Xcel Energy

Interim Interconnection System Impact Study Report
Request # GI-2008-33
(Power Flow Only)

300 MW Gas Powered Generation Interconnecting at Pawnee Substation

PSCo Transmission Planning
January 23, 2012

A. Executive Summary

On December 31, 2008, Public Service Company of Colorado (PSCo) Transmission Planning received a generation interconnection request, GI-2008-33, to determine the potential system impacts associated with interconnecting a 300 MW (270 MW net output) gas generation facility at the Pawnee Substation through a 3-mile 345 kV transmission line. The 345 kV bus at Pawnee was considered as the Point of Interconnection (POI). The customer requested a commercial operation date for the facility to coincide with the completion of a new 345 kV transmission line between Pawnee and Smoky Hill and the related 345/230 kV substations, which is expected in May 2013. The study request indicated that the 1/3 of the generation would be delivered to the Black Hills service area near Pueblo, Colorado, while the remaining 2/3 would be delivered to the Wygen substation in Wyoming through Western Area Power Administration's (WAPA) transmission network. Generation at Black Hills Pueblo Airport Generation Station will be reduced by 85 MW, and generation at Black Hills Wygen will be reduced by 185 MW in order to accommodate the requested dispatch of the new generation.

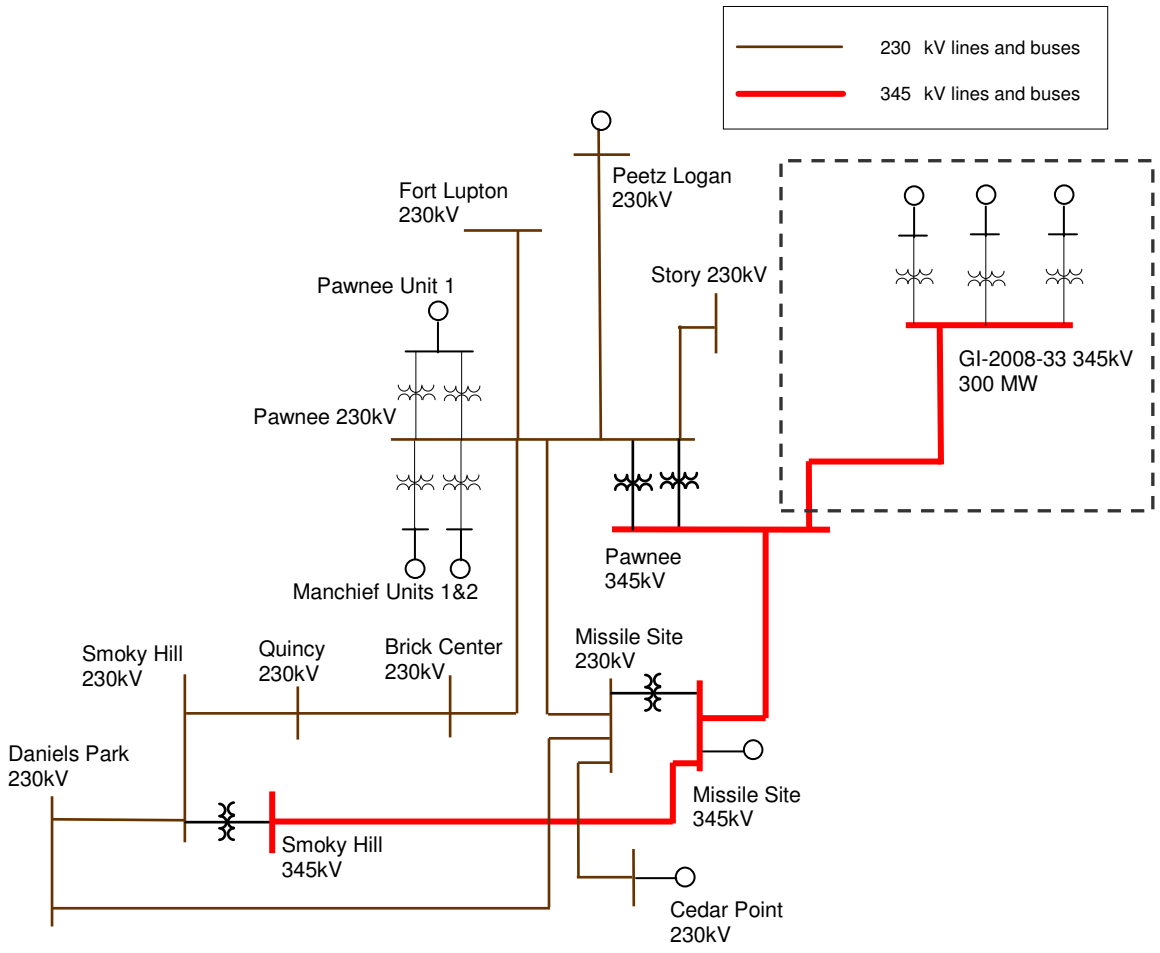
This request was studied as a Network Resource (NR)[1]. These investigations included steady-state impact power flow studies. The request was studied as a stand-alone project only, with no evaluations made of other potential new generation requests that may exist in the Large Generator Interconnection Request (LGIR) queue, other than the generation projects that are already approved and planned to be in service by the summer of 2013. The main purpose of this study was to evaluate the potential impact of GI-2008-33 on the PSCo transmission infrastructure as well as that of neighboring entities, when injecting a total of 300 MW of generation at Pawnee, and dispatching the power to Pueblo and Wyoming. This study studied facilities that are part of the PSCo transmission system as well as monitoring other nearby entities' regional transmission systems.

[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.

Three system base case scenarios were created to analyze the impact of the GI-2008-33, 300 MW project on the existing system. The generation dispatch for these three scenarios was adjusted for the base case without the new project to simulate potential low and high flow levels across TOT3. One scenario also simulated a higher north-to-south value for TOT7 flow. Single and Common-Tower contingencies were applied to each scenario.

For the addition of the GI-2008-33 project with the POI at the Pawnee 345kV substation, the most significant thermal violations observed were of the two parallel 345/230/13.8 kV transformers at Smoky Hill owned by PSCo. These violations occurred when one transformer was removed from service, resulting in and overload of the other. Another violation that was found was of the Clark to Jordan 230 kV line owned by PSCo when the common tower contingency of the Smoky Hill to Leetsdale 230kV line along with the Smoky Hill to Sullivan 230kV line was taken. There were no voltage violations to report.

Figure 1 Simple Diagram of the Pawnee Interconnection at 345 kV – 2013



Introduction

Public Service Company of Colorado (PSCo) received a large generator interconnection request (GI-2008-33) to interconnect 3 gas turbines, GE LMS100 Aero-derivative gas turbine units, rated at 100 MW each, with a total generator nameplate capacity of 300 MW. The net output of the new generation facility is 270 MW. The request indicated a commercial operation and back-feed date to coincide with the completion of the new proposed 345 kV upgrades to the Pawnee – Smoky Hill transmission line, currently scheduled for May 31, 2013. The proposed project would be located in Morgan County, Colorado. The project will be connected to the Pawnee Substation with a new 3-mile 345 kV transmission line. As per the customer's request, the 345 kV bus at Pawnee was considered to be the primary Point of Interconnection (POI), and no alternative POI is being considered for this study. This request has been evaluated as a stand-alone project with no other higher queued projects modeled.

The analytical efforts for this request were performed for a generation capacity of 300 MW facilities consisting of 3 100-MW gas turbines for the steady state analysis, and will be used for the stability analysis.

The Customer has requested that this project be evaluated as an Energy Resource (ER), with the energy delivered to Black Hills Pueblo and Black Hills Wyoming customers.

For this project, potential affected parties include the Platte River Power Authority (PRPA), Western Area Power Administration (WAPA), Tri-State Generation & Transmission (TSGT) and Black Hills Association. PSCo has forwarded a copy of this interim impact study report to the affected parties.

Power Flow Study Models

The starting power flow case was a 2013 Heavy Summer case that included the new 345-kV facilities between Pawnee and Smoky Hill as well as other committed generation and transmission system changes that are expected to be in operation for the 2013 summer peak period. Since the POI is located at Pawnee Sunstation, generation schedules for the major sources of generation in this area were reviewed. These resources included both Missile Site wind projects (a 400 MW facility connected to the Missile Site substation 345 kV bus and the Cedar Point 250 MW facility connected to the Missile Site 230 kV bus) and the Peetz Logan (575 MW) wind farm.

In this summer peak period analysis with high levels of wind generation reflected in northeastern Colorado, the Pawnee unit was dispatched at 529 MW and the Manchief units 1 and 2 were each set off-line. PSCo control area (Area 70) wind generation facilities near Pawnee, the Peetz Logan and Cedar Point facilities and the wind project that will be connected to the Missile Site 345 kV bus, were dispatched to approximately 75% of their respective ratings.

For the purpose of this study, the generation in areas 70 (PSCo) and 73 (WAPA) were re-dispatched to simulate north-to-south stress on the system. The TOT3 north-to-south flow was adjusted to two different levels, a high level at 1,360 MW and a low level of 588 MW; these levels represent boundary values for normal flows across TOT3. The TOT7 north-to-south flow was adjusted for a third case to a level of 460 MW coupled with the TOT3 flow of 1,360 MW. These three cases constitute the benchmark cases.

The proposed generation facility, as modeled, consists of 3 GE 100-MW gas turbines. The turbines have a terminal voltage of 13.8 kV and are connected to the 345 kV system through identical 13.8/345 kV transformers. For modeling purposes, each of the three generators was set to control the bus voltage on the facility's 345 kV bus to 1.030 per-unit.

The new generation was assumed to displace generation in the Black Hills Pueblo and Black Hills Wyoming systems. Specifically, generation at the Baculite 7 units in Pueblo were reduced by 85 MW, and the Wygen 3 units at Wygen were reduced by 185 MW.

Stand Alone Power Flow Results

The results of the AC contingency analyses for the GI-2008-33 addition with the Pawnee 345 kV POI were compared with those from the benchmark cases. For the 2013 case with the proposed generation addition of 300 MW and without any transmission system reinforcements, there are facilities that are adversely impacted by the new generation. Those facilities where facility loading was observed to be adversely impacted are listed in Table 1.

Table 1. AC Contingency Analysis for the 2013 Case Without Reinforcements

GI-2008-33 Thermal Peak Load Results		High TOT 3 Flow Scenario				High TOT 3 and TOT 7 Flow Scenar				Low TOT 3 Flow Scenario			
		Base Case with Project		Base Case without Project		Base Case with Project		Base Case without Project		Base Case with Project		Base Case without Project	
	TOT3 Flow	1230.5		1348		1208		1361		478		588	
	TOT7 flow	165.8		223.3		406		460.7		-152		-96.1	
Monitored Element / Contingency	**Branch Rating**	**Cont MVA**	**Loading %**	**Cont MVA**	**Loading %**	**Cont MVA**	**Loading %**	**Cont MVA**	**Loading %**	**Cont MVA**	**Loading %**	**Cont MVA**	**Loading %**
70112 CLARK 230 70241 JORDAN 230 1	438.0	483.2	110.3	446.1	101.8								
5167 5285													
70283 MEADOWHL 230 70396 SMOKYHIL 230 1	621.0	619.8	99.8	583.6	94.0								
5167 5285													
70396 SMOKYHIL 345/230 T5 Transformer	560.0	618.3	110.4	555.2	99.1	614.3	109.7	550.8	98.4				
3Wnd: OPEN SMOKYHIL 345/230 T4 Transformer													
70396 SMOKYHIL 345/230 T4 Transformer	560.0	618.3	110.4	555.2	99.1	614.3	109.7	550.8	98.4				
3Wnd: OPEN SMOKYHIL 345/230 T5 Transformer													

Given that PSCo has received the necessary CPCN to construct, and construction efforts are already underway for the Pawnee – Smoky Hill 345 kV transmission line, it is expected that this 345 kV line along with the necessary 345/230 kV transformers will be operational by the May 2013 timeframe. Under this assumption, one transmission line and both the Smoky Hill 345/230/13.8 kV transformers are overloaded under

contingency conditions when the GI-2008-33 facility is connected to the Pawnee 345 kV bus.

Table 1 shows that, for the full output of GI-2008-33, there is a contingency overload of the Smoky Hill 345/230 kV transformers at 110.4% of their 560 MVA rating with the outage of the parallel unit.

Included in Table 1 is one double contingency (N-2), common-tower outage, 5167_5285. This common-tower outage is described in Table 2. The 101.8% contingent loading of the Clark to Jordan 230 kV line, rated at 438 MVA, is increased by 8.5% to 110.3% due to the addition of GI-2008-33.

Table 2. Double Contingency (N-2) Common-Tower Outage Description

Contingency Name 5167_5285
SMOKY HILL to SULLIVAN 230 kV
SMOKY HILL to LEETSDALE 230 kV

A possible network reinforcement to address the single contingency overloads would be to add a third 345/230 kV transformer at Smoky Hill. This network upgrade was modeled and the contingency analysis was performed to identify any new violations resulting from these network upgrades. The results of this analysis with this system upgrade indicated that the Smoky Hill transformer overloads were resolved, but the violations under the double contingency (N-2), common-tower outage conditions were increased by 1.7%. The results after the network upgrade was modeled are shown in Table 3.

Table 3. AC Contingency Analysis for the 2013 Case With Reinforcements

		High TOT 3 Flow Scenario				High TOT3, TOT7 Flow Scenario				Low TOT 3 Flow Scenario			
GI-2008-33 Thermal Peak Load Results		Base Case with Project		Base Case without Project		Base Case with Project		Base Case without Project		Base Case with Project		Base Case without Project	
With 3rd 345/230/13.8 Smoky Hill Transformer	TOT3 Flow	1230.5		1348		1208		1361		478		588	
	TOT7 flow	165.8		223.3		406		460.7		-152		-96.1	
Monitored Element / Contingency	**Branch Rating**	**Cont MVA**	**Loading %**	**Cont MVA**	**Loading %**	**Cont MVA**	**Loading %**	**Cont MVA**	**Loading %**	**Cont MVA**	**Loading %**	**Cont MVA**	**Loading %**
70112 CLARK 230 70241 JORDAN 230 1	438.0	490.7	112.0	452.6	103.3								
5167_5285													
70283 MEADOWHL 230 70396 SMOKYHIL 230 1	621.0	627.3	101.0	590.1	95.0								
5167_5285													

Voltage Criteria Violations

The results of the steady state contingency analysis do not indicate high or low voltage violations or any voltage deviation criteria violations as a result of the studied contingencies.

Summary

The addition of the GI-2008-33 project with the POI at the Pawnee 345 kV substation will have an adverse impact on loading of the Smoky Hill 345/230/13.8 kV transformers under summer peak conditions. The thermal violations from this analysis indicated that the loss of one of these parallel 345/230/13.8 kV transformers would result in the loading to 110.4% of the 560 MVA rating for the other transformer. The other violation was for a double contingency (N-2), common-tower outage that causes a violation of the Clark to Jordan 230 kV line owned by PSCo at 110.3% of the 438 MVA rating. The Common-tower outage includes the Smoky Hill to Leetsdale 230kV line along with the Smoky Hill to Sullivan 230kV line. The only system improvement considered was the addition of a third 345/230/13.8 kV transformer at the Smoky Hill substation. Adding this system improvement relieves the transformer violation only. The common-tower outage violation is increased by 1.7% with this addition. For this analysis, there were no voltage violations to report.