

Transmission Network Upgrade Costs (PSCo Transmission and IREA):

\$ 3,693,000

Stand Alone Study Results

The stand-alone results assume that the new generation interconnecting at the Arapahoe 230 kV and 115 kV buses is modeled in the power flow case at full output, or approximately 587 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 2013 case (see Power Flow Study Models section below). The Customer can provide the full 587 MW generation additions at Arapahoe plant only after modifications have been completed to the PSCo Transmission system network infrastructure. The

studies investigated four main configurations for interconnecting the three new generators and associated equipment into the Arapahoe switchyard:

- 1) All three generators tied to the 230 kV switchyard bus;
- 2) The ST10 tied to the 230 kV bus, and the two GT8 & GT9 generators tied to the 115 kV switchyard bus;
- 3) The preferred option, with ST10 tied to the 115 kV bus, and the two GT8 & GT9 generators tied to the 230 kV bus;
- 4) All three generators tied to the 115 kV switchyard bus.

A list of the lines and autotransformers that either incur new single contingency (N-1) overloading, or that become significantly overloaded as a result of adding 587 MW of new generation at Arapahoe in the heavy summer 2013 power flow cases (i.e., 5% or more differential loading between the case with Arapahoe generation at 587 MW vs. 0 MW) can be found in Tables 7 through 9 in the Appendix.

The line ratings and limiting elements identified in the following list (Table 1) are based upon the latest Rev.3 of FAC-009 dated January 3, 2008 (Transmission Equipment Facility Ratings). The recommended upgrades and revised line ratings are based upon investigations performed by the PSCo Transmission 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).

Network Resource (NR):

This Study has determined that any increase in the generation injected at the Arapahoe switchyard's 230 kV and/or 115 kV buses directly increases the loading / overloading on the PSCo Transmission regional transmission system. Therefore, the 587 MW NR value requested will require interconnection and Transmission Network Upgrades.

NR = 587 MW (with required Network Upgrades)

Energy Resource (ER):

This Study has determined that any increase in the generation injected at the Arapahoe switchyard's 230 kV and/or 115 kV buses directly increases the loading / overloading on the PSCo Transmission regional transmission system. Therefore, the ER value, i.e., the amount of generation injection that the transmission network can accommodate without requiring upgrades, is 0 MW.

ER = 0 MW (without any Network Upgrades)

From Bus	To Bus	Ckt #	Line Rate (MVA)	Max N-1 Flow - Opt 3 (MVA)	Required Upgrade - Scope	Required Upgrade – Cost (2008 dollars)			
ArapahoeB	Englewood3 Tp	9336	120	151.3	Arapahoe: (3) 115kV switches, (1) 115kV Bkr, 115kV CCVT, Conductor.	<u>Arapahoe</u> : \$319,000			
ArapahoeB	South1	9335	109	166.1	Arapahoe: (3) 115kV switches, Conductor	<u>Arapahoe</u> : \$231,000			
Bancroft	Gray St	9448	120	169.5	Bancroft: Conductor; Gray St.: (2) 115kV switches, (1) 115kV Bkr, Conductor.	Bancroft: \$25,000 Gray St: \$161,000			
Bancroft	Kendrick	8024	138	159.7	Bancroft: Conductor; Kendrick: Conductor, Bus Jumpers	Bancroft: \$19,000 Kendrick: \$68,000			
Cherokee	Derby1	9543	75	90.4	Cherokee: Conductor	<u>Cherokee</u> : \$26,000			
Cherokee	Fed Hts2	9558	135	164.3	<u>Cherokee</u> : Conductor, 115kV Line Trap; <u>Fed Hts</u> : Conductor, Bus Jumpers	<u>Cherokee</u> : \$70,000 <u>Fed Hts</u> : \$79,000			
Happy Canyon	Daniels Park	9674	155	160.2 (*177.7)	IREA: New 115kV Brk Ctr – Sprng Vly – Kiowa Line by 2012; (Alt PSCo): DP – Happy Cnyn 115kV Line Upgrade – Raise seven structures	(IREA Proj Alt) 115 kV Brk Ctr – Sprng Vly – Kiowa Line: Cost not provided. (PSCo Proj Alt) DP-Happy Cnyn 9674 Upgrade: \$210,000			
Daniels Park	230/115 kV, 90/120/150 MVA Auto	T1	150	186.9	Daniels Park: Replace 150MVA with new 280 MVA Auto (submitted in Budget)	Daniels Park: \$2.672 million			
Smoky Hill	Peakview	9863 (IREA)	133.5	152	<u>T-Line (IREA)</u> : Reconductor 795 ACSS (241MVA) project scheduled for 2008.	(N/A)			
Waterton	Roxborough	9625 (IREA)	126	149.1	<u>T-Line (IREA)</u> : Line rebuild project (not in current IREA plans)	IREA Line 9625 Rebuild: \$2.275 million			
ParkerPS	Bayou	IREA	133.5	198.2	<u>T-Line (IREA)</u> : Reconductor 795 ACSS (241MVA) project scheduled for 2008.	(N/A)			
ParkerPS	Sulphur (115 kV Ckt #1)	IREA	133.5	170.8	<u>T-Line (IREA)</u> : Reconductor 795 ACSS (241MVA) project scheduled for 2008.	(N/A)			
ParkerPS	Sulphur (115 kV Ckt #2)	IREA	133.5	170.8	T-Line (IREA): Reconductor 795 ACSS (241MVA) project scheduled for 2008.(N/A)				

Table 1: Summary listing of overloaded elements with required upgrades (See Appendix for Additional N-1 Tables)

*NOTE: Max N-1 Flow on Happy Canyon – Daniels Park 115 kV line is higher for case models with existing DP 230/115 kV, 150 MVA auto replaced with new 280 VA auto (see Table 9).

Figure 1: (Proposed) Arapahoe Plant Switchyard One-Line Diagram

(Note – Revisions illustrated as dashed lines in this diagram)



Figure 2: (Proposed) Arapahoe Plant Switchyard General Arrangement / Site Plan Drawing

(Note: Provided by Customer4/7/08, and does not include new 230 kV & 115 kV switchyard interconnection equipment)



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46		Denver Terminal Bkr 5626 Repla	cement	163 days	Wed 8/15/12	Fri 3/29/13											
45		Transmission Construction		5 mons	Mon 8/1/11	Frl 12/16/11	1								[1
44	11	Material Procurement		8 mons	Mon 2/28/11	Frl 10/7/11											
43		Transmission Engineering		4 mons	Mon 1/10/11	Frl 4/29/11	1										
42		Waterton - Roxborough Ckr #9623	5 (IREA) Rebuild	245 daya	Mon 1/10/11	Fri 12/16/11								-		i	
41		Transmission Construction		2 mons	Wed 2/1/12	Tue 3/27/12	1										
40		Material Procurement		20 wks	Mon 7/18/11	Frl 12/2/11	1										
39	11	Transmission Engineering		3 mons	Wed 6/1/11	Tue 8/23/11	1										
38		Happy Canyon - Daniels Park Ckt	#9674 Uprate	215 days	Wed 6/1/11	Tue 3/27/12	1										۲
37		Substation Construction		1 mon	Mon 10/1/12	Frl 10/26/12	1										
36	11	Material Procurement		3 mons	Tue 3/20/12	Mon 6/11/12											
35		Substation Engineering		1 mon	Mon 3/5/12	Frl 3/30/12	1										
34		Kendrick Substation Jumpers		170 days	Mon 3/5/12	Fri 10/26/12											
33	11	Substation Construction		4 mons	Mon 1/30/12	Frl 5/18/12											
32		Material Procurement		26 wks	Mon 8/1/11	Frl 1/27/12	1										
31	11	Substation Engineering		3 mons	Wed 6/1/11	Tue 8/23/11											
30		Gray Street Substation Switches	s, Bkr, Jumpers	253 days	Wed 6/1/11	Fri 5/18/12											7
29	11	Substation Construction		1 mon	Mon 9/3/12	Frl 9/28/12	1										
28		Material Procurement		3 mons	Mon 2/20/12	Frl 5/11/12	1										
27		Substation Engineering		1 mon	Wed 2/1/12	Tue 2/28/12	1										
26		Federal Heights Substation Jum	pers	173 days	Wed 2/1/12	Fri 9/28/12	1										
25		Substation Construction		5 mons	Mon 1/4/10	Frl 5/21/10	1										
24	11	Material Procurement		20 mons	Fri 8/1/08	Thu 2/11/10	[
23		Substation Engineering		4 mons	Mon 5/4/09	Frl 8/21/09	_										
22		Daniels Park Autotransformer R	eplacement	471 days	Fri 8/1/08	Fri 5/21/10	🔳				-	-					
21		Substation Construction		1 mon	Mon 9/5/11	Frl 9/30/11	1										
20		Material Procurement		20 wks	Tue 3/1/11	Mon 7/18/11	1										
19		Substation Engineering		43 days	Tue 2/1/11	Thu 3/31/11	1										
18		Cherokee Switchyard Jumpers,	Line Trap	174 days	Tue 2/1/11	Fri 9/30/11	1									-	
17	11	Substation Construction		1 mon	Mon 4/16/12	Frl 5/11/12	1										
16	11	Material Procurement		3 mons	Mon 1/23/12	Frl 4/13/12	1										
15		Substation Engineering		22 days	Mon 1/2/12	Tue 1/31/12	1										
14		Bancroft Substation Jumpers		95 days	Mon 1/2/12	Fri 5/11/12	1										
13		Substation Construction		5 mons	Fri 6/1/12	Thu 10/18/12	1										1
12		Material Procurement		26 wks	Tue 11/1/11	Mon 4/30/12	1										
11		Substation Engineering		105 days	Mon 10/3/11	Frl 2/24/12	1									_	
10		Arapahoe Switchyard Switches,	Bkrs, Jumpers	274 days	Mon 10/3/11	Thu 10/18/12	1 -									-	4
9		ARAPAHOE NETWORK UPGRADES FOR	DELIVERY	1216 days	Fri 8/1/08	Frl 3/29/13	1 🖷				-			-			-
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7		Arapahoe Interconnection Backfeed		0 days	Wed 1/2/13	Wed 1/2/13	1										
6		Commissioning/Testing		10 wks	Mon 10/22/12	Frl 12/28/12	1										
5		Substation Construction		5 mons	Frl 6/1/12	Thu 10/18/12	1										
4		Material Procurement		36 wks	Tue 11/1/11	Mon 7/9/12	1										
3	11	Substation Engineering & Design		105 days	Mon 10/3/11	Frl 2/24/12	1										
2		ARAPAHOE INTERCONNECTION		325 days	Mon 10/3/11	Fri 12/28/12	-										-
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Figure 3: (Proposed) Schedule for Implementation:



Figure 3: (Proposed) Schedule for implementation (continued):

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Study Scope and Analysis

The Interconnection Feasibility Study evaluated the transmission impacts associated with the proposed interconnection of 587 MW of new generation at Arapahoe Plant into the PSCo Transmission System, replacing the approximate 156 MW net generation presently supplied by coal-fired units #3 and #4 at Arapahoe 115 kV. It consisted of steady-state power flow, and short-circuit 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 Transmission loads.

PSCo Transmission 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 Transmission 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 the Intermountain Rural Electric Association (IREA) transmission system in the southern regions south of the Denver area. PSCo Transmission has been in contact with IREA during the course of these studies.

Power Flow Study Models

This project scope includes modifying and expanding the existing Arapahoe Station to accommodate repowering (removing) the existing Arapahoe coal generation Units #3 & #4 (156 MW net total), with new combined-cycle 587 MW (summer net) / 675 MW (winter net) generation facilities (GT8, GT9, ST10). The completed transmission planning studies have concluded that the preferred interconnection at Arapahoe switchyard would consist of interconnecting the two new gas combustion turbine generators and associated new GSU transformers (GT8 & GT9), into the new 230 kV bay expansions in the existing 230 kV switchyard. The new steamturbine generator and associated new GSU transformer (ST10) would connect into a new 115 kV breaker termination in the existing 115 kV switchyard. Additionally, per the Customer's (Energy Supply) supplied information, it is assumed that the new station service aux. supply transformer(s) (18 MW total load), required for the new combined-cycle generation addition would be supplied from the GSU transformers secondary buses, and will therefore not require any additional interconnections into either of the 230 kV or 115 kV HV buses. The other presently existing Black Hills Power generation units GT5 (37 MW), GT6 (37 MW), and ST7 (45 MW) were

dispatched at their maximum generation levels to assure that the Network Upgrade requirements were properly accounted for.

The power flow studies were based on a PSCo Transmission-developed 2013 heavy summer base case that originated from the study model developed in early 2008 as part of PSCo Transmission'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 Transmission planned and approved projects and associated topology. Load levels reflect 2013 heavy summer peak system conditions. PSCo Transmission control area 70 generation was dispatched in the case to simulate a generally 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. The TOT 3 path at the Colorado – Wyoming border, and the TOT 7 path immediately north of FSV (see Figure 1) levels were adjusted to relatively high levels of approximately 1316 MW for TOT 3, 787 MW for TOT5, and approximately 406 MW for TOT 7. The WAPA RM (CA 73) to PSCo Transmission (CA 73) control areas interchange is approximately 1,000 MW in this Study case. The PSCo Transmission control area (CA 70) wind generation facilities were dispatched (Pgen) to approximately 12% of net facility ratings (Pmax), consistent with other similar planning study models.

The 2013 case model topology was further modified for the some of the alternative studies to include planned or required Transmission Network upgrades assumed to be in-place by the summer 2013 time frame. The most notable upgrades include replacing the existing 230 - 115 kV, 150 MVA autotransformer at Daniels Park Substation with a new 280 MVA rated autotransformer, and evaluating the impacts of IREA's planned new Brick Center – (Spring Valley) – Kiowa 115 kV transmission line.

Power Flow Study Results and Conclusions

Two main power flow case model generation dispatch scenarios were evaluated: a reference model without the additional new 587 MW Arapahoe Plant generation GT8, GT9, plus ST10 addition ("Without GI-2008-1" or "Arapahoe 0 Ref" case); and a model with the new 587 MW (summer) of generation included at Arapahoe ("With GI-2008-1" or "Arapahoe 587" cases). The GI-2008-1 cases were re-dispatched to lower other PSCo Transmission control area generation by 587 MW, mainly in the southern part of the PSCo Transmission system in order to maintain or maximize the north-to-south system stressing (and TOT 7 path flows) in the cases. Four main different Arapahoe generation interconnection 230 kV and 115 kV options were evaluated, and the results were utilized to evaluate the impact of required Transmission Network upgrades.

Automated contingency power flow studies were completed on all 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 Transmission)

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 Arapahoe 587, and the Arapahoe 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 587 MW of injection into the Arapahoe 230 kV and 115 kV buses could cause new and/or additional load flows in excess of present or planned element ratings on several 115 kV transmission lines (line conductor, or associated substation termination equipment), plus one 230-115 kV autotransformer (Daniels Park), under single-contingency (N-1) conditions. Furthermore, it was determined that either Option 2 (GT5 & GT6 on 115 kV, ST10 on 230 kV), or Option 3 (GT5 & GT6 on 230 kV, ST10 on 115 kV) resulted in the least significant impact on the regional Transmission Network, the Customer (Energy Supply) informed PSCo Transmission that Option 3 would be the preferred interconnection configuration. The list of required interconnection and network upgrades is included Table 1 (earlier in this report), with further details shown in the following Tables 3, 4, 5, and Some of the required upgrades are already being performed by IREA, as a result of several previously planned 115 kV transmission line reconductor projects, and are scheduled for completion by IREA in 2008-9. Based upon the investigations completed in this Study, it is believed that the modifications should be achievable by the summer of 2013. Figure 2 illustrated the proposed implementation schedule to achieve an ISD of May 2013.

Short Circuit Study Results:

Short-circuit analysis faulted at the Arapahoe Switchyard's 230 kV and 115 kV buses. Thevenin Equivalent impedance data is given in per-unit, on a 100 MVA base, 115 kV and 230 kV bases, assuming new Arapahoe GT8, GT9, and ST10 generators on-line (or off-line, as indicated), for a 2013 HS system model.

Table 2: Short-circuit study results (with new G8, G9, ST10 On-Line)

3Φ Bus Fault 230 kV (Total Amps)	S-L-G Bus Fault 230 kV (Total Amps)	Pos Seq Thev Equiv (230 kV Bus, PU)	Zero Seq Thev Equiv (230 kV Bus, PU)	GT8 (GSU8) 230 kV Contrib (Amps)	GT9 (GSU9) 230 kV Contrib (Amps)	ST10 (GSU10) 115 kV Contrib (Amps)
25,137	26,041	0.00073 + j0.00996	0.00067 + j0.00894	3ph: 2,194 SLG(3I0): 6,229	3ph: 2,194 SLG(3I0): 6,229	3ph: 2,332 SLG(3I0): 4,556

3Φ Bus Fault 115 kV (Total Amps)	S-L-G Bus Fault 115 kV (Total Amps)	Pos Seq Thev Equiv (230 kV Bus, PU)	Zero Seq Thev Equiv (230 kV Bus, PU)	GT8 (GSU8) 230 kV Contrib (Amps)	GT9 (GSU9) 230 kV Contrib (Amps)	ST10 (GSU10) 115 kV Contrib (Amps)
39,312	40,685	0.00127 + j0.01271	0.00104 + j0.01148	3ph: 824 SLG(3I0): 1,779	3ph: 824 SLG(3I0): 1,779	3ph: 4,856 SLG(3I0): 12,502

A breaker duty study was run to determine if the fault current (ground or threephase) exceeds the interrupt ratings of any circuit breakers on the PSCo Transmission transmission network. The duty study compared the short-circuit model with the proposed new generation at Arapahoe to a model without the generation, and identified which breakers are within 5% of their fault interruption rating as a result of the generation. Per PSCo Transmission policy, these breakers will require replacement and are categorized as network upgrades. Table 3 summarizes which breaker's fault interruption ratings are exceeded as a result of the new generation:

Table 3: Breakers within 5% of fault interrupt rating due to new generation

Substation	Voltage	Breaker Number(s)
Denver Terminal	230kV	5625

Costs Estimates, Schedule, and Assumptions

The estimated **total cost** for the upgrades required for interconnection and delivery is **\$6,492,000** (\$0.488 million for Customer-funded PSCo Transmission interconnection facilities, \$6.004 million PSCo Transmission-funded interconnection and delivery network facilities, including the costs for IREA Waterton – Roxborough 115 kV transmission network upgrades). This does not include costs for previously planned and funded network upgrade projects, notably the PSCo Daniels Park 230/115 kV autotransformer replacement, and the multiple IREA 115 kV line reconductoring projects (see Table 1).

The estimated costs shown are (+/-20%) estimates in 2008 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 engineering, design, procurement and construction of these new PSCo Transmission facilities. The estimates do not include the cost of AFUDC, escalation, and no contingencies were applied. The estimates do not include the cost for any other Customer owned equipment and associated design and engineering.

The following tables 4, 5, and 6 list the improvements required to accommodate the interconnection and the 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 more detailed analysis.

Table 4 – PSCo Transmission Owned; Customer Funded InterconnectionFacilities

Element	Description	Cost Est. Millions (2008 \$)
Arapahoe 230kV & 115 kV Substation	 Interconnect Customer to tap at PSCo Transmission's 230 kV & 115 kV substation. The new equipment includes: 230kV combined metering transformers (6) 115kV combined metering transformers (3) 	\$0.413
	Customer generation telemetry equipment, and witnessing the Customer generator commissioning testing.	\$0.075
	Total Cost Estimate for Customer Interconnection Facilities	\$0.488

Table 5: PSCo Transmission Owned; PSCo Transmission FundedInterconnection Facilities

Element	Description	Cost Est. Millions (2008 \$)
Arapahoe 230kV & 115	Interconnect Customer to tap at PSCo Transmission's 230 kV & 115 kV substation. The new equipment includes:	230kV: \$1.375
kV Substation	 230kV equipment: (2) circuit breakers, (6) gang switches, (1) dead-end, conduit, structures, foundations, relaying 115kV equipment: (1) circuit breaker, (2) gang switches, structures, foundations, relaying 	115kV: \$0.936
	Total Estimated Cost for PSCo Transmission Interconnection Facilities	\$2.311
Time Frame	To engineer, procure, construct, and commission interconnection facilities, work is estimated to take:	14 Months

Table 6 – PSCo Transmission (and IREA) Network Upgrades for DeliveryIREA costs and scope based upon discussions with IREA, and costestimates supplied by IREA / Stanley Consultants.

Element	Description	Cost Est.
		Millions (2008 \$)
Waterton -	Replace the existing 126 MVA rated, 3.1-mile IREA line with	\$ 2.275
Roxborough	new 150 MVA minimum rated line. Per IREA standard 795	
IREA 115 kV	ACSS conductor (241 MVA rated), includes new wood	
line rebuild.	monopole line structures.	
Ckt 9336	<u>Arapahoe Switchyard:</u> Replace one 115kV circuit breaker,	\$0.319
Uprate to	replace three 115kV gang switches, install 115kV CCVT,	
151.3 MVA	install new jumpers.	
Ckt 9335	<u>Arapahoe Switchyard:</u> Replace three 115kV gang switches,	\$0.231
Uprate to	install new jumpers.	
166.1 MVA		
Ckt 9448	Bancroft Substation: Install new jumpers.	\$0.025
Uprate to	<u>Gray St. Substation:</u> Replace one 115kV circuit breaker,	\$0.161
169.5 MVA	replace two 115kV gang switches, install new jumpers.	
Ckt 8024	Bancroft Substation: Install new jumpers.	\$0.019
Uprate to	Kendrick Substation: Install new jumpers, new bus	\$0.068
159.7 MVA	connections.	
Ckt 9543	Cherokee Switchyard: Install new jumpers.	\$0.026
Uprate to		
90.4 MVA		
Ckt 9558	Cherokee Switchyard: Replace line trap, install new jumpers.	\$0.070
Uprate to	Federal Heights Substation: Install new jumpers, new bus	\$0.079
164.3 MVA	connections.	
Ckt 9674	Raise seven transmission line structures between Daniels	\$0.210
Uprate to	Park and Happy Canyon substation (to be built in 2009).	
178 MVA	Alternative is Brick Center-Spring Valley-Klowa transmission line built by IREA for 2012 service.	
Breaker	Denver Terminal: 230kV breaker 5625	\$0.210
Replace due		
to fault		
ratings		
	Total Estimated Cost for Network Upgrades for Delivery:	\$3.693
Time Frame	Engineer, procure, construct, and commission duration:	24 Months

Schedule: (Refer to Figure 3)

The estimated time for PSCo Transmission to complete the siting and permitting, design engineering, procurement, and construction of the scope of work identified in Tables 4, 5 and 6 is **24 months**, after authorization to proceed has be obtained. This does <u>not include</u> any time for preparation and receipt of a CPCN, which would add an additional 10 to 12 months to this schedule (see Assumptions below).

Assumptions

- The cost estimates provided are "scoping estimates" with an accuracy of +/-20%.
- Estimates are based on 2008 dollars.
- There is no contingency added to the estimates. AFUDC is not included.
- Labor is estimated for straight time only no overtime included.
- The Generator is in PSCo Transmission's retail service territory. Therefore costs for retail load metering are included in these estimates.
- PSCo Transmission (or it's Contractor) crews will perform all construction and wiring associated with PSCo Transmission owned and maintained facilities.
- The estimated time to site, design, procure and construct the interconnection facilities is at least 14 months, and is completely independent of other queued projects and their respective ISD's.
- The estimated time to site, design, procure and construct the network upgrades for delivery is at least 24 months, and is completely independent of other queued projects and their respective ISD's.
- A CPCN may not be required for interconnection facility construction. However, this would be determined by the CPUC as part of the annual Rule 3206 filing by PSCo Transmission with the CPUC. Should a CPCN be required, this would add approximately 10 to 12 months time to the at the beginning of the project, increasing the 24 month time frame listed to 34 to 36 months total schedule time, after authorization to proceed has be obtained.
- PSCo Transmission crews will construct the substation additions, perform checkout, relay panel construction and final commissioning.
- Cost estimates do not include cost of tie-line between customer's generation facilities and 115kV and 230kV switchyards. Schedule assumes that a route between the facilities will be made available by removal of existing generation facilities that are due to come out as part of this project.
- Required infrastructure upgrades due to pre-existing conditions at the Arapahoe 115kV switchyard are assumed to be complete prior to the generation addition, and their cost and scope are not included in this study.
- Assumes sufficient room is available in Arapahoe control building for new relay panels.
- Schedule assumes Arapahoe generation units #3 and #4 will be removed prior to interconnection facility modifications to accommodate new interconnection points. New interconnection facilities for unit #10 (STG on 115kV) will be located in same position as unit #4 is currently located.

- Short-circuit study assumes that generator step-up transformers (GSU) for GT8, GT9, and ST10 are connected grounded-wye on the high voltage (transmission) side and delta on low voltage (generation) side.
- Short-circuit study used representative data for ST10 GSU, as none was provided by customer.
- Lead times for equipment have been considered when developing the construction schedule in Figure 3.

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 587 MW generation injection at Arapahoe, will be addressed through other separate Transmission Planning project proposals.

Table 7: Summary listing of differentially overloaded elements (newly overloaded elements, or delta overloads > 5% of rating, due to 587 MW Arapahoe repowering generation injection at POI).

NOTES:

- 1) Option 1 = GT8 & GT9 on 230kV, ST10 on 230kV; Option 2 = GT8 & GT9 on 115kV, ST10 on 230kV; Option 3 = GT8 & GT9 on 230kV, ST10 on 115kV; Option 4 = GT8 & GT9 on 115kV, ST10 on 115kV.
- 2) The results shown in this table are applicable to a 2013 heavy summer peak load case model, re-dispatched for north-to-south stressed PSCo transmission system (approx. TOT3 at 1316 MW, TOT5 at 787 MW, TOT7 at 406 MW, CA73 to CA70 interchange at 1,000 MW), other northern region PSCo generation near max output, new Arap GT8 / GT9 / ST10 gen at 587 MW Net.

3) This initial N-1 power flow summary does not include either the new / planned Daniels park 230/115 kV autotransformer replacement (90/120/150 MVA replaced with 150/200/250/280 MVA in 2010), nor a potential new IREA Brick Center – Kiowa 115 kV transmission line in 2012. See the following Tables 8 and 9 for results with these new Daniels Park, and Brick Center – Kiowa additions.

Table 7								Branch N-1 Loading With GI-2008-1, Arapahoe 587 MW															
						Bra La Witi 2	nch N-1 oading hout GI- 008-1	All (or	GT8, G 1 Arap (Opt	6T9, ST10 230kV t 1)	GT8 ST10	8, GT9 115) on Ar (Opt	on Arap kV rap 230kV t 2)	GT ST1((8, GT9 230k) on Ar Pref - (on Arap kV cap 115kV Opt 3)	GT8, GT9 2301 ST10 on Ar (Opt	on Arap V ap 115kV 4)	All GT8, G on Arap Plus Seco 230/115kV, Au (Opt	5T9, ST10 230kV nd Arap 280 MVA to 1A)			
Monitored Element (Line or Transformer) From Bus To Bus	Туре	Line Ckt #	FAC9 Limiting Element - Comments	Branch Rating MVA	Branch Rating Amps	N-1 Flow in % of Rate	Total # of Violation	N-1 f Flow s in MVA	N-1 Flow in % of Rate	Total # o Violation	N-1 f Flow s in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA Rate	Total # of Violations	N-1 Flow in MVA Rate	Total # of Violations	N-1 (Contingency Outage From Bus To Bus	
70036 ARAPAHOA 115 70037 ARAPAHOB 115 1	LN	9340 (Bus Tie Bkr)	Bkr / Bus (verify)	247.4	ŀ	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	. #N/A	#N/A	324.2 131.0	7	#N/A #N/A	#N/A	70037 ARAPAHOB	115 70401 SOUTH 1	115 1
70036 ARAPAHOA 115 70442 UNIVERS2 115 1	LN	9338	UG T-Line Cond	154.0)	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	185.4 120.4	16	#N/A #N/A	#N/A	70036 ARAPAHOA	115 70531 AIR LIQ	115 1
70037 ARAPAHOB 115 70038 ARAPAHOE 230 T5	TR	Auto	Auto	280.0)	#N/A	#N/A	306.8	8 109.6	2	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A #N/A	#N/A	#N/A #N/A	#N/A	70038 ARAPAHOE	230 70141 DAKOTA	230 1
70037 ARAPAHOB 115 70165 ENGLE3TP 115 1	LN	9336	Arap Swtchs (Submitted in FAC9 Budget Proj)	120.0)	127.3	1	151.7	126.4	1	151.3	126.1	13	151.3	3 126.1	12	154.6 128.9	1305	150.7 125.6	1	70036 ARAPAHOA	115 70037 ARAPAHC	DB 1151
70037 ARAPAHOB 115 70401 SOUTH 1 115 1	LN	9335	Arap Swtchs (Submitted in FAC9 Budget Proj)	109.0)	117.8	1	143.3	3 131.5	1	166.9	153.1	1299	166.1	152.4	1297	241.1 221.2	1310	155.3 142.5	8	70045 BANCROFT	115 70208 GRAY ST	115 1
70045 BANCROFT 115 70208 GRAY ST 115 1	LN	9448	Gray St Sw (Submitted in FAC9 Project Budget for Bancroft Jmpr Cond, Gray St Swtchs & Bus Cond)	120.0)	127.5	8	162.8	3 135.6	6	169.8	141.5	3	169.5	5 141.2	3	176.6 147.1	2	165.6 138.0	4	70037 ARAPAHOB	115 70401 SOUTH 1	115 1
70045 BANCROFT 115 70242 KENDRICK 115 1	LN	8024	Kendrick & Bancroft Cond (Submitted in FAC9 Proj Budget)	138.0)	116.5	1	159.9	115.9	1	159.7	115.7	1	159.7	7 115.7	1	159.8 115.8	2	159.3 115.5	1	70018 SODALAKE	230 70400 SODALAK	E 115 T2
70045 BANCROFT 115 70401 SOUTH 1 115 1	LN	9335	T-Line Cond (Need to verify model rate)	135.0)	#N/A	#N/A	#N/A	. #N/A	#N/A	#N/A	#N/A	#N/A	#N/A	. #N/A	#N/A	204.2 151.2	6	#N/A #N/A	#N/A	70036 ARAPAHOA	115 70037 ARAPAHC	DB 1151
70047 BARRLAKE 230 70048 GREENVAL 230 1	LN	5759	Model Error - s/b 478MVA	159.0)	167.0	1307	235.8	3 148.3	1304	235.4	148.0	1306	235.3	3 148.0	1306	235.2 147.9	1305	235.5 148.1	1305	Unit: 70936 ARAP 1) 18.0 Id:1	
70108 CHEROKEE 115 70153 DERBY 1 115 1	LN	9543	Cher & Derby Jumpr Cond (Submitted in FAC9 Proj Budget)	75.0)	109.1	1	87.9	117.2	1	90.5	120.6	1	90.4	120.5	1	93.0 124.0	1	89.2 118.9	1	70538 CHMBERS	115 70539 CHMBERS	230 1

15kV, ST10 on 115kV. 1316 MW, TOT5 at 787 MW, TOT7 at 406 MW, CA73

Table 7					Branch N-1 Loading With GI-2008-1, Arapahoe 587 MW																		
						Bra L Wit	anch N-1 .oading thout GI- 2008-1	All (or	GT8, C n Arap (Op	GT9, ST10 9 230kV t 1)	GT ST1(8, GT9 115) on Ai (Op	on Arap kV ap 230kV t 2)	GT3 ST1((8, GT9 2301) on Ar Pref - (on Arap kV ap 115kV Opt 3)	GT8 ST10	8, GT9 2301) on A1 (Opt	on Arap kV rap 115kV t 4)	All o of Plu 230/1	GT8, C n Arap 18 Seco 115kV, Au (Opt	GT9, ST10 230kV ond Arap 280 MVA tto 1A)	
Monitored Element (Line or Transformer) From Bus To Bus	Туре	Line Ckt #	FAC9 Limiting Element - Comments	Branch Rating MVA	Branch Rating Amps	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	
70108 CHEROKEE 115 70175 FEDERHT2 115 2	LN	9558	Cher & Fed Hts Jmpr Cond (Submitted in FAC9 Proj Budget)	135.0		119.8	8	163.4	121.0	9	164.3	3 121.7	12	164.3	121.7	12	165.3	122.4	13	163.8	8 121.3	10	
70115 HPCYN 115 70138 DANIELPK 115 1	LN	9674	T-Line Cond (Requires IREA joint Project, possible new Brick Ctr - Kiowa 115 Line Proj?)	155.0		100.9	9 1	162.1	104.6	1	160.2	2 103.3	1	160.2	103.4	1	158.3	102.2	1	160.9	9 103.8	1	
70138 DANIELPK 115 70139 DANIELPK 230 T1	TR	Auto	Auto (Replacement Auto Proj Submitted in Budget)	150.0		121.5	2	188.8	3 125.9	4	186.8	3 124.5	4	186.9	124.6	4	184.9	123.2	3	187.6	5 125.1	4	
70148 DENVTM 115 70208 GRAY ST 115 1	LN	9008	Model Error - s/b 219.3MVA	109.0		128.1	93	149.1	136.8	21	#N/A	. #N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	112.0	0 102.8	3	
70224 HOGBACK 115 70265 LOOKOUT 115 1	LN	9794	Hogbk Jmpr Cond (Submitted in FAC9 Proj Budget for Hogbk Jmpr Cond, Lookout Bus Cond)	138.0		101.2	. 1	142.0	0 102.9	1	#N/A	. #N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
70259 LEETSDAL 115 70443 UNIVRSTP 115 1	LN	9338	Leets Jmpr Cond (Submitted in FAC9 Proj Budget for Leets Jmpr Cond)	109.0		121.5	1	138.2	2 126.8	1	#N/A	. #N/A	#N/A	#N/A	#N/A	#N/A	113.9	104.5	3	#N/A	#N/A	#N/A	
70395 SMOKYHIL 115 70521 PEAKVIEW 115 1	LN	9863 IREA	T-Line Cond (Requires IREA joint Project, possible new Brick Ctr - Kiowa 115 Line Proj?)	133.5		101.9	1	150.9	0 113.0	3	152.1	113.9	3	152.0	113.9	3	153.2	2 1 1 4.7	3	151.4	4 113.4	3	
70441 UNIVERS1 115 70443 UNIVRSTP 115 1	LN	9338	Leets Jmpr Cond (Submitted in FAC9 Proj Budget for Leets Jmpr Cond)	109.0		121.5	1	138.3	126.8	1	#N/A	. #N/A	#N/A	#N/A	#N/A	#N/A	114.0	104.5	3	#N/A	4N/A	#N/A	
70463 WATERTON 115 70522 ROXBOROU 115 1	LN	IREA	T-Line Cond (Requires IREA joint Project?)	126.0		118.8	1	149.1	118.3	1	149.1	118.4	2	149.1	118.3	2	149.3	118.5	2	148.9	9 118.1	1	
70517 PARKERPS 115 70518 BAYOU 115 1	LN	IREA	T-Line Cond (Requires IREA joint Project, possible new Brick Ctr - Kiowa 115 Line Proj?)	133.5		142.5	1281	199.8	3 149.6	1299	198.2	2 148.4	1299	198.2	148.4	1299	196.7	147.3	1299	198.7	7 148.9	1300	

N-1 Contingency Outage From Bus To Bus
70269 LOUISVIL 115 70444 VALMONT 115 1
70517 PARKERPS 115 70518 BAYOU 115 1
70517 PARKERPS 115 70518 BAYOU 115 1
70037 ARAPAHOB 115 70038 ARAPAHOE 230 T5
70018 SODALAKE 230 70400 SODALAKE 115 T2
70037 ARAPAHOB 115 70038 ARAPAHOE 230 T5
70396 SMOKYHIL 230 70551 MURPHY 230 1
70037 ARAPAHOB 115 70038 ARAPAHOE 230 T5
70517 PARKERPS 115 70518 BAYOU 115 1
70138 DANIELPK 115 70139 DANIELPK 230 T1

Table 7												Branc	h N-1 Loac	ding V	Vith G	I-2008-1, A	rapah	ioe 587	MW				
								Branch N-1 Loading Without GI- 2008-1 All GT8, GT9, S on Arap 230k (Opt 1)			GT8, GT9 on Arap 115kV ST10 on Arap 230kV (Opt 2)			GT8, GT9 on Arap 230kV ST10 on Arap 115kV (Pref - Opt 3)			GT8, GT9 on Arap 230kV ST10 on Arap 115kV (Opt 4)			All GT8, GT9, ST10 on Arap 230kV Plus Second Arap 230/115kV, 280 MVA Auto (Ont 1A)			
Monitored Element (Line or Transformer) From Bus To Bus	Туре	Line Ckt #	FAC9 Limiting Element - Comments	Branch Rating MVA	Branch Rating Amps	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	
70517 PARKERPS 115 70523 SULPHUR 115 1	LN	IREA	T-Line Cond (Requires IREA joint Project?)	133.5	5	127.4	1	171.8	128.7	1	170.8	127.9	1	170.8	8 127.9	0 1	169.8	3 127.2	1	171.1	128.2	1	
70517 PARKERPS 115 70523 SULPHUR 115 2	LN	IREA	T-Line Cond (Requires IREA joint Project?)	133.5	5	127.4	1	171.8	128.7	1	170.8	3 127.9	1	170.8	8 127.9) 1	169.8	8 127.2	1	171.1	128.2	1	

N-1 Contingency (From Bus To Bus	Dutage	
N-1 Contingency (From Bus To Bus 70517 PARKERPS 70523 SULPHUR	Dutage 115 115 2	

Table 8: Summary listing of differentially overloaded elements (Options 1B through 4B, with new IREA Kiowa – Brick Center 115 kV Line, newly overloaded elements, or delta overloads > 5% of rating, due to 587 MW Arapahoe repowering generation injection at POI).

NOTES:

- 1) Option 1 = GT8 & GT9 on 230kV, ST10 on 230kV; Option 2 = GT8 & GT9 on 115kV, ST10 on 230kV; Option 3 = GT8 & GT9 on 230kV, ST10 on 115kV; Option 4 = GT8 & GT9 on 115kV, ST10 on 115kV.
- 2) The results shown in this table are applicable to a 2013 heavy summer peak load case model, re-dispatched for north-to-south stressed PSCo transmission system (approx. TOT3 at 1316 MW, TOT5 at 787 MW, TOT7 at 406 MW, CA73 to CA70 interchange at 1,000 MW), other northern region PSCo generation near max output, new Arap GT8 / GT9 / ST10 gen at 587 MW Net.
- 3) This N-1 power flow summary includes a potential new IREA Brick Center Kiowa 115 kV transmission line in 2012, but does not include the new / planned Daniels park 230/115 kV autotransformer replacement (90/120/150 MVA replaced with 150/200/250/280 MVA in 2010), nor. See the following Table 9 (Options 3C & 3D) for results with both of these new Daniels Park, and Brick Center – Kiowa additions.

Table 8					Branch N-1	Loading Wit	th GI-2008-1, A	Arapahoe 587	MW								
	N-1 Loading t GI-2008-1	All GT8,	GT9, ST10 on (Opt 1B)	Arap 230kV	GT8, GT9 on Arap 115kV ST10 on Arap 230kV (Opt 2B)			GT8 ST	8, GT9 on Ara F10 on Arap 1 (Pref - Opt 3	p 230kV 15kV B)	GT8, ST	GT9 on Araj 10 on Arap 1 (Opt 4B)	p 230kV 15kV				
Monitored Element (Line or Transformer) From Bus To Bus	Туре	Branch Rating (MVA)	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	i N-1 Flow in MVA	N-1 Flow n in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Contingency Outage From Bus To Bus
70036 ARAPAHOA 115 70037 ABABAHOD 115 1	LN	247.4	#NT/ A	#N1/A	#N1/ A	#NT/A	#N1/ A	#NT/ A	#N1/ A	#N1/ A	#N1/A	#NT/ A	#N1/A	225.0	121 4	7	70037 ARAPAHOB 115 70401 SOUTH 1 115 1
70036 ARAPAHOB 115 1	LIN	247.4	#1N/A	#1 N /A	#1N/A	#1 N /A	#1 N /A	#1 N /A	#1N/A	#1 N /A	#1 N /A	#1N/A	#1 N /A	525.0	131.4	/	70036 ARAPAHOA 115
70442 UNIVERS2 115 1	LN	154.0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	186.1	120.8	16	70531 AIR LIQ 115 1
70037 ARAPAHOB 115																-	70038 ARAPAHOE 230
70038 ARAPAHOE 230 T5	TR	280.0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	70141 DAKOTA 230 1
70037 ARAPAHOB 115																	70036 ARAPAHOA 115
70165 ENGLE3TP 115 1	LN	120.0	127.3	1	150.7	125.6	1	151.3	126.1	10	151.3	126.1	9	153.7	128.1	1306	70037 ARAPAHOB 115 1
/003/ ARAPAHOB 115 70401 SOUTH 1 115 1	LN	109.0	117 9	1	155.0	142.2	8	166.6	152.8	1300	165.8	152.1	1208	241.5	221.5	1311	70208 GP AV ST 115 1
70401 SOOTH 1 115 1 70045 BANCROFT 115	LIN	109.0	11/.0		155.0	142.2	8	100.0	152.8	1300	105.8	132.1	1298	241.3	221.3	1311	70037 ARAPAHOR 115
70208 GRAY ST 115 1	LN	120.0	127.5	8	165.1	137.6	3	169.3	141.1	3	169.0	140.8	3	176.1	146.7	2	70401 SOUTH 1 115 1
70045 BANCROFT 115	211	120.0	127.0	0	100.1	15710	-	107.5		-	107.0	110.0	5	17011	1.0.7	-	70018 SODALAKE 230
70242 KENDRICK 115 1	LN	138.0	116.5	1	159.3	115.4	1	159.7	115.7	1	159.7	115.7	1	159.7	115.8	2	70400 SODALAKE 115 T2
70045 BANCROFT 115																	70036 ARAPAHOA 115
70401 SOUTH 1 115 1	LN	135.0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	204.5	151.5	6	70037 ARAPAHOB 115 1
70047 BARRLAKE 230																	
70048 GREENVAL 230 1	LN	159.0	167.0	1307	234.6	147.6	1306	234.5	147.5	1306	234.5	147.5	1306	234.4	147.4	1306	Unit: 70936 ARAP 10 18.0 Id:1
70108 CHEROKEE 115																	70538 CHMBERS 115
70153 DERBY 1 115 1	LN	75.0	109.1	1	89.1	118.9	1	90.4	120.6	1	90.3	120.4	1	92.9	123.9	1	70539 CHMBERS 230 1
/0108 CHEKOKEE 115 70175 EEDEBUT2 115 2	LN	125.0	110.0	0	162.9	121.2	10	164.2	121 7	12	164.2	121.7	12	165.2	122.4	12	70269 LOUISVIL 115 70444 VALMONT 115 1
70115 HPCVN 115	LIN	155.0	119.0	0	105.8	121.5	10	104.5	121.7	12	104.5	121.7	12	105.5	122.4	15	70517 DADKEDDS 115
70138 DANIFLPK 115 1	LN	155.0	#N/A	1	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	70518 BAYOU 115 1
70138 DANIELPK 115	LIN	155.0	111/11	1	//11//11	111112	1111/11	111111	111111	1111/11	1111/11	1111/21	1111721	111111	111111	1111/21	70517 PARKERPS 115
70139 DANIELPK 230 T1	TR	150.0	100.0	2	155.7	103.8	3	154.9	103.2	3	155.0	103.3	3	152.9	101.9	3	70518 BAYOU 115 1
70148 DENVTM 115																	70037 ARAPAHOB 115
70208 GRAY ST 115 1	LN	109.0	128.1	93	111.6	102.4	2	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	70038 ARAPAHOE 230 T5
70224 HOGBACK 115																	70018 SODALAKE 230
70265 LOOKOUT 115 1	LN	138.0	#N/A	.1	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	70400 SODALAKE 115 T2
70259 LEETSDAL 115					ID Y I A	IDALA	ID T ()	IDALA	ID Y IA	15.714	ID Y (A	10.114	ID T ()		1051		70037 ARAPAHOB 115
70443 UNIVRSTP 115 1	LN	109.0	#N/A	. 1	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	114.6	105.1	3	/0038 ARAPAHOE 230 T5
/0393 SMOKYHIL 115 70521 PEAKVIEW 115 1	IN	122.5	101.0	1	133.6	100.1	1	134.3	100.6	1	134.2	100.5	1	135 /	101.4	1	70551 MURPHV 230 1
70441 UNIVERS1 115	LIN	155.5	101.9	1	155.0	100.1	1	1.54.5	100.0	1	1.34.2	100.5	1	155.4	101.4	1	70037 ARAPAHOR 115
70441 UNIVERST 115 70443 UNIVERSTP 115 1	LN	109.0	#N/A	1	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	114.6	105.1	3	70038 ARAPAHOE 230 T5
70463 WATERTON 115		109.0														-	70517 PARKERPS 115
70522 ROXBOROU 115 1	LN	126.0	118.8	1	148.8	118.1	1	149.1	118.3	1	149.0	118.3	1	149.3	118.5	1	70518 BAYOU 115 1

Table 8			Branch N-1 Loading With GI-2008-1, Arapahoe 587 MW															
Branch N-1 Loading Without GI-2008-1					All GT8, 0	GT9, ST10 on A (Opt 1B)	Arap 230kV	GT8, GT9 on Arap 115kV ST10 on Arap 230kV (Opt 2B)			GT8, ST	GT9 on Arap 10 on Arap 1 (Pref - Opt 3)	9 230kV 15kV B)	GT8, ST	GT9 on Araj 10 on Arap 1 (Opt 4B)	o 230kV 15kV		
Monitored Element (Line or Transformer) From Bus To Bus	Туре	Branch Rating (MVA)	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1	Contingency Outage From Bus To Bus
70517 PARKERPS 115 70518 BAYOU 115 1	LN	133.5	142.5	1281	164.1	122.9	10	163.6	122.5	10	163.6	122.6	10	162.3	121.6	10	70138 DANIELPK 70139 DANIELPK	115 230 T1
70517 PARKERPS 115 70523 SULPHUR 115 1	LN	133.5	127.4	1	158.4	118.7	1	158.1	118.4	1	158.1	118.4	1	157.3	117.8	1	70517 PARKERPS 70523 SULPHUR	115 115 2
70517 PARKERPS 115 70523 SULPHUR 115 2	LN	133.5	127.4	1	158.4	118.7	1	158.1	118.4	1	158.1	118.4	1	157.3	117.8	1	70517 PARKERPS 70523 SULPHUR	115 115 1
70518 BAYOU 115 70574 FRANKTWN 115 1	LN	133.5	92.9	#N/A	146.4	109.6	2	145.7	109.2	2	145.8	109.2	2	144.1	108.0	2	70138 DANIELPK 70139 DANIELPK	115 230 T1

Table 9: Summary listing of differentially overloaded elements (Options 3C / DP 280 Auto & 3D / New IREA 115 kV Line), newly overloaded elements, or delta overloads > 5% of rating, due to 587 MW Arapahoe repowering generation injection at POI).

NOTES:

- 1) Option 1 = GT8 & GT9 on 230kV, ST10 on 230kV; Option 2 = GT8 & GT9 on 115kV, ST10 on 230kV; Option 3 = GT8 & GT9 on 230kV, ST10 on 115kV; Option 4 = GT8 & GT9 on 115kV, ST10 on 115kV.
- 2) The results shown in this table are applicable to a 2013 heavy summer peak load case model, re-dispatched for north-to-south stressed PSCo transmission system (approx. TOT3 at 1316 MW, TOT5 at 787 MW, TOT7 at 406 MW, CA73 to CA70 interchange at 1,000 MW), other northern region PSCo generation near max output, new Arap GT8 / GT9 / ST10 gen at 587 MW Net.

3) This N-1 power flow summary includes the new planned Daniels Park 230/115 kV autotransformer replacement (Option 3C, 90/120/150 MVA replaced with 150/200/250/280 MVA in 2010). as well as a potential new IREA Brick Center – Kiowa 115 kV transmission line in 2012 (Option 3D, includes both autoxfmr & IREA line).

Table 9									Branch N-1 Loading With GI-2008						
		I-1 Loading GI-2008-1		(on 230 kV 115 kV VA Auto 3C)										
Monitored Element (Line or Transformer) From Bus To Bus	Туре	Line Ckt #	FAC9 Limiting Element - Comments	Branch Rating MVA	Branch Rating Amps	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violation s	N-1 Contingency Outage From Bus To Bus	N-1 Flow in MVA	N-1 F % of		
70036 ARAPAHOA 115 70037 ARAPAHOB 115 1	LN	9340 (Bus Tie Bkr)	Bkr / Bus (verify)	247.4	1,242	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N		
70036 ARAPAHOA 115 70442 UNIVERS2 115 1	LN	9338	UG T-Line Cond	154.0	773	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N		
70037 ARAPAHOB 115 70038 ARAPAHOE 230 T5	TR	Auto	Auto	280.0	N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N		
70037 ARAPAHOB 115 70165 ENGLE3TP 115 1	LN	9336	Arap Swtchs (Submitted in FAC9 Budget Proj)	120.0	602	127.3	1	151.3	126.1	11	70264 LITTLET2 115 70463 WATERTON 115 1	151.3	12		
70037 ARAPAHOB 115 70401 SOUTH 1 115 1	LN	9335	Arap Swtchs (Submitted in FAC9 Budget Proj)	109.0	547	117.8	1	165.9	152.2	1297	70045 BANCROFT 115 70208 GRAY ST 115 1	165.6	15		
70045 BANCROFT 115 70208 GRAY ST 115 1	LN	9448	Gray St Sw (Submitted in FAC9 Project Budget for Bancroft Jmpr Cond, Gray St Swtchs & Bus Cond)	120.0	602	127.5	8	169.3	141.1	3	70037 ARAPAHOB 115 70401 SOUTH 1 115 1	168.8	14		
70045 BANCROFT 115 70242 KENDRICK 115 1	LN	8024	Kendrick & Bancroft Cond (Submitted in FAC9 Proj Budget)	138.0	693	116.5	1	159.7	115.7	1	70023 ALLISON 115 70400 SODALAKE 115 1	159.6	11		
70045 BANCROFT 115 70401 SOUTH 1 115 1	LN	9335	T-Line Cond (Need to verify model rate)	135.0	678	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N		
70047 BARRLAKE 230 70048 GREENVAL 230 1	LN	5759	Model Error - s/b 478MVA	159.0	399	167.0	1307	235.5	148.1	1306	70192 FTLUPTON 230 70529 JLGREEN 230 1	234.6	14		
70108 CHEROKEE 115 70153 DERBY 1 115 1	LN	9543	Cher & Derby Jumpr Cond (Submitted in FAC9 Proj Budget)	75.0	377	109.1	1	90.1	120.2	1	70538 CHMBERS 115 70539 CHMBERS 230 1	90.1	12		
70108 CHEROKEE 115 70175 FEDERHT2 115 2	LN	9558	Cher & Fed Hts Jmpr Cond (Submitted in FAC9 Proj Budget)	135.0	678	119.8	8	164.3	121.7	12	70269 LOUISVIL 115 70444 VALMONT 115 1	164.3	12		

15kV, ST10 on 115kV. 1316 MW, TOT5 at 787 MW, TOT7 at 406 MW, CA73

-1, Arapahoe 587 MW GT8, GT9 on 230 kV ST10 on 115 kV DP 280 MVA Auto & IREA BC-Kiowa 115kV (Opt 3D) **N-1 Contingency Outage** Total # of low in From Bus Violations f Rate To Bus #N/A #N/A N/A N/A #N/A #N/A N/A #N/A #N/A 70264 LITTLET2 115 70463 WATERTON 115 1 26.1 9 70045 BANCROFT 115 70208 GRAY ST 115 1 52.0 1298 70037 ARAPAHOB 115 70401 SOUTH 1 115 1 40.7 3 70023 ALLISON 115 70400 SODALAKE 115 1 15.7 N/A #N/A #N/A 70192 FTLUPTON 230 7.5 1306 70529 JLGREEN 230 1 70538 CHMBERS 115 70539 CHMBERS 230 1 20.1 70269 LOUISVIL 115 21.7 12 70444 VALMONT 115 1

Table 9		Branch N-1 Loading With GI-2008-1, Arapahoe 587 MW														
						Branch N- Without (-1 Loading GI-2008-1		(GT8, GT9 o ST10 on DP 280 MV (Opt 3	on 230 kV 115 kV VA Auto 3C)	GT8, GT9 on 230 kV ST10 on 115 kV DP 280 MVA Auto & IREA BC-Kiowa 115kV (Opt 3D)				
Monitored Element (Line or Transformer) From Bus To Bus	Туре	Line Ckt #	FAC9 Limiting Element - Comments	Branch Rating MVA	Branch Rating Amps	N-1 Flow in % of Rate	Total # of Violations	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violation s	N-1 Contingency Outage From Bus To Bus	N-1 Flow in MVA	N-1 Flow in % of Rate	Total # of Violations	N-1 Contingency Outage From Bus To Bus	
70115 HPCYN 115 70138 DANIELPK 115 1	LN	9674	T-Line Cond (Requires IREA joint Project, possible new Brick Ctr - Kiowa 115 Line Proj?)	155.0	778	100.9	1	177.7	114.7	1	70517 PARKERPS 115 70518 BAYOU 115 1	#N/A	#N/A	#N/A	#N/A	
70138 DANIELPK 115 70139 DANIELPK 230 T1	TR	Auto	Auto (Replacement Auto Proj Submitted in Budget)	150.0	N/A	#N/A	2	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
70148 DENVTM 115 70208 GRAY ST 115 1	LN	9008	Model Error - s/b 219.3MVA	109.0	547	#N/A	93	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
70224 HOGBACK 115 70265 LOOKOUT 115 1	LN	9794	Hogbk Jmpr Cond (Submitted in FAC9 Proj Budget for Hogbk Jmpr Cond, Lookout Bus Cond)	138.0	693	#N/A	1	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
70259 LEETSDAL 115 70443 UNIVRSTP 115 1	LN	9338	Leets Jmpr Cond (Submitted in FAC9 Proj Budget for Leets Jmpr Cond)	109.0	547	#N/A	1	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
70395 SMOKYHIL 115 70521 PEAKVIEW 115 1	LN	9863 IREA	T-Line Cond (Requires IREA joint Project, possible new Brick Ctr - Kiowa 115 Line Proj?)	133.5	670	101.9	1	149.5	112.0	3	70396 SMOKYHIL 230 70551 MURPHY 230 1	#N/A	#N/A	#N/A	#N/A	
70441 UNIVERS1 115 70443 UNIVRSTP 115 1	LN	9338	Leets Jmpr Cond (Submitted in FAC9 Proj Budget for Leets Jmpr Cond)	109.0	547	#N/A	1	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
70463 WATERTON 115 70522 ROXBOROU 115 1	LN	IREA	T-Line Cond (Requires IREA joint Project?)	126.0	633	118.8	1	149.1	118.3	1	70091 CASTLRCK 115 70520 WOLFSBTP 115 1	149.0	118.3	1	70091 CASTLRCK 115 70520 WOLFSBTP 115 1	
70517 PARKERPS 115 70518 BAYOU 115 1	LN	IREA	T-Line Cond (Requires IREA joint Project, possible new Brick Ctr - Kiowa 115 Line Proj?)	133.5	670	142.5	1281	198.2	148.4	1291	70138 DANIELPK 115 70139 DANIELPK 230 T1	163.6	122.6	8	70138 DANIELPK 115 70139 DANIELPK 230 T1	
70517 PARKERPS 115 70523 SULPHUR 115 1	LN	IREA	T-Line Cond (Requires IREA joint Project?)	133.5	670	127.4	1	166.6	124.8	1	70517 PARKERPS 115 70523 SULPHUR 115 2	154.6	115.8	1	70517 PARKERPS 115 70523 SULPHUR 115 2	
70517 PARKERPS 115 70523 SULPHUR 115 2	LN	IREA	T-Line Cond (Requires IREA joint Project?)	133.5	670	127.4	1	166.6	124.8	1	70517 PARKERPS 115 70523 SULPHUR 115 1	154.6	115.8	1	70517 PARKERPS 115 70523 SULPHUR 115 1	