

Interconnection System Impact Study Report REQUEST # GI-2003-2

Elbert County 500 MW Generation Addition

**Xcel Energy Transmission Planning
June 2004**

Executive Summary

This Interconnection System Impact Study Report summarizes the analysis performed by the Transmission Planning group of Public Service Company of Colorado (PSCo) to interconnect two 250 MW lignite-coal power plants in Elbert County. The Customer proposed in-service date for commercial operation of the 500 MW facility is June 1, 2008, with a back-feed date of January 1, 2008. At the request of the Customer, the Project was evaluated as both a Network Resource (NR) and as an Energy Resource (ER) with the power going to PSCo customers.

The results of this study are based on the assumption that proposed generation projects and the associated transmission from higher queued interconnection requests are in service.

Energy Resource:

As an Energy Resource, an interconnected generator is only eligible to deliver on an “as available” basis using the existing capacity of the transmission system. This study indicated that the most effective method to interconnect the 500 MW of generation was with a new 230kV switching station (herein referred to as Corner Point) that would bisect the existing PSCo Pawnee – Daniels Park 230kV line and provide a point of interconnection for the new generation. The Corner Point switching station would be constructed at a location approximately four miles northwest of the town of Deer Trail. Studies indicated that the output of the proposed facility would be in the range of 440 to 500 MW without requiring any additional Network Upgrades, depending on regional generation patterns and Tot 3 path flow. The estimated cost of the PSCo Network Upgrades associated with an Interconnection for an Energy Resource is \$4.5 Million. The time frame to get the interconnection constructed for the generation addition would be approximately 24 months from the signing of an Interconnection Agreement (IA).

Network Resource:

For the Project to be considered a Network Resource, studies indicate that the integration of the full 500 MW of new generation would require approximately 64 miles of new 230kV transmission between the Corner Point Switching Station and the Daniels Park Substation. The estimated incremental cost for Network Upgrades associated with delivery (above the Energy Resource cost) is \$63.5 Million. The total estimated cost of the Network Upgrades associated with the Interconnection and Delivery of the 500 MW facility is \$68 Million. The time frame to get the transmission requirements constructed for the generation addition would be a minimum of 54 months from the signing of the IA.

Customer Interconnection:

At the request of the Customer, a preliminary estimate was prepared for the transmission between the proposed new generator and the Corner Point Switching Station. For an approximately 25-mile, single-circuit 230kV line, the estimated cost is \$11 Million and the estimated time for completion is 24 months.

According to the LGIP, interconnection studies must consider other requests that have a higher queue positions when performing system analyses. For this study, system models included PSCo Interconnection Request # GI-2003-1, which consists of a 300 MW generator interconnection in Morgan County, Colorado and associated infrastructure. That project is listed on the Rocky Mountain Area OASIS web site (www.rmao.com) and has a Customer proposed in-service date of December 1, 2006.

The infrastructure associated with that project includes:

1. Upgrade the PSCo Pawnee to Quincy to Smoky Hill 230kV line from 637 MVA to 800 MVA.
2. Rebuild the PSCo Pawnee to Ft. Lupton 230kV, 416 MVA rated line to 230kV double-circuit transmission with 834 MVA/circuit capability.

PSCo estimated the total costs for the Network Upgrades required for the Interconnection and Delivery of Request # GI-2003-1 to be \$42,850,000, and estimated that it would take at least 27 months to construct the facilities from an execution of an Interconnection Agreement. If that request were to drop out of the queue, it is likely that a re-study of this Interconnection System Impact Study would be required. If the assumed Network Upgrades for Request # GI-2003-1 are not constructed, the amount of delivery for this ER request could be zero and additional Network Upgrades and time would be required.

The current PSCo generation interconnection queue can be found in Appendix A.

A simple diagram of the Network Upgrades and the regional transmission system for this request is shown in Figure 1.

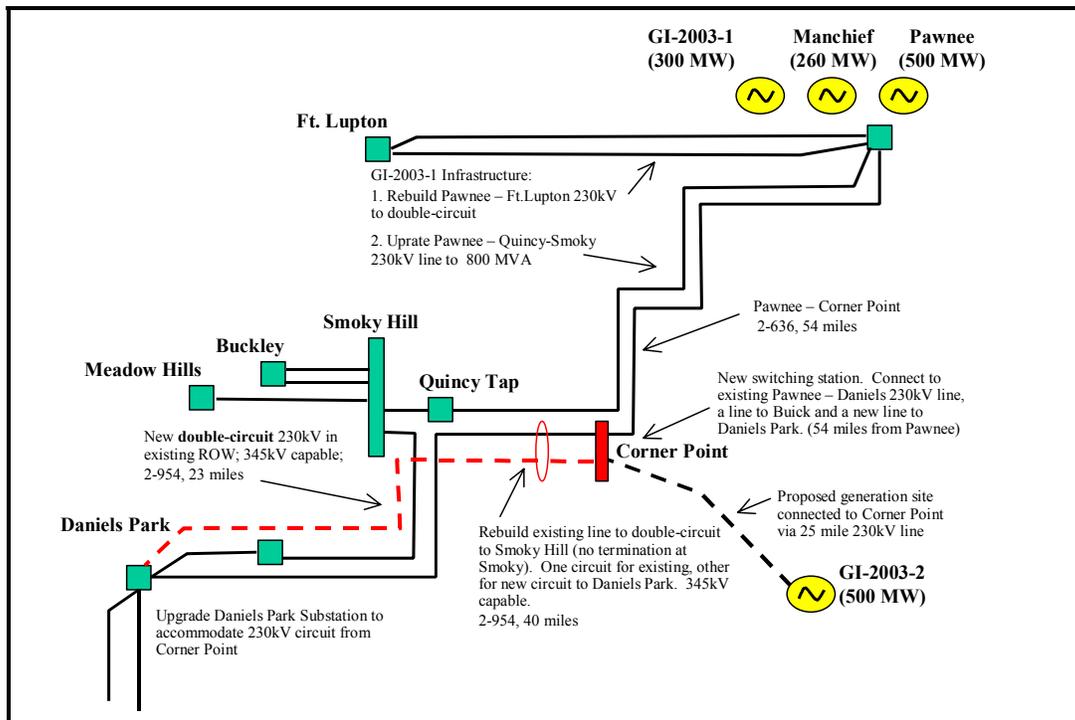


Figure 1

Introduction

On November 3, 2003 Xcel Energy Transmission received a request to conduct a feasibility study that would evaluate the integration of a 500 MW coal fired generating unit in Elbert County, Colorado. The approximate location of the interconnection will be four miles northwest of the town of Deer Trail, Colorado. The Customer proposed in-service date for commercial operation of the facility is June 1, 2008, with a back-feed date of January 1, 2008. The Feasibility Study was completed and the report issued to the Customer and posted on the RMAO web site in February 2004. An Interconnection System Impact Study Agreement was executed on or around March 10, 2004 indicating a targeted completion date for studies of 120 days from that date.

Study Scope and Analysis

The Interconnection System Impact Study evaluated the transmission requirements associated with the proposed interconnection to the PSCo Transmission System. As per section 7.3 of the FERC LGIP, the Study considered the Base Case as well as all Generating Facilities (and with respect to (iii), any identified Network Upgrades) that, on the date the Interconnection Feasibility Study is commenced:

- (i) are directly interconnected to the Transmission System;
- (ii) are interconnected to Affected Systems and may have an impact on the Interconnection Request;
- (iii) that have a pending higher queued Interconnection Request to interconnect to the Transmission System; and
- (iv) have no Queue Position but have executed an LGIA or requested that an unexecuted LGIA be filed with FERC.

The Study consisted of power flow, short circuit, and dynamic stability analyses. The power flow analysis provided an identification of any thermal or voltage limit violations resulting for the interconnection; and for a NR request, a preliminary identification of network upgrades required to deliver the proposed generation to PSCo loads. The short circuit analysis provided a preliminary identification of any circuit breaker short circuit capability limits exceeded as a result of the Interconnection and for a NR request, the delivery of the proposed generation to PSCo loads. The dynamic stability analysis verified that there were no limitations due to angular instability of the system for regional disturbances.

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

Powerflow Study Models

For this analysis, a power flow model was developed to reflect 2008 heavy summer loading conditions. Data representation in the area of study was reviewed and modified to accurately reflect the Rocky Mountain regional transmission system. The Tot 3 transfer path was increased to a relatively high level, and power transfers from north to south through Colorado were increased to study the regional transmission system¹. Power flow models also included the generation and associated infrastructure from the PSCo Interconnection Queue including:

GI-2003-1: 300 MW generation facility connected to the Pawnee 230kV bus and associated infrastructure:

- Rebuild the existing Pawnee - Ft. Lupton 230kV, 416 MVA rated line to double-circuit with 800 MVA/circuit capability.
- Uprate the Pawnee – Smoky Hill 230kV line from 637 MVA to 800 MVA.

Again, if Project # GI-2003-01 drops out of the queue, then additional facilities and time will be required to support both an ER and NR request.

The proposed project was modeled as two 250 MW units. Since the specified point of interconnection for the new generation is not near an existing substation or switching station, a new switching station will have to be constructed. To model the new switching station, a powerflow bus called Corner Point was created that could tie into

¹ High north to south transfers are generally used to analyze the transmission system between Pawnee and Denver. The Tot 3 transfer path was modeled at approximately 1500 MW. The 2004 summer transfer limit for that path is approximately 1600 MW.

the existing Pawnee – Daniels Park or Pawnee – Smoky Hill 230kV lines approximately four miles northeast of Deer Trail, Colorado. The proposed project was connected to the Corner Point bus with a single 230kV line, approximately 25 miles long. As an NR request, the proposed generation was scheduled to PSCo peaking units.

Study Results

Power Flow Analysis

At the request of the Customer, the Project was evaluated as both a Network Resource (NR) and as an Energy Resource (ER) with the power going to PSCo customers.

Energy Resource

Three alternatives were evaluated for the interconnection of the Project to the PSCo transmission system:

- Connect to the Pawnee – Daniels Park 230kV line
- Connect to the Pawnee – Smoky Hill 230kV line
- Connect to both the Pawnee – Daniels Park and Smoky Hill 230kV lines

The alternative that bisected the existing Pawnee – Daniels Park 230kV line exhibited the best system performance and lowest contingency overloads. Table 1 summarizes the contingency results for the Pawnee – Daniels Park interconnection alternative. The other alternatives that tied into the Pawnee - Smoky Hill line resulted in contingency overloads on the 230kV system west of Smoky Hill. Even though interconnecting to the Pawnee – Daniels Park line was the best interconnection alternative, studies showed that additional transmission would have to be built to accommodate the full 500 MW of proposed generation.

Table 1 Power Flow Contingency Results

Contingency Results Interconnect the Pawnee - Daniels Park 230kV line		Contingency / Loaded Element/ MVA Rating	
Case	Description	Pawnee-SmokyHill230 CornerPt-Daniels230 (637 MVA)	Smoky-Buckley230 Smoky-Meadow230 (435 MVA)
bu08a1	Add 500 MW Project Interconnect Pawnee-Daniels230	105%	105%
bu08a1-g1	Reduce Project to 440 MW No additional transmission	100%	105%
bu08a1-A	Add Project at 500 MW Preferred Alternative: Add CornerPoint-Daniels230	<90%	96%
bu08a1-B	Add Project at 500 MW Transmission Alternative: Add CornerPoint-Smoky230	<90%	129%
bu08a1-C	Add Project at 500 MW Transmission Alternative: Add CornerPoint-Smoky-Daniels230	<90%	114%

Studies showed that without additional transmission, the output of the proposed generation could be approximately 440 MW. That limit was established by modeling heavy north to south flows in the region, a relatively high Tot 3, and an outage of the Pawnee – Smoky Hill 230kV line. That contingency loaded the parallel Corner Point

to Daniels Park 230kV line to 100% of its flow limit (case bu08a1-g1 in Table 1). Higher Tot 3 flows could result in lower delivery capability.

Network Resource

With the proposed project generating 500 MW, loss of the Pawnee – Smoky Hill 230kV line caused a 105% overload on the Corner Point to Daniels Park 230kV line. To alleviate the overload and accommodate the full 500 MW of generation, approximately 64 miles of new 230kV transmission was modeled between Corner Point Switching Station and Daniels Park Substation (bu08a1-A).

Some sensitivity studies were performed to analyze other transmission alternatives. Those alternatives included:

- A new 230kV transmission line between Corner Point and Smoky Hill substation (bu08a1-B);
- New 230kV transmission lines between Corner Point and Smoky Hill, and between Smoky Hill and Daniels Park substations (bu08a1-C).

Studies showed that any alternative that connected to the Smoky Hill substation would cause contingency overloads on the 230kV system west of Smoky Hill. The contingency tables are provided in Appendix B.

Therefore, the recommended infrastructure is new 230kV transmission between Corner Point and Daniels Park. It should be constructed as follows:

- Between Corner Point Switching Station and the Smoky Hill Substation, the existing 230kV line (that originates at Pawnee and terminates at Daniels Park) should be rebuilt to double-circuit configuration. One rebuilt circuit will replace the existing circuit. The other rebuilt circuit would be the new circuit. Neither circuit would tie in at Smoky Hill. To minimize future siting and construction concerns, new transmission should consist of 345kV construction, although initially be operated at 230kV.
- From Smoky Hill, the new circuit would continue to Daniels Park using new 230kV transmission within the existing corridor. To minimize future siting and construction concerns, this transmission should be built with double-circuit 345kV capability.

Short Circuit Study Results

The short circuit analysis consisted of faulting 230kV buses in the region of study. Three-phase and single-line to ground faults were evaluated and the three-phase faults were found to be more severe. The results are shown in Table 2.

Table 2 Short Circuit Study Results

Configuration	Fault Current (Amps)			
	Daniels Park	Smoky Hill	Corner Point	Pawnee
Benchmark Existing system 2008 system	26004	28987	NA	19382
(GI-2003-2) Add proposed generation and Corner Point – Daniels Park 230kV line	27047	29630	15373	20505

Results indicated that the largest increase in fault currents would be at the Daniels Park substation, which showed an increase of approximately 1000 Amps. There are some breakers at Daniels Park that have a 31.5 kA rating, but they will not be at risk for the faults studied.

Stability Study Results

Transient stability analysis was performed by modeling three-phase faults and single contingencies in the region of study. The three-phase faults were cleared and elements removed after six cycles. Dynamic models for the proposed project were prepared using Customer supplied data. The analysis indicated that the project would not adversely affect the transient stability performance of the system and results met WECC/NERC Reliability Criteria. The disturbances modeled are shown in Table 3. Plots of the stability analysis are available upon request.

Table 3 Transient Stability Results

Case	3-Phase Fault	Element(s) Lost	Results
bu08a1a-s1	Corner Point 230	Corner Point – Daniels Park 230kV Line #2	Stable and well damped
bu08a1a-s2	Corner Point 230	Corner Point– Pawnee 230kV Line	Stable and well damped
bu08a1a-s3	Proposed Generator Bus	Generator Bus - Corner Point 230kV Line and Proposed Generation	Stable and well damped

Cost Estimates and Assumptions

The estimated costs shown are “indicative” (+/-30%) preliminary budgetary costs 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, and construction of these new PSCo facilities. The estimates do not include any costs for any Customer-owned, supplied, and installed equipment and associated design and engineering, other than the transmission line between the generation and Corner Point. This estimate also does not include any costs that may, or may not be required for other entities’ systems. The cost responsibilities associated with these facilities shall be handled as per current FERC guidelines

Based upon the System Impact Study performed here, in order for PSCo to provide an interconnection for the Customer requested generation interconnection a new switching station must be built at Corner Point.

PSCo Network Upgrades for Interconnection:

Table 4 describes the costs associated with providing an interconnection to PSCo’s system. It does not include all of the costs required for full delivery of the generation. Those costs are included in Table 5.

Table 4 PSCo Network Upgrades Required for Interconnection

Element	Description	Cost
Corner Point Substation	Construct a three-breaker ring substation that will sectionalize the Pawnee – Daniels Park 230kV line and interconnect the 230kV line to the Project. The equipment required includes: <ul style="list-style-type: none"> • Site development • Control building • 3 circuit breakers • 8 disconnect switches • 3 dead-end structures, associated bus and connectors • High voltage metering with associated revenue metering equipment • Bus voltage transformers and line synchronizing transformers • Siting and Land Rights for misc. permits 	\$4.5
TOTAL	Total Cost	\$4.5
Time Frame		24 months

PSCo Network Upgrades required to deliver the proposed 500 MW as an NR Request:

Table 5 lists the costs associated with developing the transmission system in order to deliver the full 500 MW of generation. The Corner Point substation would be modified from the simple Interconnection facility shown in Table 4. The cost of the Network Delivery facilities is the additional change in cost between Interconnection and Delivery.

Table 5 PSCo Network Upgrades Required for Power Delivery

Element	Description	Cost (\$Million)
Corner Point Substation	<p>The 230kV station would require a different configuration than for a simple interconnection. It would be configured as a 6-breaker, breaker and a half arrangement, at Corner Point. The total equipment required includes:</p> <ul style="list-style-type: none"> • Site development • Control building • 6 circuit breakers • 12 disconnect switches • 4 dead-end structures, associated bus and connectors • High voltage metering with associated revenue metering equipment • Bus voltage transformers and line synchronizing transformers • Relaying and communication equipment 	<p>\$5.6 -\$4.5 =\$1.1</p>
Daniels Park Substation	<p>The existing station must be modified to accommodate a single 230kV line from Corner Point. Modifications include:</p> <ul style="list-style-type: none"> • Site development • 3 circuit breakers • 12 disconnect switches • 1 dead-end structure, associated bus and connectors • Relaying and communication equipment 	\$3.7
Transmission	<ul style="list-style-type: none"> • Between Corner Point Switching Station and the Smoky Hill Substation, rebuild the existing 40 mile 230kV line (that originates at Pawnee and terminates at Daniels Park) to double-circuit configuration. One rebuilt circuit will replace the existing circuit. The other rebuilt circuit will be the new circuit. Neither circuit will tie in at Smoky Hill. To minimize future siting and construction concerns, build the new transmission to 345kV capability, (initially operated at 230kV). Standard conductor is bundled 954 kcmil ACSR. • From Smoky Hill, continue the new circuit to Daniels Park using 24-miles of new 230kV transmission within the existing corridor. To minimize future siting and construction concerns, construct this transmission in double-circuit configuration with 345kV capability (initially operated at 230kV). Standard conductor is bundled 954 kcmil ACSR. • Siting and Land Rights for misc. permits 	\$58.7
TOTAL		\$63.5 Million
Time Frame		54 Months

Total costs for Network Upgrades for Interconnection and Delivery Costs = **\$68 Million**

Customer Interconnection:

At the request of the Customer, a preliminary estimate was prepared for the transmission between the proposed new generating facility and the Corner Point Switching Station. The cost estimates are provided in Table 6.

Table 6 Customer Interconnection

Element	Description	Cost
Transmission	<ul style="list-style-type: none">• Construct a 25-mile, single-circuit 230kV (double-circuit capable) line between the proposed generation project and the Corner Point switching station. Structures would be steel pole, and have the capability to accommodate a second future circuit. Standard conductor is bundled 954 kcmil ACSR.• Siting and Land Rights for misc. permits	\$11
TOTAL	Total Cost	\$11 Million
Time Frame		24 Months

Major Assumptions for Cost Estimates

1. Infrastructure associated with Interconnection Request GI-2003-1 was assumed to be in service for these studies (see previous description). It was determined that these network upgrades required a minimum of 27 months to complete following the execution of an IA and cost approximately \$42,850,000. The feasibility study report for GI-2003-1 is available via www.rmao.com.
2. PSCo (or its contractor) crews will perform all construction and wiring associated with PSCo-owned and maintained equipment.
3. Any NEPA requirements imposed on transmission as a result of the generation addition will most likely have adverse effects on schedule and deliverables.
4. No screening has been estimated at any of the substations. If this is required the cost will be significant at each location.
5. Detailed field investigations have not been conducted and could increase these estimates.
6. Only minimal transmission line ROW acquisition is assumed for Network Delivery related facilities, since existing ROW will be utilized. The Customer Interconnection requires new ROW.
7. Where prudent, Xcel Energy pre-constructs 230kV lines to 345kV specifications. Permitting the new double-circuit 345kV transmission line from Smoky Hill to Daniels Park will be extremely difficult and could require legal action. These estimates do not include any cost for legal fees.
8. All necessary transmission line outages can be obtained. If not, construction duration times will be longer.
9. All cost estimates have been escalated to reflect the appropriate year of project activity.

Overall timeline to complete all required transmission and substation facilities is expected to require a minimum of 54 months. If there are problems with local and state approvals, this could require an additional year.

APPENDIX A
PSCo Generation Interconnection
Request Queue

GENERATION INTERCONNECTION REQUESTS
June 18, 2004

Queue Number	Date Received	Generation Type	Service Type	Location County/State	Interconnection Point Station or Line	Net Plant Max MW Sum Win	In-Service Date	Comments/Status/Reason not Completed
GI-2003-1	10/21/2003	Wind	Network Resource	Morgan Co., CO	Pawnee Substation	300 300	12/1/2006	Feasibility Study complete System Impact Study underway
GI-2003-2	11/3/2003	Coal	Network +Energy Resource	Elbert Co., CO	Smokey Hill- Pawnee 230kV line	500 500	6/1/2008	Feasibility Study complete System Impact Study underway
GI-2003-3	11/7/2003	Coal	Network Resource	Pueblo Co., CO	Comanche Substation	750 750	10/1/2009	Feasibility Study complete System Impact Study underway
GI-2003-4	11/11/2003	Wind	Network +Energy Resource	Laramie Co., WY	Ponnequin Substation	30 30	Q2-2004	Feasibility Study complete System Impact Study underway
GI-2003-5	12/29/2003	Coal	Network Resource	Morgan Co., CO	Pawnee Substation	750 750	10/1/2009	Request withdrawn 2/20/04
GI-2004-1	1/19/2004	Wind	Network +Energy Resource	Morgan Co., CO	Story Substation	150 150	12/31/2005	Feasibility Study complete
GI-2004-2	2/9/2004	Wind	Network +Energy Resource	Baca Co., CO	Lamar Substation	238 238	9/31/2005	Feasibility Study complete

APPENDIX B

POWER FLOW RESULTS

Table 7

Contingency Results Interconnect the Pawnee - Daniels Park 230kV line		Contingency / Loaded Element	Pawnee-Smoky230 CornerPt-Daniels230	Smoky-Buckley230 Smoky-Meadow230
Case	Description	MVA Rating→	637	435
bu08a1	Add 500 MW Project Interconnect Pawnee-Daniels230		105%	105%
bu08a1-A	Preferred Alternative: Add CornerPoint-Daniels230		<90%	96%
bu08a1-B	Alternative B: Add CornerPoint-Smoky230		<90%	129%
bu08a1-C	Alternative C: Add CornerPoint-Smoky-Daniels230		<90%	114%
bu08a1-g1	Alternative A; Reduce Project to 440 MW Add CornerPoint-Daniels230		100%	105%

Table 8

Contingency Results Interconnect the Pawnee – Smoky Hill 230kV Line		Contingency / Loaded Element/ MVA Rating
Case	Description	Smoky-Buckley230 Smoky-Meadow230 (435 MVA)
bu08b1	Add 500 MW Project Interconnect Pawnee-SmokyHill230	124%
bu08b1-A	Alternative A: Add CornerPoint-Daniels230	103%
bu08b1-B	Alternative B: Add CornerPoint-Smoky230	132%
bu08b1-C	Alternative C: Add CornerPoint-Smoky-Daniels230	115%

Table 9

Contingency Results Interconnect the Pawnee - Daniels Park 230kV line		Contingency / Loaded Element	Pawnee-Smoky230 Corner-Daniels230	Smoky-Buckley230 Smoky-Meadow230
Case	Description	MVA Rating→	637	435
bu08a1	Add 500 MW Project Interconnect Pawnee-Daniels230		105%	105%
bu08a1-A	Preferred Alternative: Add CornerPoint-Daniels230		<90%	96%
bu08a1-B	Alternative: Add CornerPoint-Smoky230		<90%	129%
bu08a1-C	Alternative: Add CornerPoint-Smoky-Daniels230		<90%	114%