Interconnection System Impact Study Report
Request # GI-2007-11

CTG #'s 5 & 6 (269 MW total - summer) Additions at Fort St. Vrain Generation Plant in Summer 2009

PSCo Transmission Planning
March 4, 2008

Executive Summary

On or about October 24, 2007 Public Service Company of Colorado (PSCo) Transmission Planning received a generation interconnection request to perform an Interconnection System Impact Study (SIS, or "Study") to assess the impact of interconnecting two simple-cycle gas-fired combustion turbine generators (CTG 5 & CTG 6) at its Fort St. Vrain (FSV) generation plant located north of Denver in Weld County, Colorado. Based upon information provided by the Customer (PSCo – Energy Supply Function), the total net output of the two General Electric CTGs is 269 MW (summer net) / 331 MW (winter net), with a planned back-feed date of January 15, 2009, and a commercial operation in-service date of no later than May 31, 2009. This Study was performed for the summer 2009 (269 MW total) ratings, and included short-circuit and dynamic stability studies. The details of these studies are identified in the Dynamic Stability Analysis Study Results section of this report. Steady-state power flow studies were not performed in this SIS, as these were performed for a 300 MW total, 2009 summer case in the previous Special Study (NQ-2007-2, final report issued 10/24/07). Additional steady-state power flow studies based upon a winter peak load (2009-2010) for a 331 MW CTG5 – CTG6 output will be performed separately, and a separate study report will be issued once this study is completed.

This study also determined the scope of work and costs associated with the installation and interconnection of the two new generator step-up transformers (GSU, one each per CTG 5 & 6) into the existing 230 kV switchyard at FSV, and has identified additional transmission network upgrades and costs that were not identified in the initial NQ-2007-2 study. The upgrades include replacing seventeen 230 kV breakers in the FSV switchyard, due to the increased level of maximum 230 kV short-circuit levels associated with the added generation at FSV, and a required relocation of the two 230 kV cap banks at FSV. The details of these upgrades are identified in the Cost Summaries and Details section of this report.

Based upon the investigations completed, the required transmission interconnections and network upgrades (except all FSV breaker replacements) should be achievable by the summer of 2009. The work required consists of:

- **Upgrades Required for Interconnection (FSV):** Install two new 230 kV, 2-breaker bays and associated relaying, and metering at FSV, to provide 230 kV interconnection facilities for the two new main GSU transformers for the CTG5 & CTG6. Includes costs associated with re-locating one of two existing 230 kV capacitor banks.

- **Network Upgrades Required for Delivery:**

  - FSV: replace seventeen 230 kV breakers due to increased short-circuit interrupting duty requirements (completed in 2009 – 6/2010, but do not impede 5/31/09 Commercial Operation Date).
  - Replace the conductor on a 2.5-mile section of the Ft. Lupton – FSV 230 kV double circuit line.
  - Minor line termination upgrades (conductor jumpers, relay settings changes, etc.), or utilize the 4-hr. emergency ratings capability of existing bus conductor at six substations.
  - Expedite from May 2010 to May 2009 the previously approved and budgeted project to install a second 230/115 kV, 280 MVA autotransformer at Valmont Substation.

Total Project Cost for Interconnection & Network Upgrades for Delivery: $7.568 million (plus $4.7 million separately budgeted, but expedited Valmont 230-115 kV, 280 MVA Autotransformer #2 installation).

Dynamics Stability Analysis Study Results (performed by Siemens / PTI)

Input Data

The benchmark stability analysis started from a WECC approved 2011HS1BP power flow base case, with the associated machine model data for the 2011 summer peak period. This case has been successfully used in recent stability analyses for several other generator system impact studies. The case was further modified with the topology and load data imported from a recent 2009 heavy summer peak load "PSCo budget case", for the PSCo (control area 70) and WAPA (control area 73). A second power flow case was created that added the two combustion turbines (CTG5 & CTG6, 135 MW / 206 MVA ea.), along with their respective main 230-18 kV, 200 MVA GSU transformers, to the benchmark power flow case. Generation from the new units was assumed to displace generation from the existing Comanche units. The machine models for the two new units were based on test results for similar units at FSV (e.g., CTG4), as the specific manufacturer (GE) data was not made available at the time the study was begun. The Customer provided the actual GE

machine data after the studies were completed. This new data was compared to the typical model data, and was determined to have insignificant differences with the typical machine model data used in the study. The test results were also used to update the machine dynamics models for the existing combustion turbines.

Methodology

The stability analysis was performed using PSS™E version 30.2. After reviewing the data for reasonableness and obtaining a flat start with the benchmark case, dynamic simulations were performed for both the benchmark case and the case with the new FSV CTG5 & CTG6 generators (GI-2007-11) for a common set of system disturbances to determine if the addition of the new FSV generation would have any adverse impacts on the system.

Rotor angles, mechanical and electrical power, generator terminal voltages, and frequency were monitored for representative generating units throughout control areas 70 and 73. In addition, voltages at the 115-, 230-, and 345-kV buses in areas 70 and 73 were also monitored.

WECC planning criteria including voltage deviation criteria for system response after disturbances was used in the analysis. Specifically, WECC requires that for a single contingency, transient voltage dips cannot exceed 25% at load buses, or 30% at non-load buses, cannot exceed 20% for more than 20 cycles at any load bus, cannot have a post-transient voltage deviation exceed 5% at any bus, and the frequency cannot dip below 59.6 Hz for 6 cycles or more at a load bus. For multiple contingencies, transient voltage dips cannot exceed 30% at any bus and cannot exceed 20% for more than 40 cycles at any load bus, cannot have a post-transient voltage deviation exceed 10% at any bus, and frequency cannot dip below 59.0 Hz for 6 cycles or more at a load bus. The addition of any new generation cannot produce system performance that is out of compliance with the values stated above.

Contingencies Studied

A list of faults near the proposed GI-2007-11 project were developed that should provide a reasonably thorough evaluation of system performance (see Table 1). Twelve three-phase faults on single 230-kV circuits were studied, with fault clearing in 5 cycles. In addition, four three-phase faults were studied that required the tripping of two circuits in 5 cycles. Finally three contingencies were studied that consisted of single-line-to-ground faults with delayed clearing, at 23 cycles.

Results

For all contingencies that were studied, the results of the stability analysis indicates that the addition of GI-2007-11 (FSV CTG5 and CTG6) does not have an adverse

impact on the response of the system to severe system disturbances. All generation remained on line, except where disconnected from the system. All oscillations were positively damped and voltage deviations on nearby 115 kV and 230 kV buses were well within criteria. The contingencies consisting of delayed clearing were similarly behaved with no undamped oscillations and voltage response within criteria as well. Results of system behavior in the benchmark case were similar to those observed for the case with GI-2007-11 generation.

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Table 1: List of Bus Faults Used in Dynamics Study

Fault				Cleared Circuit 1							Cleared Circuit 2 (N - 2 and Breaker Failure)						
Location			Duration	Bus 1			Bus 2			Circuit	Bus 1			Bus 2			Ckt
Name	kV	Number	(Cycles)	Name	kV	Number	Name	kV	Number		Name	kV	Number	Name	kV	Number	
St.Vrain	230	70410	5	St.Vrain	230	70410	FtLupton	230	70192	1	None						
St.Vrain	230	70410	5	St.Vrain	230	70410	Isabelle	230	70544	1	None						
St.Vrain	230	70410	5	St.Vrain	230	70410	Weld PS	230	70471	1	None						
St.Vrain	230	70410	5	St.Vrain	230	70410	*Fordham*	*230*	*73562*	1	None						
St.Vrain	230	70410	5	St.Vrain	230	70410	GreenVal	230	70048	1	None						
St.Vrain	230	70410	5	St.Vrain	230	70410	LongPeak	230	73116	1	None						
St.Vrain	230	70410	5	St.Vrain	230	70410	Spndle	230	70592	1	None						
St.Vrain	230	70410	5	St.Vrain	230	70410	Windsor	230	70474	1	None						
FtLupton	230	70192	5	St.Vrain	230	70410	FtLupton	230	70192	1	None						
Spndle	230	70592	5	St.Vrain	230	70410	Spndle	230	70592	1	None						
Niwot	230	70297	5	Isabelle	230	70544	Niwot	230	70297	1	None						
St.Vrain	230	70410	5	St.Vrain	230	70410	Spndle	230	70592	1	St.Vrain	230	70410	Isabelle	230	70544	1
St.Vrain	230	70410	5	St.Vrain	230	70410	GreenVal	230	70048	1	Keenesbg	230	70820	GreenVal	230	70048	1
St.Vrain	230	70410	5	St.Vrain	230	70410	FtLupton	230	70192	1	St.Vrain	230	70410	FtLupton	230	70192	2
St.Vrain	230	70410	5	St.Vrain	230	70410	Isabelle	230	70544	1	Spndle	230	70592	Valmont	230	70447	1
St.Vrain	230	70410	23	St.Vrain	230	70410	LongPeak	230	73116	1	St.Vrain	230	70410	Isabelle	230	70544	1
St.Vrain	230	70410	23	St.Vrain	230	70410	Weld PS	230	70471	1	St.Vrain	230	70410	*Fordham*	*230*	*73562*	1
St.Vrain	230	70410	23	St.Vrain	230	70410	Windsor	230	70474	1	St.Vrain	230	70410	*Fordham*	*230*	*73562*	1

Note: If the N - 2 breaker failure simulations meet criteria with a clearing time of 23 cycles, no further simulations for that scenario will be run. If the N - 2 simulations do not meet criteria with a clearing time of 23 cycles, the critical clearing time for that scenario will be determined.

Cost Summaries and Details

The following is a summary of the interconnection costs and network upgrades required to connect two new simple-cycle gas-fired combustion turbine generators (CTG5 and CTG6, each rated approximately 135MW (summer) / 206 MVA) into the PSCo transmission system at the Fort Saint Vrain 230 kV switchyard. The scope of the interconnection facilities and network upgrades were identified in Non-Queued Study Report labeled NQ-2007-2 provided by PSCo Transmission System Planning on October 19, 2007.

Facility	Description	Cost
Fort Saint Vrain 230kV Switching Station	Interconnection Facilities funded by TAM: • Expand two 230kV buses to the east • Install two 230kV bays in the Breaker & Half, one interconnection point per bay • Four 230kV circuit breakers • Ten 230kV gang switches • Associated foundations, structures, and yard work	$2,461,836
Fort Saint Vrain 230kV Switching Station	Network Upgrades funded by TAM: • Replace 17 230kV circuit breakers due to insufficient fault duty	$3,692,890
Fort Saint Vrain 230kV Switching Station	Operations and Maintenance Costs funded by TAM: • Relocate 50MVAR capacitor bank to the west of current position	$28,194
Fort Saint Vrain 230kV Switching Station	Interconnection Costs funded by Customer: • Metering instrument transformers (set of three per interconnection) • Two dead-end towers • Metering panel equipment • Associated foundations, structures, and buswork	$594,321
Fort Saint Vrain Generating Plant	LF/AGC Costs funded by Customer: • Load control RTU • All required cabinets, wiring, and associated controls equipment	$123,280
Ft. Lupton – Ft. St. Vrain 230kV Lines 5311, 5329	Network Upgrade funded by TAM: Reconductor 15 spans (2.5 miles) of existing double-circuit 230kV transmission line • 1033.5 Ortolan conductor (540 MVA)	$621,946

Facility	Description	Cost
Cherokee Substation	Network Upgrade funded by TAM: Upgrade line termination jumpers on Cherokee - Lacombe 230kV Ckt #5057	$15,000
Hogback Substation	Network Upgrades funded by TAM: • Upgrade line termination jumpers on Hogback – Lookout 115kV Ckt #9794 • Upgrade line termination jumpers on Hogback – Soda Lakes 115kV Ckt #9794	$30,000
	Total Interconnection Costs by TAM	**$2,461,836**
	Total Network Upgrades by TAM	**$4,359,836**
	Total Operations & Maintenance Costs by TAM	**$28,194**
	Total Interconnection Costs funded by Customer	**$717,601**
Total	**Total cost of GI-2007-11** (Not including previously funded Valmont Autos)	**$7,567,467**
Time Frame	See Schedule – Figure 2	

230kV Bus Fault Current Ratings – Fort Saint Vrain Switching Station

The 230kV bus fault currents at the Fort Saint Vrain switching station, with the addition of the new CTG5 & CTG6 generation, are as follows:

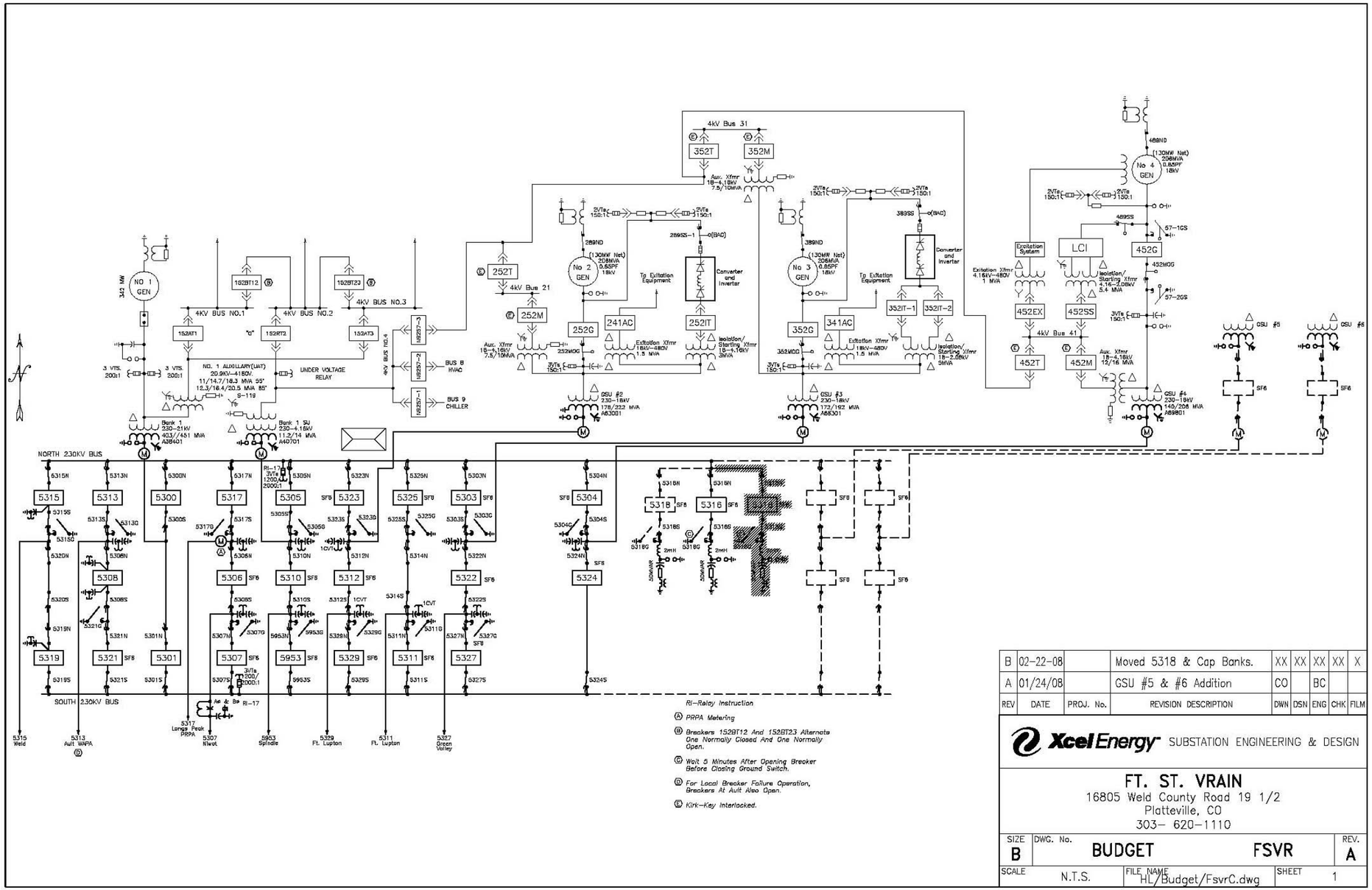
Single-line to Ground Fault: ~40,783A < -85.7 deg
3-Phase Fault: ~38,949A < -86.1 deg

GI-2007-11 Ft. St. Vrain Generation Addition Assumptions

- The cost estimates provided are “scoping estimates” with an accuracy of +/- 30%.
- All applicable overheads are included. AFUDC has been excluded.
- There is no contingency added to the estimates.
- All estimates are in 2008 dollars.
- No overtime is included in the labor estimates.
- PSCo (or its contractor) crews will perform all construction and wiring associated with PSCo-owned and maintained equipment.
- No siting or permitting work will be required.
- A Certificate of Public Convenience and Necessity (CPCN) will be required from Colorado Public Utility Commission (CPUC) for the PSCo generation addition (GT5 & GT6, NQ-2007-2 / GI-2007-11) project, and has already been filed, with CPUC ruling expected by 4/1/08.

- Spare fiber optics between plant and switchyard.
- All required transmission outages necessary to support construction would be obtained as needed.
- Assumes a dedicated construction force to the project (in-house crews).
- Construction of new substation facilities is within existing property boundaries.
- Back-feed date of new generation is 1/15/2009. Interconnection facilities must be complete by this date.
- Commercial date of new generation is 5/31/2009. All network upgrades other than the 17 breaker replacements must be complete by this date. Breaker numbers requiring replacement:
  5316, 5318, 5300, 5301, 5303, 5304, 5308, 5311, 5312, 5315, 5319, 5322, 5323, 5324, 5325, 5327, 5329.
- Breaker replacements are anticipated to be complete by 2nd quarter, 2010.

Figure 1: Fort St.Vrain Budget One-Line Diagram
(Note – additions for new GTG5 & GTG6 GSU's interconnection equipment shown dashed)



REV	DATE	PROJ. No.	REVISION DESCRIPTION	DWN	DSN	ENG	CHK	FILM
B	02-22-08		Moved 5318 & Cap Banks.	XX	XX	XX	XX	X
A	01/24/08		GSU #5 & #6 Addition	CO		BC		

Xcel Energy SUBSTATION ENGINEERING & DESIGN

FT. ST. VRAIN
16805 Weld County Road 19 1/2
Platteville, CO
303- 620-1110

SIZE	DWG. No.	REV.
B	BUDGET FSVR	A

SCALE	FILE NAME	SHEET
N.T.S.	HL/Budget/FsvrC.dwg	1

Figure 2: Fort St.Vrain Preliminary / Draft Schedule

ID	Task Name	Duration	Start	Finish
1	**GI-2007-11 FT ST VRAIN G5 & G6 ADDITIONS**	**328 days?**	**Wed 2/27/08**	**Fri 5/29/09**
2	**FT ST VRAIN SWITCHYARD INTERCONNECTION**	**231 days?**	**Wed 2/27/08**	**Wed 1/14/09**
3	**Add Two 230kV Bays**	**231 days?**	**Wed 2/27/08**	**Wed 1/14/09**
4	Substation Engineering & Design	64 days?	Wed 2/27/08	Mon 5/26/08
5	Material Procurement	130 days?	Mon 3/3/08	Fri 8/29/08
6	Substation Construction	173 days?	Mon 5/5/08	Wed 12/31/08
7	Commissioning/Testing	44 days?	Fri 11/14/08	Wed 1/14/09
8	FSV G5 & G6 BACKFEED	0 days	Thu 1/15/09	Thu 1/15/09
9	**FT ST VRAIN NETWORK UPGRADES**	**281 days?**	**Mon 3/3/08**	**Mon 3/30/09**
10	**FSV-Ft Lupton Lines 5311, 5329 Reconductor**	**185 days?**	**Mon 3/3/08**	**Fri 11/14/08**
11	Transmission Engineering	65 days?	Mon 3/3/08	Fri 5/30/08
12	Material Procurement	110 days?	Wed 4/30/08	Tue 9/30/08
13	Transmission Construction	33 days?	Wed 10/1/08	Fri 11/14/08
14	**Cherokee Substation Jumper Upgrades**	**130 days?**	**Mon 9/1/08**	**Fri 2/27/09**
15	Substation Engineering	22 days?	Mon 9/1/08	Tue 9/30/08
16	Material Procurement	86 days?	Mon 9/22/08	Mon 1/19/09
17	Substation Construction	20 days?	Mon 2/2/09	Fri 2/27/09
18	**Hobgack Substation Jumper Upgrades**	**136 days?**	**Mon 9/22/08**	**Mon 3/30/09**
19	Substation Engineering	23 days?	Wed 10/1/08	Fri 10/31/08
20	Material Procurement	86 days?	Mon 9/22/08	Mon 1/19/09
21	Substation Construction	21 days?	Mon 3/2/09	Mon 3/30/09
22	**FT ST VRAIN CUSTOMER LF/AGC - TESTING**	**260 days?**	**Mon 6/2/08**	**Fri 5/29/09**
23	Substation Engineering	44 days?	Mon 6/2/08	Thu 7/31/08
24	Material Procurement	87 days?	Fri 6/27/08	Mon 10/27/08
25	LF/AGC Installation	54 days?	Mon 11/3/08	Thu 1/15/09
26	Plant Testing	106 days?	Fri 1/2/09	Fri 5/29/09
27	FSV PLANT COMMERCIAL DATE	0 days	Mon 6/1/09	Mon 6/1/09
28	**FSV BREAKER REPLACEMENTS**	**543 days?**	**Mon 3/3/08**	**Wed 3/31/10**
29	Substation Engineering	109 days?	Tue 7/1/08	Fri 11/28/08
30	Material Procurement	226 days?	Mon 3/3/08	Mon 1/12/09
31	Substation Construction	313 days?	Mon 1/19/09	Wed 3/31/10

Project: Schedule.mpp
Date: Wed 2/27/08

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

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